Attachment O

Appendix W Text with AISI-Proposed Edits Shown

PART 51—REQUIREMENTS FOR PREPARATION, ADOPTION, AND SUBMITTAL OF IMPLEMENTATION PLANS

1. The authority citation for part 51 continues to read as follows:

Authority: 23 U.S.C. 101; 42 U.S.C. 7401-7671q.

2. Appendix W to part 51 is revised to read as follows:

APPENDIX W TO PART 51—GUIDELINE ON AIR QUALITY MODELS

PREFACE

a. Industry and control agencies have long expressed a need for consistency in the application of air quality models for regulatory purposes. In the 1977 Clean Air Act (CAA), Congress mandated such consistency and encouraged the standardization of model applications. The *Guideline on Air Quality Models* (hereafter, *Guideline*) was first published in April 1978 to satisfy these requirements by specifying models and providing guidance for their use. The *Guideline* provides a common basis for estimating the air quality concentrations of criteria pollutants used in assessing control strategies and developing emissions limits.

b. The continuing development of new air quality models in response to regulatory requirements and the expanded requirements for models to cover even more complex problems have emphasized the need for periodic review and update of guidance on these techniques. Historically, three primary activities have provided direct input to revisions of the *Guideline*. The first is a series of periodic EPA workshops and modeling conferences conducted for the purpose of ensuring consistency and providing clarification in the application of models. The second activity was the solicitation and review of new models from the technical and user community. In the March 27, 1980, *Federal Register*, a procedure was outlined for the submittal to the EPA of privately developed models. After extensive evaluation and scientific review, these models, as well as those made available by the EPA, have been considered for recognition in the *Guideline*. The third activity is the extensive on-going research efforts by the EPA and others in air quality and meteorological modeling.

c. Based primarily on these three activities, new sections and topics have been included as needed. The EPA does not make changes to the guidance on a predetermined schedule, but rather on an as-needed basis. The EPA believes that revisions of the *Guideline* should be timely and responsive to user needs and should involve public participation to the greatest possible extent. All future changes to the guidance will be proposed and finalized in the *Federal Register*. Information on the current status of modeling guidance can always be obtained from EPA's Regional Offices.

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APPENDIX A TO APPENDIX W OF PART 51—SUMMARIES OF PREFERRED AIR QUALITY MODELS

List of Tables

1.1 Introduction

a. The *Guideline* recommends air quality modeling techniques that should be applied to State Implementation Plan (SIP) submittals and revisions, to New Source Review (NSR), including new or modifying sources under Prevention of Significant Deterioration (PSD),[1, 2, 3] conformity analyses,[4] and other air quality assessments required under EPA regulation. Applicable only to criteria air pollutants, the *Guideline* is intended for use by the EPA Regional Offices in judging the adequacy of modeling analyses performed by the EPA, by state, local, and tribal permitting authorities, and by industry. It is appropriate for use by other federal government agencies and by state, local, and tribal agencies with air quality and land management responsibilities. The *Guideline* serves to identify, for all interested parties, those modeling techniques and databases that the EPA considers acceptable. The *Guideline* is not intended to be a compendium of modeling techniques. Rather, it should serve as a common measure of acceptable technical analysis when supported by sound scientific judgment.

b. Air quality measurements[5] are routinely used to characterize ambient concentrations of criteria pollutants throughout the nation but are rarely sufficient for characterizing the ambient impacts of individual sources or demonstrating adequacy of emissions limits for an existing source due to limitations in spatial and temporal coverage of ambient monitoring networks. The impacts of new sources that do not yet exist and modifications to existing sources that have yet to be implemented can only be determined through modeling. Thus, models have become a primary analytical tool in most air quality assessments. Air quality measurements can be used in a complementary manner to air quality models, with due regard for the strengths and weaknesses of both analysis techniques, and are particularly useful in assessing the accuracy of model estimates.

c. It would be advantageous to categorize the various regulatory programs and to apply a designated model to each proposed source needing analysis under a given program. However, the diversity of the nation's topography and climate, and variations in source configurations and operating characteristics dictate against a strict modeling "cookbook." There is no one model capable of properly addressing all conceivable situations even within a broad category such as point sources. Meteorological phenomena associated with threats to air quality standards are rarely amenable to a single mathematical treatment; thus, case-by-case analysis and judgment are frequently required. As modeling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology. Further, they should be coordinated closely with specialists in emissions characteristics, air monitoring and data processing. The judgment of experienced meteorologists, atmospheric scientists, and analysts is essential.

d. The model that most accurately estimates concentrations in the area of interest is always sought. However, it is clear from the needs expressed by the EPA Regional Offices, by state, local, and tribal agencies, by many industries and trade associations, and also by the deliberations of Congress that consistency in the selection and application of models and databases should also be sought, even in case-by-case analyses. Consistency ensures that air quality control agencies and the general public have a common basis for estimating pollutant concentrations, assessing control strategies, and specifying emissions limits. Such consistency is not, however, promoted at the expense of model and database accuracy. The *Guideline* provides a consistent basis for selection of the most accurate models and databases for use in air quality assessments.

e. Recommendations are made in the *Guideline* concerning air quality models and techniques, model evaluation procedures, and model input databases and related requirements. The guidance provided here should be followed in air quality analyses relative to SIPs, NSR, and in supporting analyses required by the EPA and by state, local, and tribal permitting authorities. Specific models are identified for particular applications. The EPA may approve the use of an alternative model or technique that can be demonstrated to be more appropriate than those recommended in the *Guideline*. In all cases, the model or technique applied to a given situation should be the one that provides the most accurate representation of atmospheric transport, dispersion, and chemical transformations in the area of interest. However, to ensure consistency, deviations from the *Guideline* should be carefully documented as part of the public record and fully supported by the appropriate reviewing authority, as discussed later.

f. From time to time, situations arise requiring clarification of the intent of the guidance on a specific topic. Periodic workshops are held with EPA headquarters, EPA Regional Office, and state, local, and tribal agency modeling representatives to ensure consistency in modeling guidance and to promote the use of more accurate air quality models, techniques, and databases. The workshops serve to provide further explanations of *Guideline* requirements to the EPA Regional Offices and workshop materials are issued with this clarifying information. In addition, findings from ongoing research programs, new model development, or results from model evaluations and applications are continuously evaluated. Based on this information, changes in the applicable guidance may be indicated and appropriate revisions to the *Guideline* may be considered.

g. All changes to the *Guideline* must follow rulemaking requirements since the *Guideline* is codified in appendix W to 40 Code of Federal Regulations (CFR) part 51. The EPA will promulgate proposed and final rules in the *Federal Register* to amend this appendix. The EPA utilizes the existing procedures under CAA section 320 that requires EPA to conduct a Conference on Air Quality Modeling at least every 3 years. These modeling conferences are intended to develop standardized air quality modeling procedures and form the basis for associated revisions to this *Guideline* in support of the EPA's continuing effort to prescribe with "reasonable particularity" air quality models and meteorological and emission databases suitable for modeling National Ambient Air Quality Standards (NAAQS)[6] and PSD increments (CAA 320, 42 U.S.C. 7620). Ample opportunity for public comment will be provided for each proposed change and public hearings scheduled.

~~h.~~ EPA periodically makes refinements to existing model formulations or makes modeling updates that constitute guidance, but not rulemaking. EPA may also issue "bug fixes" which are corrections to address minor model code or logic errors. EPA will also provide an opportunity for public comment on these types of modeling changes.

h.

i. A wide range of topics on modeling and databases are discussed in the *Guideline*. Section 2 gives an overview of models and their suitability for use in regulatory applications. Section 3 provides specific guidance on the determination of preferred air quality models and on the selection of alternative models or techniques. Sections 4 through 6 provide recommendations on modeling techniques for assessing criteria pollutant impacts from single and multiple sources with specific modeling requirements for selected regulatory applications. Section 7 discusses general considerations common to many modeling analyses for stationary and mobile sources. Section 8 makes recommendations for data inputs to models including source, background air quality, and meteorological data. Section 9 summarizes how estimates and measurements of air quality are used in assessing source impact and in evaluating control strategies.

j. Appendix W to 40 CFR part 51 contains an appendix: Appendix A. Thus, when reference is made to "appendix A" in this document, it refers to appendix A to appendix W to 40 CFR part 51. Appendix A contains summaries of refined air quality models that are "preferred" for particular applications; both EPA models and models developed by others are included.

2.1 Overview of Model Use

a. Increasing reliance has been placed on concentration estimates from air quality models as the primary basis for regulatory decisions concerning source permits and emission control requirements. In many situations, such as review of a proposed new source, no practical alternative exists. Before attempting to implement the guidance contained in this document, the reader should be aware of certain general information concerning air quality models and their evaluation and use. Such information is provided in this section.

2.1 Suitability of Models

a. The extent to which a specific air quality model is suitable for the assessment of source impacts depends upon several factors. These include: (1) the topographic and meteorological complexities of the area; (2) the detail and accuracy of the input databases, *i.e.*, emissions inventory, meteorological data, and air quality data; (3) the manner in which complexities of atmospheric processes are handled in the model; (4) the technical competence of those undertaking such simulation modeling; and (5) the resources available to apply the model. Any of these factors can have a significant influence on the overall model performance, which must be thoroughly evaluated to determine the suitability of an air quality model to a particular application or range of applications.

b. Air quality models are most accurate and reliable in areas that have gradual transitions of land use and topography. Meteorological conditions in these areas are spatially uniform such that observations are broadly representative and air quality model projections are not further complicated by a heterogeneous environment. Areas subject to major topographic influences experience meteorological complexities that are often difficult to measure and simulate. Models with adequate performance are available for increasingly complex environments. However, they are resource intensive and frequently require site-specific observations and formulations. Such complexities and the related challenges for the air quality simulation should be considered when selecting the most appropriate air quality model for an application.

c. Appropriate model input data should be available before an attempt is made to evaluate or apply an air quality model. Assuming the data are adequate, the greater the detail with which a model considers the spatial and temporal variations in meteorological conditions and permit-enforceable emissions, the greater the ability to evaluate the source impact and to distinguish the effects of various control strategies.

d. There are three types of models that have historically been used in the regulatory demonstrations applicable in the *Guideline*, each having strengths and weaknesses that lend themselves to particular regulatory applications.

i. Gaussian plume models use a "steady-state" approximation, which assumes that over the model time step, the emissions, meteorology and other model inputs, are constant throughout the model domain, resulting in a resolved plume with the emissions distributed throughout the plume according to a Gaussian distribution. This formulation allows Gaussian models to estimate near-field impacts of a limited number of sources at a relatively high resolution, with temporal scales of an hour and spatial scales of meters. However, this formulation allows for only relatively inert pollutants, with very limited considerations of transformation and removal (*e.g.*, deposition), and further limits the domain for which the model may be used. Thus, Gaussian models may not be appropriate if model inputs are changing sharply over the model time step or within the desired model domain or if more advanced considerations of chemistry are needed.

ii. Lagrangian puff models, on the other hand, are non-steady-state, and assume that model input conditions are changing over the model domain and model time step. Lagrangian models can also be used to determine near and far-field impacts from a limited number of sources at a high resolution. Traditionally, Lagrangian models have been used for relatively inert pollutants, with slightly more complex considerations of removal than Gaussian models. Some Lagrangian models treat in-plume gas and particulate chemistry. However, these models require time and space varying concentration fields of oxidants and, in the case of fine particulate matter ($PM_{2.5}$), neutralizing agents, such as ammonia. Reliable background fields are critical for applications involving secondary pollutant formation because secondary impacts generally occur when in-plume precursors mix and react with species in the background atmosphere[7, 8]. These oxidant and neutralizing agents are not routinely measured, but can be generated with a three-dimensional photochemical grid model.

iii. Photochemical grid models are three-dimensional Eulerian grid-based models that treat chemical and physical processes in each grid cell and use diffusion and transport processes to move chemical species between grid cells.[9] Eulerian models assume that emissions are spread evenly throughout each model grid cell. Typically, Eulerian models have difficulty with fine scale resolution of individual plumes. Approaches for resolving individual plumes include use of high resolution grid cells and/or use of a subgrid-scale Lagrangian "plume-in-grid" model. However, these types of models can be appropriately applied for assessment of near-field and regional scale reactive pollutant impacts from specific sources[7, 10, 11, 12] or all sources.[13, 14, 15] Photochemical gri~~r~~d models simulate a more realistic environment for chemical transformation,[7, 12] but simulations can be more resource intensive than Lagrangian or Gaussian plume models.

e. Competent and experienced meteorologists, atmospheric scientists, and analysts are an essential prerequisite to the successful application of air quality models. The need for such specialists is critical when the more sophisticated models are used or the area being investigated has complicated meteorological or topographic features. It is important to note that a model applied improperly or with inappropriate data can lead to serious misjudgments regarding the source impact or the effectiveness of a control strategy.

f. The resource demands generated by use of air quality models vary widely depending on the specific application. The resources required may be important factors in the selection and use of a model or technique for a specific analysis. These resources depend on the nature of the model and its complexity, the detail of the databases, the difficulty of the application, the amount and level of expertise required, and the costs of manpower and computational facilities.

2.1.1 Model Accuracy and Uncertainty

a. The formulation and application of air quality models are accompanied by several sources of uncertainty. "Irreducible" uncertainty stems from the "unknown" conditions, which may not be explicitly accounted for in the model (*e.g.,* the turbulent velocity field). Thus, there are likely to be deviations from the observed concentrations in individual events due to variations in the unknown conditions. "Reducible" uncertainties[16] are caused by: (1) uncertainties in the "known'' input conditions (*e.g.,* emission characteristics and meteorological data); (2) errors in the measured concentrations; and (3) inadequate model physics and formulation.

b. Evaluations of model accuracy should focus on the reducible uncertainty associated with physics and the formulation of the model. The accuracy of the model is normally determined by an evaluation procedure which involves the comparison of model concentration estimates with measured air quality data.[17] The statement of model accuracy is based on statistical tests or performance measures such as bias, noise, correlation, etc.[18, 19]

c. Since the 1980's, the EPA has worked with the modeling community to encourage development of standardized model evaluation methods and the development of continually improved methods for the characterization of model performance.[16, 18, 20, 21, 22].There is general consensus on what should be considered in the evaluation of air quality models; namely, quality assurance planning, documentation and scrutiny should be consistent with the intended use and should include:

- Scientific peer review;
- Supportive analyses (diagnostic evaluations, code verification, sensitivity
- analyses);
- Diagnostic and performance evaluations with data obtained in trial locations; and
- Statistical performance evaluations in the circumstances of the intended applications.

Performance evaluations and diagnostic evaluations assess different qualities of how well a model is performing, and both are needed to establish credibility within the client and scientific community.

d. Performance evaluations allow the EPA and model users to determine the relative performance of a model in comparison with alternative modeling systems. Diagnostic evaluations allow determination of a model capability to simulate individual processes that affect the results, and usually employ smaller spatial/ temporal scale date sets (*e.g.,* field studies).

Diagnostic evaluations enable the EPA and model users to build confidence that model predictions are accurate for the right reasons. However, the objective comparison of modeled concentrations with observed field data provides only a partial means for assessing model performance. Due to the limited supply of evaluation datasets, there are practical limits in assessing model performance. For this reason, the conclusions reached in the science peer reviews and the supportive analyses have particular relevance in deciding whether a model will be useful for its intended purposes.

2.2 Levels of Sophistication of Air Quality Analyses and Models

a. It is desirable to begin an air quality analysis by using simplified or conservative methods (or both) followed, as appropriate, by more complex and refined methods. The purpose of this approach is to streamline the process and sufficiently address regulatory requirements by eliminating the need of more detailed modeling when it is not necessary in a specific regulatory application. For example, in the context of a PSD permit application, a simplified or conservative analysis may be sufficient where it shows the proposed construction clearly will not cause or contribute to ambient concentrations in excess of either the NAAQS or the PSD increments.[2, 3]

b. There are two general levels of sophistication of air quality models. The first level consists of screening models that provide conservative modeled estimates of the air quality impact of a specific source or source category based on simplified assumptions of the model inputs (*e.g.*, preset, worst-case meteorological conditions). In the case of a PSD assessment, if a screening model indicates that the concentration contributed by the source could cause or contribute to a violation of any NAAQS or PSD increment, then the second level of more sophisticated models should be applied.

c. The second level consists of refined models that provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide spatially and temporally resolved concentration estimates. As a result they provide a more sophisticated and, at least theoretically, a more accurate estimate of source impact and the effectiveness of control strategies.

d. There are situations where a screening model or a refined model is not available such that screening and refined modeling are not viable options to determine source-specific air quality impacts. In such situations, a screening technique or reduced-form model may be viable options for estimating source impacts.

i. Screening techniques are differentiated from a screening model in that screening techniques are approaches that make simplified and conservative assumptions about the physical and chemical atmospheric processes important to determining source impacts while screening models make assumptions about conservative inputs to a specific model. The complexity of screening techniques ranges from simplified assumptions of chemistry applied to refined or screening model output to sophisticated approximations of the chemistry applied within a refined model.

ii. Reduced-form models are computationally efficient simulation tools for characterizing the pollutant response to specific types of emission reductions for a particular geographic area or background environmental conditions that reflect underlying atmospheric science of a refined model but reduce the computational resources of running a complex, numerical air quality model such as a photochemical grid model.

In such situations, an attempt should be made to acquire or improve the necessary databases and to develop appropriate analytical techniques, but the screening technique or reduced-form model may be sufficient in conducting regulatory modeling applications when applied in consultation with the EPA Regional Office.

e. Consistent with the general principle described in paragraph 2.2(a), the EPA may establish a demonstration tool or method as a sufficient means for a user or applicant to make a demonstration required by regulation, either by itself or as part of a modeling demonstration. To be used for such regulatory purposes, such a tool or method must be reflected in a codified regulation or have a well-documented technical basis and reasoning that is contained or incorporated in the record of the regulatory decision in which it is applied.

2.3 Availability of Models

a. For most of the screening and refined models discussed in the *Guideline*, codes, associated documentation and other useful information are publicly available for download from the EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website at http://www.epa.gov/ttn/scram. This is a website with which air quality modelers should become familiar and regularly visit for important model updates and additional clarifications and revisions to modeling guidance documents that are applicable to EPA programs and regulations. Codes and documentation may also available from the National Technical Information Service (NTIS), http://www.ntis.gov, and, when available, is referenced with the appropriate NTIS accession number.

3.1 Preferred and Alternative Air Quality Models

a. This section specifies the approach to be taken in determining preferred models for use in regulatory air quality programs. The status of models developed by the EPA, as well as those submitted to the EPA for review and possible inclusion in this *Guideline*, is discussed in this section. The section also provides the criteria and process for obtaining EPA approval for use of alternative models for individual cases in situations where the preferred models are not applicable or available. Additional sources of relevant modeling information are the EPA's Model Clearinghouse[23] (section 3.3), EPA modeling conferences, periodic Regional, State, and Local Modelers' Workshops, and the EPA's SCRAM website (section 2.3).

b. When approval is required for a specific modeling technique or analytical procedure in this *Guideline*, we refer to the *"appropriate reviewing authority."* Many states and some local agencies administer NSR and PSD permitting under programs approved into SIPs. In some EPA regions, federal authority to administer NSR and PSD permitting and related activities has been delegated to state or local agencies. In these cases, such agencies *"stand in the shoes"* of the respective EPA regions. Therefore, depending on the circumstances, the appropriate reviewing authority may be an EPA Regional Office, a state, local, or tribal agency, or perhaps the Federal Land Manager (FLM). In some cases, the *Guideline* requires review and approval of the use of an alternative model by the EPA Regional Office (sometimes stated as *"Regional Administrator"*). For all approvals of alternative models or techniques that do not already have approvals previously granted by the Model Clearinghouse, the EPA Regional Office will coordinate and shall seek concurrence with the EPA's Model Clearinghouse. This concurrence step should not exceed 30 days. If there is any question as to the appropriate reviewing authority, you should contact the EPA Regional Office modeling contact (http://www.epa.gov/ttn/scram/guidance_cont_regions.htm), whose jurisdiction generally includes the physical location of the source in question and its expected impacts.

c. In all regulatory analyses, early discussions among the EPA Regional Office staff, state, local, and tribal agency staff, industry representatives, and where appropriate, the FLM, are invaluable and are strongly encouraged. Prior to the actual analyses, agreement on the databases to be used, modeling techniques to be applied, and the overall technical approach helps avoid misunderstandings concerning the final results and may reduce the later need for additional analyses. The preparation of a written modeling protocol that is vetted with the appropriate reviewing authority helps to keep misunderstandings and resource expenditures at a minimum.

d. 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.

~~c.~~e. The identification of preferred models in this *Guideline* should not be construed as a determination that the preferred models identified here are to be permanently used to the exclusion of all others or that they are the only models available for relating emissions to air quality. The model that most accurately estimates concentrations in the area of interest is always sought. However, designation of specific preferred models is needed to promote consistency in model selection and application.

3.1 Preferred Models

3.1.1 Discussion

a. The EPA has developed some models suitable for regulatory application, while other models have been submitted by private developers for possible inclusion in the *Guideline*. Refined models that are preferred and required by the EPA for particular applications have undergone the necessary peer scientific reviews[24, 25] and model performance evaluation exercises[26, 27] that include statistical measures of model performance in comparison with measured air quality data as described in section 2.1.1.

b. An American Society for Testing and Materials (ASTM) reference[28] provides a general philosophy for developing and implementing advanced statistical evaluations of atmospheric dispersion models, and provides an example statistical technique to illustrate the application of this philosophy. Consistent with this approach, the EPA has determined and applied a specific evaluation protocol that provides a statistical technique for evaluating model performance for predicting peak concentration values, as might be observed at individual monitoring locations.[29]

c. When a single model is found to perform better than others, it is recommended for application as a preferred model and listed in appendix A. If no one model is found to clearly perform better through the evaluation exercise, then the preferred model listed in appendix A may be selected on the basis of other factors such as past use, public familiarity, resource requirements, and availability. Accordingly, the models listed in appendix A meet these conditions:

i. The model must be written in a common programming language, and the executable(s) must run on a common computer platform.

ii. The model must be documented in a user's guide or model formulation report which identifies the mathematics of the model, data requirements and program operating characteristics at a level of detail comparable to that available for other recommended models in appendix A.

iii. The model must be accompanied by a complete test dataset including input parameters and output results. The test data must be packaged with the model in computer-readable form.

iv. The model must be useful to typical users, *e.g.*, state air agencies, for specific air quality control problems. Such users should be able to operate the computer program(s) from available documentation.

v. The model documentation must include a robust comparison with air quality data (and/or tracer measurements) or with other well- established analytical techniques.

vi. The developer must be willing to make the model and source code available to users at reasonable cost or make them available for public access through the Internet or National Technical Information Service. The model and its code cannot be proprietary.

d. The EPA's process of establishing a preferred model includes a determination of technical merit, in accordance with the above six items including the practicality of the model for use in ongoing regulatory programs. Each model will also be subjected to a performance evaluation for an appropriate database and to a peer scientific review. Models for wide use (not just an isolated case) that are found to perform better will be proposed for inclusion as preferred models in future *Guideline* revisions.

e. No further evaluation of a preferred model is required for a particular application if the EPA requirements for regulatory use specified for the model in the *Guideline* are followed. Alternative models to those listed in appendix A should generally be compared with measured air quality data when they are used for regulatory applications consistent with recommendations in section 3.2.

3.1.2 Requirements

a. Appendix A identifies refined models that are preferred for use in regulatory applications. If a model is required for a particular application, the user must select a model from appendix A or follow procedures in section 3.2.2 for use of an alternative model or technique. Preferred models may be used without a formal demonstration of applicability as long as they are used as indicated in each model summary in appendix A. Further recommendations for the application of preferred models to specific source applications are found in subsequent sections of the *Guideline*.

b. If changes are made to a preferred model without affecting the modeled concentrations (by more than 2%, as discussed below), the preferred status of the model is unchanged. Examples of modifications that do not affect concentrations are those made to enable use of a different computer platform or those that only affect the format or averaging time of the model results. The integration of a graphical user interface (GUI) to facilitate setting up the model inputs and/or analyzing the model results without otherwise altering the model kernel is another example of a modification that does not affect concentrations. However, when any changes are made, the Regional Administrator must require a test case example to demonstrate that the modeled concentrations are not affected.

c. A preferred model must be operated with the options listed in appendix A (or provided through other regulatory guidance) for its intended regulatory application. If other options are exercised, the model is no longer "preferred." Any other modification to a preferred model that would result in a change in the concentration estimates likewise alters its status so that it is no longer a preferred model. Use of the modified model must then be justified as an alternative model on a case-by-case basis to the appropriate reviewing authority and approved by the

Regional Administrator.

d. Where the EPA has not identified a preferred model for a particular pollutant or situation, the EPA may establish a multi-tiered approach for making a demonstration required under PSD or another CAA program. The initial tier or tiers may involve use of demonstration tools, screening models, screening techniques, or reduced-form models; while the last tier may involve the use of demonstration tools, refined models or techniques, or alternative models approved under section 3.2.

3.2 Alternative Models

3.2.1 Discussion

a. Selection of the best model or techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner. A simple listing of models in this *Guideline* cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations. As discussed in section 3.1.1, the EPA has determined and applied a specific evaluation protocol that provides a statistical technique for evaluating model performance for predicting peak concentration values, as might be observed at individual monitoring locations.[29] This protocol is available to assist in developing a consistent approach when justifying the use of other-than-preferred models recommended in the *Guideline* (*i.e.*, alternative models). The procedures in this protocol provide a general framework for objective decision-making on the acceptability of an alternative model for a given regulatory application. These objective procedures may be used for conducting both the technical evaluation of the model and the field test or performance evaluation.

b. This subsection discusses the use of alternate models and defines three situations when alternative models may be used. This subsection also provides a procedure for implementing 40 CFR 51.166(l)(2) in PSD permitting. This provision requires written approval of the Administrator for any modification or substitution of an applicable model. An applicable model for purposes of 40 CFR 51.166(l) is a preferred model in appendix A to the *Guideline*. Approval to use an alternative model under section 3.2 of the *Guideline* qualifies as approval for the modification or substitution of a model under 40 CFR 51.166(l)(2). The Regional Administrators are delegated authority to issue such approvals under section 3.2 of the *Guideline*, provided that such approval is issued after consultation with EPA's Model Clearinghouse and formally documented in a concurrence memorandum from EPA's Model Clearinghouse which demonstrates that the requirements within section 3.2 for use of an alternative model have been met.

3.2.2 Requirements

a. Determination of acceptability of an alternative model is an EPA Regional Office responsibility in consultation with EPA's Model Clearinghouse as discussed in paragraphs 3.0(b) and 3.2.1(b). Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the approval of the EPA Regional Office based on the requirements of this subsection. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or technique is available and applicable.

b. An alternative model shall be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model may be approved for use:

1. If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model;
2. If a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in appendix A; or
3. If there is no preferred model.

Any one of these three separate conditions may justify use of an alternative model. Some known alternative models that are applicable for selected situations are listed on the EPA's SCRAM website (section 2.3). However, inclusion there does not confer any unique status relative to other alternative models that are being or will be developed in the future.

c. Equivalency, condition (1) in paragraph (b) of this subsection, is established by demonstrating that the design ~~maximum or highest, second highest~~ values~~concentrations~~ associated with the form of the controlling concentrations are within +/- 2 percent of the estimates obtained from the preferred model. The option to show equivalency is intended as a simple demonstration of acceptability for an alternative model that is so nearly identical (or contains options that can make it identical) to a preferred model that it can be treated for practical purposes as the preferred model. However, notwithstanding this demonstration, models that are not equivalent may be used when one of the two other conditions described in paragraphs (d) and (e) of this subsection are satisfied.

d. For condition (2) in paragraph (b) of this subsection, established statistical performance evaluation procedures and techniques[28, 29] for determining the acceptability of a model for an individual case based on superior performance should be followed, as appropriate. Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

e. Finally, for condition (3) in paragraph (b) of this subsection, an alternative model or technique may be approved for use provided that:

i. The model or technique has received a scientific peer review;
ii. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis;
iii. The databases which are necessary to perform the analysis are available and adequate;
iv. Appropriate performance evaluations of the model or technique have shown that the

model or technique is not inappropriately biased for regulatory application[a]; and

v. A protocol on methods and procedures to be followed has been established.

f. To formally document that the requirements of section 3.2 for use of an alternative model are satisfied for a particular application or range of applications, a memorandum will be prepared by the EPA's Model Clearinghouse through a consultative process with the Regional Office.

3.3 EPA's Model Clearinghouse

a. The Regional Administrator has the authority to select models that are appropriate for use in a given situation. However, there is a need for assistance and guidance in the selection process so that fairness, consistency, and transparency in modeling decisions are fostered among the EPA Regional Offices and the state, local, and tribal agencies. To satisfy that need, the EPA established the Model Clearinghouse[23] to serve a central role of coordination and collaboration between EPA headquarters and the EPA Regional Offices. Additionally, the EPA holds periodic workshops with EPA headquarters, EPA Regional Office, and state, local, and tribal agency modeling representatives.

b. The EPA Regional Office should always be consulted for information and guidance concerning modeling methods and interpretations of modeling guidance, and to ensure that the air quality model user has available the latest most up-to-date policy and procedures. As appropriate, the EPA Regional Office may also request assistance from the EPA's Model Clearinghouse on other applications of models, analytical techniques, or databases or to clarify interpretation of the *Guideline* or related modeling guidance.

The EPA Regional Office will coordinate with the EPA's Model Clearinghouse after an initial evaluation and decision has been developed concerning the application of an alternative model. The acceptability and formal approval process for an alternative model is described in section 3.2.

c. The EPA Regional Office will coordinate with the EPA's Model Clearinghouse after an initial evaluation and decision has been developed concerning the application of an alternative model. The acceptability and formal approval process for an alternative model is described in section 3.2.

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[a] For PSD and other applications that use the model results in an absolute sense, the model should not be biased toward underestimates. Alternatively, for ozone and $PM_{2.5}$ SIP attainment demonstrations and other applications that use the model results in a relative sense, the model should note be biased toward overestimates.

4.0 Models for Carbon Monoxide, Lead, Sulfur Dioxide, Nitrogen Dioxide and Primary Particulate Matter

4.1 Discussion

a. This section identifies modeling approaches generally used in the air quality impact analysis of sources that emit the criteria pollutants carbon monoxide (CO), lead, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and primary particulates ($PM_{2.5}$ and PM_{10}).

b. The guidance in this section is specific to the application of the Gaussian plume models identified in appendix A. Gaussian plume models assume that emissions and meteorology are in a steady-state, which is typically based on an hourly time step. This approach results in a plume that has an hourly-averaged distribution of emission mass according to a Gaussian curve through the plume. Though Gaussian steady-state models conserve the mass of the primary pollutant throughout the plume, they can still take into account a limited consideration of first-order removal processes (*e.g.*, wet and dry deposition) and limited chemical conversion (*e.g.*, OH oxidation).

c. Due to the steady-state assumption, Gaussian plume models are generally considered applicable to distances less than 50 km (or a single hour of transport, whichever is less), beyond which, modeled predictions of plume impact are likely conservative. The locations of ~~these~~ impacts due to travel times more than one hour are expected to be unreliable due to changes in meteorology that are likely to occur during the travel time.

d. The applicability of Gaussian plume models may vary depending on the topography of the modeling domain, *i.e.*, simple or complex. Simple terrain, as used here, is considered to be an area where terrain features are all lower in elevation than the top of the stack of the source(s) in question. Complex terrain is defined as terrain exceeding the height of the stack being modeled.

e. Gaussian models determine source impacts at discrete locations (receptors) for each meteorological and emission scenario, and generally attempt to estimate concentrations at specific sites that represent an ensemble average of numerous repetitions of the same "event." Uncertainties in model estimates are driven by this formulation, and as noted in section 2.1.1, evaluations of model accuracy should focus on the reducible uncertainty associated with physics and the formulation of the model. The "irreducible" uncertainty associated with Gaussian plume models may be responsible for variation in concentrations of as much as +/- 50 percent.[30] "Reducible" uncertainties[16] can be on a similar scale. For example, Pasquill [31] estimates that, apart from data input errors, maximum ground-level concentrations at a given hour for a point source in flat terrain could be in error by 50 percent due to these uncertainties. Errors of 5 to 10 degrees in the measured wind direction can result in concentration errors of 20 to 70 percent for a particular time and location, depending on stability and station location. Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt. Composite errors in highest estimated concentrations of 10 to 40 percent are found to be typical.[32, 33] However, estimates of concentrations paired in time and space with observed concentrations are less certain.

f. Model evaluations and inter-comparisons should take these aspects of uncertainty into account. For a regulatory application of a model, the emphasis of model evaluations is generally placed on the ~~highest~~ modeled impacts associated with the form of the ambient standard. Thus, the Cox-Tikvart model evaluation approach (or a variation that accounts for the form of the NAAQS of concern and updated model formulations), which compares the highest modeled impacts on several timescales, is recommended for comparisons of models and measurements and model inter-comparisons. The approach includes bootstrap techniques to determine the significance of various modeled predictions and increases the robustness of such comparisons when the number of available measurements are limited.[34, 35] Because of the uncertainty in paired modeled and observed concentrations, any attempts at calibration of models based on these comparisons is of questionable benefit and shall not be done.

4.2 Requirements

a. For NAAQS compliance demonstrations under PSD, use of the screening and preferred models for the pollutants listed in this subsection shall be limited to the near-field at a nominal distance of 50 km or less. Near-field application is consistent with capabilities of Gaussian plume models and, based on the EPA's assessment, is sufficient to address whether a source will cause or contribution to ambient concentrations in excess to a NAAQS. In most cases, maximum source impacts of inert pollutant are anticipated to occur within 10 ~~to 20~~ km from the source. Therefore, the EPA does not consider a long-range transport assessment beyond 50 km necessary for these pollutants.[36]

b. For assessment of PSD increments within the near-field nominal distance of 50 km or less, use of the screening and preferred models for the pollutants listed in this subsection shall be limited to the same screening and preferred models approved for NAAQS compliance demonstrations.

c. To determine if a Class I PSD increment analyses may be necessary beyond 50 km (i.e., long-range transport assessment), the following screening approach shall be used to determine if a significant impact will occur with particular focus on Class I areas that may be threatened at such distances.

i. Based on application in the near-field of the appropriate screening and/or preferred model, determine the significance of the ambient impacts at the closest distance to the relevant Class I area(s) from the new or modifying source. If this distance is more than ~~or about~~ 50 km, the near-field model can still be used as a screening tool out to the distance to the Class I area. ~~from the new or modifying source.~~ If this initial step indicates there may be significant ambient impacts at that distance or such near-field assessment is not available, then further assessment is necessary.

ii. For assessment of Class I significance of ambient impacts and cumulative increment analyses, there is not a preferred long-range transport model or screening approach for distances beyond 50 km. Thus, the EPA Regional Office shall be consulted in determining the appropriate and agreed upon modeling approach to conduct the second level assessment. Typically a Lagrangian model such as CALPUFF may be the type of model used for this second level assessment, but applicants shall reach agreed upon approaches (models and modeling parameters) on a case-by-case basis. When Lagrangian models are used in this manner, they shall not include plume-depleting reactions, such that model estimates are considered conservative, as is generally appropriate for screening assessments.

d. In those ~~limited~~ situations where a cumulative increment analysis beyond 50 km is necessary, a screening model such as CALPUFF version 7 can be used after consultation with the appropriate reviewing authority. CALPUFF is the model recommended by the Federal Land Managers in their FLAG 2010 guidance[67]. If a refined model is preferred, the selection and use of such an alternative model shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)) and approval by the EPA Regional Office based on the requirements of paragraph 3.2.2(e).

4.2.1 Screening Models and Techniques

a. Where a preliminary or conservative estimate is desired, point source screening techniques are an acceptable approach to air quality analyses.

b. As discussed in paragraph 2.2(a), screening models or techniques are designed to provide a conservative estimate of concentrations. The screening models used in most applications are the screening versions of the preferred models for refined applications. The two screening models, AERSCREEN[37, 38] and CTSCREEN, are screening versions of AERMOD (American Meteorological Society (AMS)/EPA Regulatory Model) and CTDMPLUS (Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations), respectively. AERSCREEN is the preferred screening model for most applications in all types of terrain and for applications involving building downwash. The predecessor screening model, SCREEN3, is also informative and may be used with concurrence of the appropriate reviewing authority. For those applications in complex terrain where the application involves a well-defined hill or ridge, CTSCREEN[39] can be used.

c. Although AERSCREEN and CTSCREEN are designed to address a single-source scenario, there are approaches that can be used on a case-by-case basis to address multi-source situations using screening meteorology or other conservative model assumptions. However, the appropriate reviewing authority (paragraph 3.0(b)) shall be consulted, and concurrence obtained, on the protocol for modeling multiple sources with AERSCREEN or CTSCREEN to ensure that the worst case is identified and assessed.

d. As discussed in section 4.2.3.4, there are also screening techniques built into AERMOD that use simplified or limited chemistry assumptions for determining the partitioning of NO and NO_2 for NO_2 modeling. These screening techniques are part of the EPA's preferred modeling approach for NO_2 and do not need to be approved as an alternative model. However, as with other screening models and techniques, their usage shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)).

e. All screening models and techniques shall be configured to appropriately address the site and problem at hand. Close attention must be paid to whether the area should be classified urban or rural in accordance with section 7.2.1.1. The climatology of the area must be studied to help define the worst-case meteorological conditions. Agreement shall be reached between the model user and the appropriate reviewing authority (paragraph 3.0(b)) on the choice of the screening model or technique for each analysis, on the input data and model settings, and the appropriate metric for satisfying regulatory requirements.

4.2.1.1 AERSCREEN

a. Released in 2011, AERSCREEN is the EPA's recommended screening model for simple and complex terrain for single sources including point sources, area sources, horizontal stacks, capped stacks, and flares. AERSCREEN runs AERMOD in a screening mode and consists of two main components: 1) the MAKEMET program which generates a site-specific matrix of meteorological conditions for input into the AERMOD model; and 2) the AERSCREEN command-prompt interface.

b. The MAKEMET program generates a matrix of meteorological conditions, in the form of AERMOD-ready surface and profile files, based on user-specified surface characteristics, ambient temperatures, minimum wind speed, and anemometer height. The meteorological matrix is generated based on looping through a range of wind speeds, cloud covers, ambient temperatures, solar elevation angles, and convective velocity scales (w*, for convective conditions only) based on user-specified surface characteristics (Z_o, Bo, r). For unstable cases, the convective mixing height (Z_{ic}) is calculated based on w*, and the mechanical mixing height (Z_{im}) is calculated for unstable and stable conditions based on the friction velocity, u*.

c. For applications involving simple or complex terrain, AERSCREEN interfaces with AERMAP. AERSCREEN also interfaces with BIPPRM to provide the necessary building parameters for applications involving building downwash using the PRIME downwash algorithm. AERSCREEN generates inputs to AERMOD via MAKEMET, AERMAP, and BPIPPRM and invokes AERMOD in a screening mode. The screening mode of AERMOD forces the AERMOD model calculations to represent values for the plume centerline, regardless of the source-receptor-wind direction orientation. The maximum concentration output from AERSCREEN represents a worst-case 1-hour concentration. Averaging-time scaling factors of 0.9 for 3-hour, 0.7 for 8-hour, 0.40 for 24-hour, and 0.08 for annual concentration averages are applied internally by AERSCREEN to the highest 1-hour concentration calculated by the model for non-area type sources. For area type source concentrations for averaging times greater than one hour, the concentrations are equal to the 1-hour estimates.[37, 40]

SCREEN3 has similarities to AERSCREEN and is simpler to run. It may be used in lieu of AERSCREEN with concurrence by the appropriate reviewing authority.

4.2.1.2 CTSCREEN

a. CTSCREEN[39, 41] can be used to obtain conservative, yet realistic, worst-case estimates for receptors located on terrain above stack height. CTSCREEN accounts for the three-dimensional nature of plume and terrain interaction and requires detailed terrain data representative of the modeling domain. The terrain data must be digitized in the same manner as for CTDMPLUS and a terrain processor is available.[42] CTSCREEN is designed to execute a fixed matrix of meteorological values for wind speed (u), standard deviation of horizontal and vertical wind speeds (σv, σw), vertical potential temperature gradient (dθ/dz), friction velocity (u*), Monin-Obukhov length (L), mixing height (z_i) as a function of terrain height, and wind directions for both neutral/stable conditions and unstable convective conditions. The maximum concentration output from CTSCREEN represents a worst-case 1-hour concentration. Time-scaling factors of 0.7 for 3-hour, 0.15 for 24-hour and 0.03 for annual concentration averages are applied internally by CTSCREEN to the highest 1-hour concentration calculated by the model.

4.2.1.3 Screening in Complex Terrain

a. For applications utilizing AERSCREEN, AERSCREEN automatically generates a polar-grid receptor network with spacing determined by the maximum distance to model. If the application warrants a different receptor network than that generated by AERSCREEN, it may be necessary to run AERMOD in screening mode with a user-defined network. For CTSCREEN applications or AERMOD in screening mode outside of AERSCREEN, placement of receptors requires very careful attention when modeling in complex terrain. Often the highest concentrations are predicted to occur under very stable conditions, when the plume is near, or impinges on, the terrain. The plume under such conditions may be quite narrow in the vertical, so that even relatively small changes in a receptor's location may substantially affect the predicted concentration. Receptors within about a kilometer of the source may be even more sensitive to location. Thus, a dense array of receptors may be required in some cases.

b. For applications involving AERSCREEN, AERSCREEN interfaces with AERMAP to generate the receptor elevations. For applications involving CTSCREEN, digitized contour data must be preprocessed[42] to provide hill shape parameters in suitable input format. The user then supplies receptors either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptors will generally be necessary to assure that the maximum concentrations are estimated by either model. In cases where a terrain feature may "appear to the plume" as smaller, multiple hills, it may be necessary to model the terrain both as a single feature and as multiple hills to determine design concentrations.

c. Other screening techniques may be acceptable for complex terrain cases where established procedures[43] are used. The user is encouraged to confer with the appropriate reviewing authority (paragraph 3.0(b)) if any unresolvable problems are encountered, *e.g.*, applicability, meteorological data, receptor siting, or terrain contour processing issues.

4.2.2 Refined Models

a. A brief description of each preferred model for refined applications is found in appendix A. Also listed in that appendix are availability, the model input requirements, the standard options that shall be selected when running the program, and output options.

4.2.2.1 AERMOD

a. For a wide range of regulatory applications in all types of terrain, and for aerodynamic building downwash, the recommended model is AERMOD.[44, 45] The AERMOD regulatory modeling system consists of the AERMOD dispersion model, the AERMET meteorological processor, and the AERMAP terrain processor. AERMOD is a steady-state Gaussian plume model applicable to directly emitted air pollutants that employs best state-of-practice parameterizations for characterizing the meteorological influences and dispersion. Differentiation of simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the well-known dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions.

b. The AERMOD modeling system has been extensively evaluated across a wide range of scenarios based on numerous field studies, including tall stacks in flat and complex terrain settings, sources subject to building downwash influences, and low-level non-buoyant sources.[27] These evaluations included several long-term field studies associated with operating plants as well as several intensive tracer studies. Based on these evaluations, AERMOD has shown consistently good performance, with “errors” in predicted vs. observed peak concentrations, based on the Robust Highest Concentration (RHC) metric, consistently within the range of 10 to 40 percent cited in paragraph 4.1(g).

c. AERMOD incorporates the Plume Rise Model Enhancements (PRIME) algorithm to account for enhanced plume growth and restricted plume rise for plumes affected by building wake effects.[46] The PRIME algorithm accounts for entrainment of plume mass into the cavity recirculation region, including re-entrainment of plume mass into the wake region beyond the cavity.

d. AERMOD incorporates the Buoyant Line and Point Source (BLP) Dispersion model to account for buoyant plume rise from line sources. The BLP option within AERMOD utilizes the standard meteorological inputs provided by the AERMET meteorological processor.

e. The state-of-the-science for modeling atmospheric deposition is evolving and new modeling techniques are continually being assessed and their results are being compared with observations. Consequently, while deposition treatment is available in AERMOD, the approach taken for any purpose shall be coordinated with the appropriate reviewing authority (paragraph 3.0(b)).

4.2.2.2 CTDMPLUS

a. If the modeling application involves an elevated point source with a well-defined hill or ridge and a detailed dispersion analysis of the spatial pattern of plume impacts is of interest, CTDMPLUS is available. CTDMPLUS provides greater resolution of concentrations about the contour of the hill feature than does AERMOD through a different plume-terrain interaction algorithm.

4.2.2.3 OCD

a. If the modeling application involves determining the impact of offshore emissions from point, area, or line sources on the air quality of coastal regions, the recommended model is the OCD (Offshore and Coastal Dispersion) Model. OCD is a straight-line Gaussian model that incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. OCD is also applicable for situations that involve platform building downwash.

4.2.3 Pollutant Specific Modeling Requirements

4.2.3.1 Models for Carbon Monoxide

a. Models for assessing the impact of CO emissions are needed to meet NSR requirements, including PSD, to address compliance with the CO NAAQS and to determine localized impacts from transportations projects. Examples include evaluating effects of point sources, congested roadway intersections, and highways, as well as the cumulative effect of numerous sources of CO in an urban area.

b. The general modeling recommendations and requirements for screening models in section and refined models in section 4.2.2 shall be applied for CO modeling. Given the relatively low CO background concentrations, screening techniques are likely to be adequate in most cases. However, since the screening model specified in section 4.2.1 (AERSCREEN) can only handle one source at a time, a section 4.2.2 model may be used with screening meteorology (e.g., generated with MAKEMET) to conduct screening assessments of CO projects involving more than one source (e.g., roadway hotspot assessments).

4.2.3.2 Models for Lead

a. In January 1999 (40 CFR part 58, appendix D), the EPA gave notice that concern about ambient lead impacts was being shifted away from roadways and toward a focus on stationary point sources. Thus, models for assessing the impact of lead emissions are needed to meet NSR requirements, including PSD, to address compliance with the lead NAAQS and for SIP attainment demonstrations. The EPA has also issued guidance on siting ambient monitors in the vicinity of stationary point sources.[48] For lead, the SIP should contain an air quality analysis to determine the maximum rolling 3-month average lead concentration resulting from major lead point sources, such as smelters, gasoline additive plants, etc. The EPA has developed a post-processor to calculate rolling 3-month average concentrations from model output.[49] General guidance for lead SIP development is also available.[50]

b. For major lead point sources, such as smelters, which contribute fugitive emissions and for which deposition is important, professional judgment should be used, and there shall be coordination with the appropriate reviewing authority (paragraph 3.0(b)). For most applications, the general requirements for screening and refined models of section 4.2.1 and 4.2.2 are applicable to lead modeling.

4.2.3.3 Models for Sulfur Dioxide

a. Models for SO_2 are needed to meet NSR requirements, including PSD, to address compliance with the SO_2 NAAQS and PSD increments, for SIP attainment demonstrations,[51] and for characterizing current air quality via modeling.[52] SO_2 is one of a group of highly reactive gasses known as "oxides of sulfur" with largest emissions sources being fossil fuel combustion at power plants and other industrial facilities.

b. Given the relatively inert nature of SO_2 on the short-term time scales of interest (*i.e.*, 1-hour) and the sources of SO_2 (*i.e.,* stationary point sources), the general modeling requirements for screening models in section 4.2.1 and refined models in section 4.2.2 are applicable for SO_2 modeling applications. For urban areas, AERMOD automatically invokes a half-life of 4 hours[53] to SO_2. Therefore, care must be taken when determining whether a source is urban or rural (*see* section 7.2.1.1 for urban/rural determination methodology).

4.2.3.4 Models for Nitrogen Dioxide

a. Models for assessing the impact of sources on ambient NO_2 concentrations are needed to meet NSR requirements, including PSD, to address compliance with the NO_2 NAAQS and PSD increments. Impact of an individual source on ambient NO_2 depends, in part, on the chemical environment into which the source's plume is to be emitted. This is due to the fact that NO_2 sources co-emit NO along with NO_2 and any emitted NO may react with ambient ozone to convert to additional NO_2 downwind. Thus, comprehensive modeling of NO_2 would need to consider the ratio of emitted NO and NO_2, the ambient levels of ozone and subsequent reactions between ozone and NO, and the photolysis of NO_2 to NO.

b. Due to the complexity of NO_2 modeling, a multi-tiered approach is required to obtain hourly and annual average estimates of NO_2.[54] Since these methods are considered screening, their usage shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)). Additionally, since screening techniques are conservative by their nature, there are limitations to how these options can be used. Specifically, negative emissions should not be modeled because decreases in concentrations would be overestimated. Each tiered approach (*see* Figure 4-1) accounts for increasing complex considerations of NO_2 chemistry and is described in paragraphs b through d of this subsection. The tiers of NO_2 modeling include:

i. A first-tier (most conservative) "full" conversion approach;
ii. A second-tier approach that assumes ambient equilibrium between NO and NO_2; and
iii. A third-tier consisting of several detailed screening techniques that account for ambient ozone and the relative amount of NO and NO_2 emitted from a source.

c. For Tier 1, use an appropriate section 4.2.2 refined model to estimate nitrogen oxides (NO_x) concentrations and assume a total conversion of NO to NO_2. If the resulting design concentrations exceed the NAAQS or PSD increments for NO_2, proceed to Tier 2.

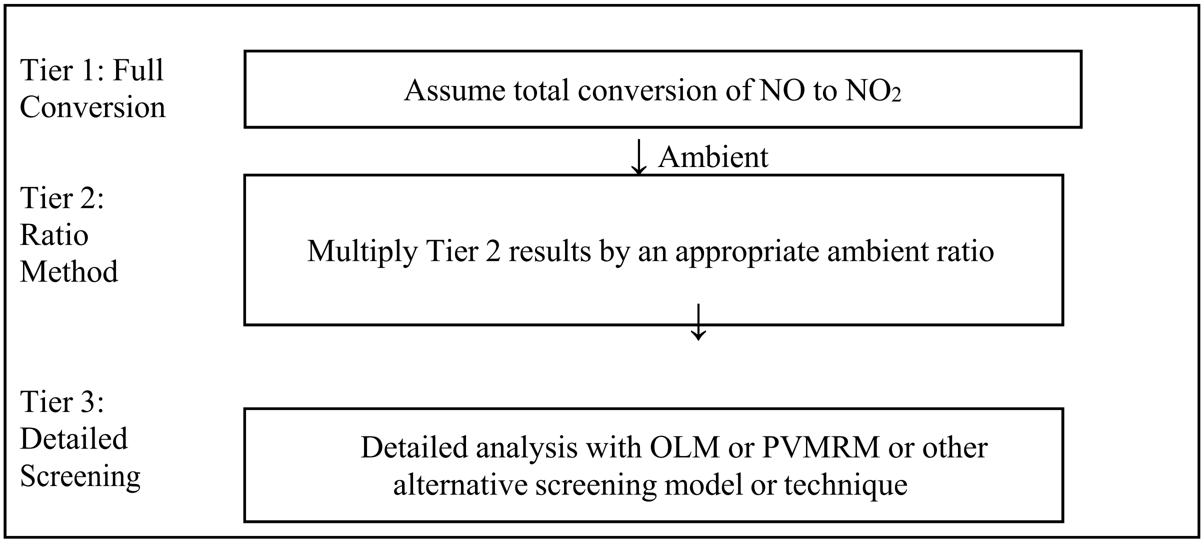
d. For Tier 2, multiply the Tier 1 result(s) by the Ambient Ratio Method 2 (ARM2), which provides estimates of representative equilibrium ratios of NO_2/NO_x value based ambient levels of NO_2 and NO_x derived from national data from the EPA's Air Quality System (AQS)[55]. The national default for ARM2 will include a minimum NO_2/NO_x ratio of 0.5 and a maximum ratio of 0.9. The reviewing agency may establish alternative default minimum NO_2/NO_x values based on the source's in-stack emissions ratios, with alternative minimum values reflecting the source's in-stack NO_2/NO_x ratios. Alternate default minimum NO_2/NO_x values established by the appropriate reviewing agency for Tier 2 and Tier 3 modeling assessments do not require approval by the Model Clearinghouse. Preferably, alternative default NO_2/NO_x values should be based on source-specific data which satisfies all quality assurance procedures that ensure data accuracy for both NO_2 and NO_x within the typical range of measured values. However, alternate information may be used to justify a source's anticipated NO_2/NO_x in-stack ratios, such as manufacturer test data, state or local agency guidance, peer-reviewed literature, the EPA's NO_2/NO_x ratio database.

e. For Tier 3, a detailed screening technique shall be applied on a case-by-case basis. Because 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. The Ozone Limiting Method (OLM)[56] and the Plume Volume Molar Ratio Method (PVMRM)[57] are two detailed screening techniques that may be used for most sources. These two techniques use an appropriate section 4.2.2 model to estimate NO_x concentrations and then estimate the conversion of primary NO emissions to NO_2 based on the ambient levels of ozone and the plume characteristics. OLM only accounts for NO_2 formation based on the ambient levels of ozone while PVMRM also accommodates distance-dependent conversion ratios based on ambient ozone. Both PVMRM and OLM require that ambient ozone concentrations be provided on an hourly basis and explicit specification of the speciation of the NO_2/NO_x in-stack ratios. PVMRM works best for relatively isolated and elevated point source modeling while OLM works best for large groups of sources, area sources, and near-surface releases, including road-way sources.

f. Alternative models or techniques may be considered on a case-by-case basis and their usage shall be approved by the EPA Regional Office (section 3.2). Such techniques should consider individual quantities of NO and NO_2 emissions, atmospheric transport and dispersion, and atmospheric transformation of NO to NO_2. Dispersion models that account for more explicit photochemistry may also be applied to estimate ambient impacts of NO_x sources.

g. The Tier 3 NO_2 models have the capability of determining the limits of NO conversion to NO_2 in the first several seconds or minutes of travel due to the finite reaction time of ozone titration of NO to NO_2. The limitation of this reaction can be considered in determining NO_2 concentrations at very short distances from the source.

Figure 4-1: Multi-Tiered Approach for Estimating NO_2 Concentrations



4.2.3.5 Models for $PM_{2.5}$

a. The $PM_{2.5}$ NAAQS, promulgated on July 18, 1997, includes particles with an aerodynamic diameter nominally less than or equal to 2.5 micrometers. $PM_{2.5}$ is a mixture consisting of several diverse components[58]. Ambient $PM_{2.5}$ generally consists of two components, the primary component, emitted directly from a source, and the secondary component, which is formed in the atmosphere from other pollutants emitted from the source. Models for $PM_{2.5}$ are needed to meet NSR requirements, including PSD, to address compliance with the $PM_{2.5}$ NAAQS and PSD increments and for SIP attainment demonstrations.

b. For NSR, including PSD, modeling assessments, the refined methods in section 4.2.2 are required for modeling the primary component of $PM_{2.5}$, while the methods in section 5.4 are recommended for addressing the secondary component of $PM_{2.5}$. Guidance for PSD assessments is available for determining the best approach to handling sources of primary and secondary $PM_{2.5}$.[59]

c. For SIP attainment demonstrations and regional haze reasonable progress goal analyses, effects of a control strategy on $PM_{2.5}$ are estimated from the sum of the effects on the primary and secondary components composing $PM_{2.5}$. Model users should refer to section 5.4.1 and associated SIP modeling guidance[60] for further details concerning appropriate modeling approaches.

d. The general modeling requirements for the refined models discussed in section 4.2.2 should be applied for PM2.5 hot-spot modeling for mobile sources. Specific guidance is available for analyzing direct PM2.5 impacts from highways, terminals, and other projects.[61]

4.2.3.6 Models for PM_{10}

a. The NAAQS for PM_{10} was promulgated on July 1, 1987. The EPA promulgated regulations for PSD increment measured as PM_{10} in a document published on June 3, 1993. Models for PM_{10} are needed to meet NSR requirements, including PSD, to address compliance with the PM_{10} NAAQS and PSD increments and for SIP attainment demonstrations.

b. For most sources, the general modeling requirements for screening models in section 4.2.1 and refined models in section 4.2.2 shall be applied for PM_{10} modeling. In cases where the particle size and its effect on ambient concentrations need to be considered, particle deposition may be used in on a case-by-case basis and their usage shall be approved by the EPA Regional Office (section 3.2). A SIP development guide[62] is also available to assist in PM_{10} analyses and control strategy development.

c. Fugitive dust, which consists primarily of coarse particulate matter (PM_{10}), usually refers to dust put into the atmosphere by the wind blowing over plowed fields, dirt roads or desert or sandy areas with little or no vegetation. Fugitive emissions include the emissions resulting from the industrial process that are not captured and vented through a stack but may be released from various locations within the complex. In some unique cases, a model developed specifically for the situation may be needed. Due to the difficult nature of characterizing and modeling fugitive dust and fugitive emissions, the proposed procedure shall be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) for each specific situation before the modeling exercise is begun. Re-entrained dust is created by vehicles driving over dirt roads (*e.g.*, haul roads) and dust-covered roads typically found in arid areas. Such sources can be characterized as line, area or volume sources.[61, 63] Emission rates may be based on site-specific data or values from the general literature.

d. Under certain conditions, source characterization approaches can be developed for fugitive dust emissions to account for the capture by barriers or agglomeration effects. These "source characterization" approaches can be considered for routine application without a need for a non-guideline model approval if adequate documentation of the effects is provided. recommended dispersion models may not be suitable to appropriately address the nature of ambient PM10. In these circumstances, the alternative modeling approach shall be approved by the EPA Regional Office (section 3.2).c

e. The general modeling requirements for the refined models discussed in section 4.2.2 should be applied for PM10 hot-spot modeling for mobile sources. Specific guidance is available for analyzing direct PM10 impacts from highways, terminals, and other projects.[61]

5.0 Models for Ozone and Secondarily Formed Particulate Matter

5.1 Discussion

a. Air pollutants formed through chemical reactions in the atmosphere are referred to as secondary pollutants. For example, ground-level ozone and a portion of particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$ or fine PM) are secondary pollutants formed through photochemical reactions. Ozone and secondarily formed particulate matter are closely related to each other in that they share common sources of emissions or are formed in the atmosphere from chemical reactions with similar precursors.

b. Ozone formation is driven by emissions of NO_x and volatile organic compounds (VOCs). Ozone formation is a complicated nonlinear process that requires favorable meteorological conditions in addition to VOC and NO_x emissions. Sometimes complex terrain features also contribute to the build-up of precursors and subsequent ozone formation or destruction.

c. $PM_{2.5}$ can be either primary (*i.e.*, emitted directly from sources) or secondary in nature. The fraction of $PM_{2.5}$ which is primary versus secondary varies by location and season. In the United States, $PM_{2.5}$ is dominated by a variety of chemical species or components of atmospheric particles, such as ammonium sulfate, ammonium nitrate, organic carbon (OC) mass, elemental carbon (EC), and other soil compounds and oxidized metals. $PM_{2.5}$ sulfate, nitrate, and ammonium ions are predominantly the result of chemical reactions of the oxidized products of sulfur dioxide (SO_2) and NO_x emissions with direct ammonia (NH_3) emissions.[64]

d. Modeled strategies designed to reduce ozone or $PM_{2.5}$ levels typically need to consider the chemical coupling between these pollutants. Control measures reducing ozone and $PM_{2.5}$ precursor emissions may not lead to proportional reductions in ozone and $PM_{2.5}$. This coupling is important in understanding processes that control the levels of both pollutants. Thus, when feasible, it is important to use models that take into account the chemical coupling between ozone and $PM_{2.5}$. In addition, using such a multi-pollutant modeling system can reduce the resource burden associated with applying and evaluating separate models for each pollutant and promotes consistency among the strategies themselves.

e. $PM_{2.5}$ is a mixture consisting of several diverse chemical species or components of atmospheric particles. Because chemical and physical properties and origins of each component differ, it may be appropriate to use either a single model capable of addressing several of the important components or to model primary and secondary components using different models. Effects of a control strategy on $PM_{2.5}$ is estimated from the sum of the effects on the specific components composing $PM_{2.5}$.

5.2 Recommendations

a. Chemical transformations can play an important role in defining the concentrations and properties of certain air pollutants. Models that take into account chemical reactions and physical processes of various pollutants (including precursors) are needed for determining the current state of air quality, as well as predicting and projecting the future evolution of these pollutants. It is important that a modeling system provide a realistic representation of chemical and physical processes leading to secondary pollutant formation and removal from the atmosphere.

b. Chemical transport models treat atmospheric chemical and physical processes such as deposition and motion. There are two types of chemical transport models, Eulerian (grid based) and Lagrangian. These types of models are differentiated from each other by their frame of reference. Eulerian models are based on a fixed frame of reference and Lagrangian models use a frame of reference that moves with parcels of air between the source and receptor point.[9] Photochemical grid models are three-dimensional Eulerian grid-based models that treat chemical and physical processes in each grid cell and use diffusion and transport processes to move chemical species between grid cells.[9] These types of models are appropriate for assessment of near-field and regional scale reactive pollutant impacts from specific sources[7, 10, 11, 12] or all sources.[13, 14, 15] In some limited cases , the secondary processes can be treated with a box model, potentially in combination with a number of other modeling techniques and/or analyses to treat individual source sectors.

c. Regardless of the modeling system used to estimate secondary impacts of ozone and/or $PM_{2.5}$, model results should be compared to observation data to generate confidence that the modeling system is representative of the local and regional air quality. For ozone related projects, model estimates of ozone should be compared with observations in both time and space. For $PM_{2.5}$, model estimates of speciated $PM_{2.5}$ components (such as sulfate ion, nitrate ion, etc.) should be compared with observations in both time and space.[65]

d. Model performance metrics comparing observations and predictions are often used to summarize model performance. These metrics include mean bias, mean error, fractional bias, fractional error, and correlation coefficient.[65] There are no specific levels of any model performance metric that indicate “acceptable” model performance. The EPA’s preferred approach for providing context about model performance is to compare model performance metrics with similar contemporary applications.[60, 65] Because model application purpose and scope vary, model users should consult with the appropriate reviewing authority (paragraph 3.0(b)) to determine what model performance elements should be emphasized and presented to provide confidence in the regulatory model application.

e. There is no preferred modeling system or technique for estimating ozone or secondary $PM_{2.5}$ for specific source impacts or to assess impacts from multiple sources. For assessing secondary pollutant impacts from single sources, the degree of complexity required to assess potential impacts varies depending on the nature of the source, its emissions, and the background environment. The EPA recommends a two-tiered approach where the first tier consists of using existing technically credible and appropriate relationships between emissions and impacts developed from previous modeling that is deemed sufficient for evaluating a source’s impacts. The second tier consists of more sophisticated case-specific modeling analyses. The appropriate tier for a given application should be selected in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and be consistent with EPA guidance.[66]

5.3 Recommended Models and Approaches for Ozone

a. Models that estimate ozone concentrations are needed to guide the choice of strategies for the purposes of a nonattainment area demonstrating future year attainment of the ozone NAAQS. Additionally, models that estimate ozone concentrations are needed to assess impacts from specific sources or source complexes to satisfy requirements for NSR, including PSD, and other regulatory programs. Other purposes for ozone modeling include estimating the impacts of specific events on air quality, ozone deposition impacts, and planning for areas that may be attaining the ozone NAAQS.

5.3.1 Models for NAAQS Attainment Demonstrations and Multi-Source Air Quality Assessments

a. Simulation of ozone formation and transport is a complex exercise. Control agencies with jurisdiction over areas with ozone problems should use photochemical grid models to evaluate the relationship between precursor species and ozone. Use of photochemical grid models is the recommended means for identifying control strategies needed to address high ozone concentrations in such areas. Judgment on the suitability of a model for a given application should consider factors that include use of the model in an attainment test, development of emissions and meteorological inputs to the model, and choice of episodes to model. Guidance on the use of models and other analyses for demonstrating attainment of the air quality goals for ozone is available.[60] Users should consult with the appropriate reviewing authority (paragraph 3.0(b)) to ensure the most current modeling guidance is applied.

5.3.2 Models for Single-Source Air Quality Assessments

a. Depending on the magnitude of emissions, estimating the impact of an individual source's emissions of NO_x and VOC on ozone concentrations is necessary for obtaining a permit. The simulation of ozone formation and transport requires realistic treatment of atmospheric chemistry and deposition. Models should be applied which integrate chemical and physical processes important in the formation, decay, and transport of ozone and important precursor species (*e.g.*, Lagrangian and photochemical grid models). Photochemical grid models are primarily designed to characterize precursor emissions and impacts from a wide variety of sources over a large geographic area but can also be used to assess the impacts from specific sources.[7, 11, 12]

b. The first tier of assessment for ozone impacts involves those situations where existing technical information is available (*e.g.*, results from existing photochemical grid modeling, published empirical estimates of source specific impacts, or reduced-form models) 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. The appropriate reviewing authority (paragraph 3.0(b)) and appropriate EPA guidance[66] should be consulted to determine what types of assessments may be appropriate on a case-by-case basis.

c. The second tier of assessment for ozone impacts involves those situations where existing technical information is not available such that chemical transport models (*e.g.*, photochemical grid models) should be used to address single-source impacts. Special considerations are needed when using these models to evaluate the ozone impact from an individual source. Guidance on the use of models and other analyses for demonstrating the impacts of single sources for ozone is available.[66] This document provides a more detailed discussion of the appropriate approaches to obtaining estimates of ozone impacts from a single source. Model users should use the latest version of this guidance in consultation with the appropriate reviewing authority (paragraph 3.0(b)) to determine the most suitable single-source ozone modeling approach on a case-by-case basis.

5.4 Recommended Models and Approaches for Secondarily Formed $PM_{2.5}$

a. Models are needed to guide the choice of strategies to address an observed $PM_{2.5}$ problem in an area not attaining the $PM_{2.5}$ NAAQS. Additionally, models are needed to assess $PM_{2.5}$ impacts from specific sources or industrial source complexes to satisfy requirements for NSR, including PSD, and other regulatory programs. Other purposes for $PM_{2.5}$ modeling include estimating the impacts of specific events on air quality, visibility, deposition impacts, and planning for areas that may be attaining the $PM_{2.5}$ NAAQS.

5.4.1 Models for NAAQS Attainment Demonstrations and Multi-Source Air Quality Assessments

a. Models for $PM_{2.5}$ are needed to assess the adequacy of a proposed strategy for meeting the annual and/or 24-hour $PM_{2.5}$ NAAQS. Modeling primary and secondary $PM_{2.5}$ can be a multi- faceted and complex problem, especially for secondary components of $PM_{2.5}$ such as sulfates and nitrates. Control agencies with jurisdiction over areas with secondary $PM_{2.5}$ problems should use models which integrate chemical and physical processes important in the formation, decay, and transport of these species (*e.g.*, photochemical grid models). Suitability of a modeling approach or mix of modeling approaches for a given application requires technical judgment as well as professional experience in choice of models, use of the model(s) in an attainment test, development of emissions and meteorological inputs to the model, and selection of days to model. Guidance on the use of models and other analyses for demonstrating attainment of the air quality goals for $PM_{2.5}$ is available.[59, 60] Users should consult with the appropriate reviewing authority (paragraph 3.0(b)) to ensure the most current modeling guidance is applied.

5.4.2 Models for Single-Source Air Quality Assessments

a. Depending on the magnitude of emissions, estimating the impact of an individual source's emissions on secondary particulate matter concentrations is necessary for obtaining a permit. Primary $PM_{2.5}$ components shall be simulated using AERMOD (*see* section 4.2.2). The simulation of secondary particulate matter formation and transport is a complex exercise requiring realistic treatment of atmospheric chemistry and deposition. Models should be applied which integrate chemical and physical processes important in the formation, decay, and transport of these species (e.g., Lagrangian and photochemical grid models). Photochemical grid models are primarily designed to characterize precursor emissions and impacts from a wide variety of sources over a large geographic area and can also be used to assess the impacts from specific sources.[7, 10]

b. The first tier of assessment for secondary $PM_{2.5}$ impacts involves those situations where existing technical information is available (*e.g.*, results from existing photochemical grid modeling, published empirical estimates of source specific impacts, or reduced-form models) 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. The appropriate reviewing authority (paragraph 3.0(b)) and appropriate EPA guidance[66] should be consulted to determine what types of assessments may be appropriate on a case-by-case basis.

c. The second tier of assessment for secondary $PM_{2.5}$ impacts involves those situations where existing technical information is not available such that chemical transport models (*e.g.*, photochemical grid models) should be used for assessments of single-source impacts. Special considerations are needed when using these models to evaluate the secondary particulate matter impact from an individual source. Guidance on the use of models and other analyses for demonstrating the impacts of single sources for secondary $PM_{2.5}$ is available.[66] This document provides a more detailed discussion of the appropriate approaches to obtaining estimates of secondary particulate matter concentrations from a single source. Model users should use the latest version of this guidance in consultation with the appropriate reviewing authority (paragraph 3.0(b)) to determine the most suitable single-source modeling approach for secondary $PM_{2.5}$ on a case-by-case basis.

6.0 Modeling for Air Quality Related Values and Other Governmental Programs

6.1 Discussion

a. Other federal agencies have also developed specific modeling approaches for their own regulatory or other requirements. Although such regulatory requirements and guidance have come about because of EPA rules or standards, the implementation of such regulations and the use of the modeling techniques is under the jurisdiction of the agency issuing the guidance or directive. This section covers such situations with reference to those guidance documents, when they are available.

b. When using the model recommended or discussed in the *Guideline* in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate federal or state agency to ensure the proper application and use of the models and/or techniques. Other federal agencies have developed specific modeling approaches for their own regulatory or other requirements. Most of the programs have, or will have when fully developed, separate guidance documents that cover the program and a discussion of the tools that are needed. The following paragraphs reference those guidance documents, when they are available. No attempt has been made to provide a comprehensive discussion of each topic since the reference documents were designed to do that.

6.2 Air Quality Related Values

a. The 1997 CAA Amendments give FLMs an "affirmative responsibility" to protect the natural and cultural resources of Class I areas from the adverse impacts of air pollution and to provide the appropriate procedures and analysis techniques. The Act identifies the FLM as the Secretary of the department, or their designee, with authority over these lands. Mandatory Federal Class I areas are defined in the CAA as international parks, national parks over 6,000 acres and wilderness areas and memorial parks over 5,000 acres, established as of 1977. The FLMs are also concerned with the protection of resources in federally managed Class II areas because of other statutory mandates to protect these areas.

b. The FLM agency responsibilities include the review of air quality permit applications from proposed new or modified major pollution sources that may affect these Class I areas to determine if emissions from a proposed or modified source will cause or contribute to adverse impacts on air quality related values (AQRVs) of a Class I area and making recommendations to the FLM. AQRVs are resources identified by the FLM agencies, which have the potential to be affected by air pollution. These resources may include visibility, scenic, cultural, physical, or ecological resources for a particular area. The FLM agencies take into account the particular resources and AQRVs that would be affected; the frequency and magnitude of any potential impacts; and the direct, indirect, and cumulative effects of any potential impacts in making their recommendations.

c. While the AQRV notification and impact analysis requirements are outlined in the PSD regulations at 40 CFR 51.166(p) and 40 CFR 52.21(p), determination of appropriate analytical methods and metrics for AQRV's are determined by the FLM agencies and are published in guidance external to the general recommendations of this paragraph.

d. To develop greater consistency in the application of air quality models to assess potential AQRV impacts in both Class I areas and protected Class II areas, the FLM agencies have developed the Federal Land Managers' Air Quality Related Values Work Group Phase I Report (FLAG)[67]. FLAG focuses upon specific technical and policy issues associated with visibility impairment, effects of pollutant deposition on soils and surface waters, and ozone effects on vegetation. Model users should consult the latest version of the FLAG report for current modeling guidance and with affected FLM agency representatives for any application specific guidance which is beyond the scope of the *Guideline*.

6.2.1 Visibility

a. Visibility in important natural areas (*e.g.*, Federal Class I areas) is protected under a number of provisions of the CAA, including sections 169A and 169B (addressing impacts primarily from existing sources) and section 165 (new source review). Visibility impairment is caused by light scattering and light absorption associated with particles and gases in the atmosphere. In most areas of the country, light scattering by $PM_{2.5}$ is the most significant component of visibility impairment. The key components of $PM_{2.5}$ contributing to visibility impairment include sulfates, nitrates, organic carbon, elemental carbon, and crustal material.[67]

b. Visibility regulations (40 CFR 51.300-309) require state, local, and tribal agencies to mitigate current and prevent future visibility impairment in any of the 156 mandatory Federal Class I areas where visibility is considered an important attribute. In 1999, the EPA issued revisions to the regulations to address visibility impairment in the form of regional haze, which is caused by numerous, diverse sources (*e.g.*, stationary, mobile, and area sources) located across a broad region (40 CFR 51.308-309). The state of relevant scientific knowledge has expanded significantly since the 1997 CAA Amendments. A number of studies and reports[68, 69] have concluded that long-range transport (*e.g.*, up to hundreds of kilometers) of fine particulate matter plays a significant role in visibility impairment across the country. CAA section 169A requires states to develop SIPs containing long-term strategies for remedying existing and preventing future visibility impairment in the 156 mandatory Class I Federal areas, where visibility is considered an important attribute. In order to develop long-term strategies to address regional haze, many state, local, and tribal agencies will need to conduct regional-scale modeling of fine particulate concentrations and associated visibility impairment.

c. The FLAG visibility modeling recommendations are divided into two distinct sections to address different requirements for 1) near field modeling where plumes or layers are compared against a viewing background and 2) distant/multi-source modeling for plumes and aggregations of plumes that affect the general appearance of a scene.[67] The recommendations separately address visibility assessments for sources proposing to locate relatively near and at farther distances from these areas.[67]

6.2.1.1 Models for Estimating Near-Field Visibility Impairment

a. To calculate the potential impact of a plume of specified emissions for specific transport and dispersion conditions ("plume blight") for source-receptor distances less than 50 km, a screening model and guidance are available.[67, 70] If a more comprehensive analysis is necessary, a refined model should be selected. The model selection, procedures, and analyses should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s).

6.2.1.2 Models for Estimating Visibility Impairment for Long-Range Transport

a. Chemical transformations can play an important role in defining the concentrations and properties of certain air pollutants. Models that take into account chemical reactions and physical processes of various pollutants (including precursors) are needed for determining the current state of air quality, as well as predicting and projecting the future evolution of these pollutants. It is important that a modeling system provide a realistic representation of chemical and physical processes leading to secondary pollutant formation and removal from the atmosphere.

b. Chemical transport models treat atmospheric chemical and physical processes such as deposition and motion. There are two types of chemical transport models, Eulerian (grid based) and Lagrangian. These types of models are differentiated from each other by their frame of reference. Eulerian models are based on a fixed frame of reference and Lagrangian models use a frame of reference that moves with parcels of air between the source and receptor point.[9] Photochemical grid models are three-dimensional Eulerian grid-based models that treat chemical and physical processes in each grid cell and use diffusion and transport processes to move chemical species between grid cells.[9] These types of models are appropriate for assessment of near-field and regional scale reactive pollutant impacts from specific sources[7, 10, 11, 12] or all sources.[13, 14, 15] As noted above, the 2010 FLM guidance for long-range transport modeling (FLAG, 2010) recommends the use of CALPUFF.

~~b.~~c. Development of the requisite meteorological and emissions databases necessary for use of photochemical grid models to estimate AQRVs should conform to recommendations in section 8 and those outlined in the EPA's Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze.[60] Demonstration of the adequacy of prognostic meteorological fields can be established through appropriate diagnostic and statistical performance evaluations consistent with recommendations provided in the appropriate guidance.[60] Model users should consult the latest version of this guidance and with the appropriate reviewing authority (paragraph 3.0(b)) for any application specific guidance which is beyond the scope of this subsection.

6.2.2 Models for Estimating Deposition Impacts

a. For many Class I areas, AQRVs have been identified that are sensitive to atmospheric deposition of air pollutants. Emissions of NO_x, sulfur oxides, NH_3, mercury, and secondary pollutants such as ozone and particulate matter affect components of ecosystems. In sensitive ecosystems, these compounds can acidify soils and surface waters, add nutrients that change biodiversity, and affect the ecosystem services provided by forests and natural areas.[67] To address the relationship between deposition and ecosystem effects the FLM agencies have developed estimates of critical loads. A critical load is defined as "A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge."[71]

b. The FLM deposition modeling recommendations are divided into two distinct sections to address different requirements for 1) near field modeling, and 2) distant/multi-source modeling for cumulative effects. The recommendations separately address deposition assessments for sources proposing to locate relatively near and at farther distances from these areas.[67] Where the source and receptors are not in close proximity, chemical transport (*e.g.*, photochemical grid) models generally should be applied for an assessment of deposition impacts due to one or a small group of sources. Over these distances chemical and physical transformations can change atmospheric residence time due to different propensity for deposition to the surface of different forms of nitrate and sulfate. Users should consult the latest version of the FLAG report[67] and relevant FLM representatives for guidance on the use of models for deposition. Where source and receptors are in close proximity, users should contact the appropriate FLM for application specific guidance.

6.3 Modeling Guidance for Other Governmental Programs

a. Dispersion and photochemical grid modeling need to be conducted to ensure that individual and cumulative offshore oil and gas exploration, development, and production plans and activities do not significantly affect the air quality of any state as required under the Outer Continental Shelf Lands Act (OCSLA). Air quality modeling requires various input datasets, including emissions sources, meteorology, and pre-existing pollutant concentrations. For sources under the reviewing authority of the Department of Interior, Bureau of Ocean Energy Management (BOEM), guidance for the development of all necessary Outer Continental Shelf (OCS) air quality modeling inputs and appropriate model selection and application is available from the BOEMS's website: http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/Approved-Air-Quality-Models-for-the-GOMR.aspx.

b. The Federal Aviation Administration (FAA) is the appropriate reviewing authority for air quality assessments of primary pollutant impacts at airports and air bases. Air quality application for this purpose is intended for estimating the collective impact of changes in aircraft operations, point source, and mobile source emissions at airports on pollutant concentrations. The latest version of the Aviation Environmental Design Tool (AEDT), is developed and is supported by the FAA, and is appropriate for air quality assessment of primary pollutant impacts at airports or air bases. AEDT has adopted AERMOD for treating dispersion. Application of AEDT is intended for estimating the collective impact of changes in aircraft operations, point source, and mobile source emissions on pollutant concentrations. It is not intended for PSD, SIP, or other regulatory air quality analyses of point or mobile sources at or peripheral to airport property that are unrelated to airport operations. The latest version of AEDT may be obtained from FAA at its Web site: https://aedt.faa.gov.

7.0 General Modeling Considerations

7.1 Discussion

a. This section contains recommendations concerning a number of different issues not explicitly covered in other sections of the *Guideline*. The topics covered here are not specific to any one program or modeling area but are common to dispersion modeling analyses for criteria pollutants.

7.2 Recommendations

7.2.1 All sources

7.2.1.1 Dispersion Coefficients

a. For any dispersion modeling exercise, the urban or rural determination of a source is critical in determining the boundary layer characteristics that affect the model's prediction of downwind concentrations. Historically, steady-state Gaussian plume models used in most applications have employed dispersion coefficients based on Pasquill-Gifford[72] in rural areas and McElroy- Pooler[73] in urban areas. These coefficients are still incorporated in the BLP and OCD models. However, the AERMOD model incorporates a more up-to-date characterization of the atmospheric boundary layer using continuous functions of parameterized horizontal and vertical turbulence based on Monin-Obukhov similarity (scaling) relationships.[44] Another key feature of AERMOD's formulation is the option to use directly observed variables of the boundary layer to parameterize dispersion.[44, 45]

b. The selection of rural or urban dispersion coefficients in a specific application should follow one of the procedures suggested by Irwin[74] to determine whether the character of an area is primarily urban or rural:

i. Land Use Procedure: (1) Classify the land use within the total area, A_o, circumscribed by a 3km radius circle about the source using the meteorological land use typing scheme proposed by Auer;[75] (2) if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of A_o, use urban dispersion coefficients; otherwise, use appropriate rural dispersion coefficients.

ii. Population Density Procedure: (1) Compute the average population density, $\bar{p}$ per square kilometer with A_o as defined above; (2) If $\bar{p}$ is greater than 750 people/km^2, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients. (Of the two methods, the land use procedure is considered more definitive.)

c. Population density should be used with caution and generally not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated. However, the area is likely to be sufficiently built-up so that the urban land use criteria would be satisfied. Therefore, in this case, the classification should be ''urban'' and urban dispersion parameters should be used.

d. For applications of AERMOD in urban areas, under either the Land Use Procedure or the Population Density Procedure, the user needs to estimate the population of the urban area affecting the modeling domain because the urban influence in AERMOD is scaled based on a user-specified population. For non-population oriented urban areas, or areas influenced by both population and industrial activity, the user will need to estimate an equivalent population to adequately account for the combined effects of industrialized areas and populated areas within the modeling domain. Selection of the appropriate population for these applications should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the latest version of the AERMOD Implementation Guide[76]. Case-specific source characterizations include the assignment of urban characteristics to large industrialized areas, the merging of stack flues within one diameter of each other, and other related effects. These source characterization techniques are not an integral part of EPA's approved models. Therefore, they are not subject to the Appendix W Section 3.2.2 alternative model evaluation criteria and may be approved by the appropriate reviewing authority.

e. It should be noted that AERMOD allows for modeling rural and urban sources in a single model run. For analyses of whole urban complexes, the entire area should be modeled as an urban region if most of the sources are located in areas classified as urban. For tall stacks located within or adjacent to small or moderate sized urban areas, the stack height or effective plume height may extend above the urban boundary layer and, therefore, may be more appropriately modeled using rural coefficients. Model users should consult with the appropriate reviewing authority (paragraph 3.0(b)) when evaluating this situation and the latest version of the AERMOD Implementation Guide[76].

f. Buoyancy-induced dispersion (BID), as identified by Pasquill,[77] is included in the preferred models and should be used where buoyant sources, *e.g.*, those involving fuel combustion, are involved.

7.2.1.2 Complex Winds

a. *Inhomogeneous local winds*. In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient winds and circulations. Geographic effects are most apparent when the ambient winds are light or calm.[78] In general these geographically induced wind circulation effects are named after the source location of the winds, *e.g.*, lake and sea breezes, and mountain and valley winds. In very rugged hilly or mountainous terrain, along coastlines, or near large land use variations, the characterization of the winds is a balance of various forces, such that the assumptions of steady-state straight-line transport both in time and space are inappropriate. In such cases, a model should be chosen to fully treat the time and space variations of meteorology effects on transport and dispersion. The setup and application of such a model should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) consistent with limitations of paragraph 3.2.2(e). The meteorological input data requirements for developing the time and space varying three-dimensional winds and dispersion meteorology for these situations are discussed in paragraph 8.4.1.2(c). Examples of inhomogeneous winds include, but are not limited to, situations described in the following paragraphs:

i. *Inversion breakup fumigation*. Inversion breakup fumigation occurs when a plume (or multiple plumes) is emitted into a stable layer of air and that layer is subsequently mixed to the ground through convective transfer of heat from the surface or because of advection to less stable surroundings. Fumigation may cause excessively high concentrations but is usually rather short- lived at a given receptor. There are no recommended refined techniques to model this phenomenon. There are, however, screening procedures[40] that may be used to provide conservatively high modeled concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.

ii. *Shoreline fumigation*. Fumigation can be an important phenomenon on and near the shoreline of bodies of water. This can affect both individual plumes and area-wide emissions. When fumigation conditions are expected to occur from a source or sources with tall stacks located on or just inland of a shoreline, this should be addressed in the air quality modeling analysis. EPA has evaluated several coastal fumigation models, and the evaluation results of these models are available for their possible application on a case-by-case basis when air quality estimates under shoreline fumigation conditions are needed.[79] Selection of the appropriate model for applications where shoreline fumigation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

iii. *Stagnation*. Stagnation conditions are characterized by calm or very low wind speeds, and variable wind directions. These stagnant meteorological conditions may persist for several hours to several days. During stagnation conditions, the dispersion of air pollutants, especially those from low- level emissions sources, tends to be minimized, potentially leading to relatively high ground-level concentrations. If point sources are of interest, users should note the guidance provided in paragraph (a) of this subsection. Selection of the appropriate model for applications where stagnation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

7.2.1.3 Gravitational Settling and Deposition

a. Gravitational settling and deposition may be directly included in a model if either is a significant factor. When particulate matter sources can be quantified and settling and dry deposition are problems, professional judgment should be used, and there should be coordination with the appropriate reviewing authority (paragraph 3.0(b)). AERMOD contains algorithms for dry and wet deposition of gases and particles.[80] For other Gaussian plume models, an "infinite half-life" may be used for estimates of particle concentrations when only exponential decay terms are used for treating settling and deposition. Lagrangian models have varying degrees of complexity for dealing with settling and deposition and the selection of a parameterization for such should be included in the approval process for selecting a Lagrangian model. Eulerian grid models tend to have explicit parameterizations for gravitational settling and deposition as well as wet deposition parameters already included as part of the chemistry scheme.

7.2.2 Stationary Sources

7.2.2.1 Good Engineering Practice Stack Height

a. The use of stack height credit in excess of Good Engineering Practice (GEP) stack height or credit resulting from any other dispersion technique is prohibited in the development of emissions limits by 40 CFR 51.118 and 40 CFR 51.164. The definition of GEP stack height and dispersion technique are contained in 40 CFR 51.100. Methods and procedures for making the appropriate stack height calculations, determining stack height credits and an example of applying those techniques are found in several references,[81, 82, 83, 84] which provide a great deal of additional information for evaluating and describing building cavity and wake effects.

b. If stacks for new or existing major sources are found to be less than the height defined by the EPA's refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. The EPA refined formula height is defined as H + 1.5L.[83] Since the definition of GEP stack height defines excessive concentrations as a maximum ground-level concentration due in whole or in part to downwash of at least 40 percent in excess of the maximum concentration without downwash, the potential air quality impacts associated with cavity and wake effects should also be considered for stacks that equal or exceed the EPA formula height for GEP. The AERSCREEN model can be used to obtain screening estimates of potential downwash influences, based on the PRIME downwash algorithm incorporated in the AERMOD model. If more refined concentration estimates are required, the recommended steady-state plume dispersion model in section 4.2.2, AERMOD, should be used. Due to the predominant focus on the PRIME evaluations for stacks well below GEP height, AERMOD model estimates for stacks at and above GEP height should be interpreted with considerable caution.

7.2.2.2 Plume Rise

a. The plume rise methods of Briggs[85, 86] are incorporated in many of the preferred models and are recommended for use in many modeling applications. In AERMOD,[44, 45] for the stable boundary layer, plume rise is estimated using an iterative approach, similar to that in the CTDMPLUS model. In the convective boundary layer, plume rise is superposed on the displacements by random convective velocities.[87] In AERMOD, plume rise is computed using the methods of Briggs except cases involving building downwash, in which a numerical solution of the mass, energy, and momentum conservation laws is performed.[88] No explicit provisions in these models are made for multistack plume rise enhancement or the handling of such special
plumes as flares; these problems should be considered on a case-by-case basis.

b. Gradual plume rise is generally recommended where its use is appropriate: (1) In AERMOD; (2) in complex terrain screening procedures to determine close-in impacts and (3) when calculating the effects of building wakes. The building wake algorithm in AERMOD incorporates and exercises the thermodynamically based gradual plume rise calculations as described in (a) above. If the building wake is calculated to affect the plume for any hour, gradual plume rise is also used in downwind dispersion calculations to the distance of final plume rise, after which final plume rise is used. Plumes captured by the near wake are re-emitted to the far wake as a ground-level volume source.

c. Stack tip downwash generally occurs with poorly constructed stacks and when the ratio of the stack exit velocity to wind speed is small. An algorithm developed by Briggs[86] is the recommended technique for this situation and is used in preferred models for point sources.

d. On a case-by-case basis, source-specific refinements may be considered for plume rise and downwash effects. These refinements may address one or more of the following situations: fugitive heat releases on buildings that alter the aerodynamic flow relative to building downwash effects; stacks in a line, as addressed by Briggs (1984); and stack exhaust that has considerable moisture which leads to heat of condensation effects on plume rise. These source characterization approaches are not an integral part of EPA's approved models. Therefore, they are not subject to the Appendix W Section 3.2.2 alternative model evaluation criteria and may be approved by the appropriate reviewing authority.

7.2.3 Mobile Sources

a. Emissions of primary pollutants from mobile sources can be modeled with an appropriate model identified in section 4.2. Screening of mobile sources can be accomplished by using screening meteorology, such as that generated by the MAKEMET component of AERSCREEN, which can generate a range of meteorological scenarios using site-specific characteristics, such as albedo, Bowen ratio, and surface roughness. Maximum hourly concentrations computed from screening runs can be converted to longer averaging periods using the scaling ratios specific in the AERSCREEN User's Guide.[37]

b. Mobile sources can be modeled in AERMOD as either line (*i.e.*, elongated area) sources or as a series of volume sources. However, since mobile source modeling usually includes an analysis of very near-source impacts (*e.g.*, hot-spot modeling, which can include receptors within 5-10 meters of the roadway), the results can be highly sensitive to the characterization of the mobile emissions. When modeling roadway links, such as highway and arterial links, the EPA recommends that line/area sources instead of volume sources be used whenever possible, as it is easier to characterize them correctly. Important characteristics for both line/area and volume sources include the plume release height, source width, and initial dispersion characteristics, which should also take into account the impact of traffic-induced turbulence, which can cause roadway sources to have larger initial dimensions than might normally be used for representing line sources.

c. The EPA's quantitative PM hot-spot guidance[61] and Haul Road Workgroup Final Report[63] provide guidance on the appropriate characterization of mobile sources as a function of the roadway and vehicle characteristics. The EPA's quantitative PM hot-spot guidance includes important considerations and should be consulted when modeling roadway links. Line or area sources are recommended for mobile sources. However, if volume sources are used, it is particularly important to insure that roadway emissions are appropriately spaced when using volume source so that the emissions field is uniform across the roadway. Additionally, receptor placement is particularly important for volume sources, which have "exclusion zones", where concentrations are not calculated for receptors located "within" the volume sources, *i.e.*, less than 2.15 times the initial lateral dispersion coefficient from the center of the volume.[61] Placing receptors in these "exclusion zones" will result in underestimates of roadway impacts.

8.1 Model Input Data

a. Databases and related procedures for estimating input parameters are an integral part of the modeling process. The most appropriate input data available should always be selected for use in modeling analyses. Modeled concentrations can vary widely depending on the source data or meteorological data used. This section attempts to minimize the uncertainty associated with database selection and use by identifying requirements for input data used in modeling. More specific data requirements and the format required for the individual models are described in detail in the users' guide and/or associated documentation for each model.

8.1 Modeling Domain

8.1.1 Discussion

a. The modeling domain is the geographic area for which the required air quality analyses for the NAAQS and PSD increments are conducted.

8.1.2 Requirements

a. For a NAAQS or PSD increment assessment, the modeling domain or project's impact area shall include all locations where the emissions of a pollutant from the new or modifying source(s) may cause a significant ambient impact. This impact area is defined as an area with a radius extending from the new or modifying source to: (1) the most distant point source where air quality modeling predicts a significant ambient impact will occur, or (2) the nominal 50 km distance considered applicable for Gaussian dispersion models, whichever is less. The required air quality analysis shall be carried out within this geographical area with characterization of source impacts, nearby source impacts, and background concentrations, as recommended later in this section.

b. For SIP attainment demonstrations for ozone and $PM_{2.5}$, or regional haze reasonable progress goal analyses, the modeling domain is determined by the nature of the problem being modeled and the spatial scale of the emissions which impact the nonattainment or Class I area(s). The modeling domain shall be designed so that all major upwind source areas that influence the downwind nonattainment area are included in addition to all monitor locations that are currently or recently violating the NAAQS or close to violating the NAAQS in the nonattainment area. Similarly, all Class I areas to be evaluated in a regional haze modeling application shall be included and sufficiently distant from the edge of the modeling domain. Guidance on the determination of the appropriate modeling domain for photochemical grid models in demonstrating attainment of these air quality goals is available.[60] Users should consult the latest version of this guidance for the most current modeling guidance and with the appropriate reviewing authority (paragraph 3.0(b)) for any application specific guidance which is beyond the scope of this section.

8.2 Source Data

8.2.1 Discussion

a. Sources of pollutants can be classified as point, line, area, and volume sources. Point sources are defined in terms of size and may vary between regulatory programs. The line sources most frequently considered are roadways and streets along which there are well-defined movements of motor vehicles. They may also be lines of roof vents or stacks, such as in aluminum refineries. Area and volume sources are often collections of a multitude of minor sources with individually small emissions that are impractical to consider as separate point or line sources. Large area sources are typically treated as a grid network of square areas, with pollutant emissions distributed uniformly within each grid square. Generally, input data requirements for air quality models necessitate the use of metric units. As necessary, any English units common to engineering applications should be appropriately converted to metric.

b. For point sources, there are many source characteristics and operating conditions that may be needed to appropriately model the facility. For example, the plant layout (*e.g.*, location of stacks and buildings), stack parameters (*e.g.*, height and diameter), boiler size and type, potential operating conditions, and pollution control equipment parameters. Such details are required inputs to air quality models and are needed to determine maximum potential impacts.

c. Modeling mobile emissions from streets and highways requires data on the road layout, including the width of each traveled lane, the number of lanes, and the width of the median strip. Additionally, traffic patterns should be taken into account (*e.g.*, daily cycles of rush hour, differences in weekday and weekend traffic volumes, and changes in the distribution of heavy- duty trucks and light-duty passenger vehicles), as these patterns will affect the types and amounts of pollutant emissions allocated to each lane, and the height of emissions.

d. Emission factors can be determined through source specific testing and measurements (*e.g.*, stack test data) from existing sources or provided from a manufacturing association or vendor. Additionally, emissions factors for a variety of source types are compiled in an EPA publication commonly known as AP-42[89]. AP-42 also provides an indication of the quality and amount of data on which many of the factors are based. Other information concerning emissions is available in EPA publications relating to specific source categories. The appropriate reviewing authority (paragraph 3.0(b)) should be consulted to determine appropriate source definitions and for guidance concerning the determination of emissions from and techniques for modeling the various source types.

8.2.2 Requirements

a. For SIP attainment demonstrations for the purpose of projecting future year NAAQS attainment for ozone, PM2.5, and regional haze reasonable progress goal analyses, emissions which reflect actual emissions during the base modeling year time period should be input to models for base year modeling. Emissions projections to future years should account for key variables such as growth due to increased or decreased activity, expected emissions controls due to regulations, settlement agreements or consent decrees, fuel switches, and any other relevant information. Guidance on emissions estimation techniques (including future year projections) for SIP attainment demonstrations is available.[60, 90]

b. For the purpose of SIP revisions for stationary point sources, the regulatory modeling of inert pollutants shall use the emissions input data shown in Table 8-1 for short-term and long-term NAAQS. To demonstrate compliance and/or establish the appropriate SIP emissions limits, Table 8-1 generally provides for the use of "allowable" emissions in the regulatory dispersion modeling of the stationary point source(s) of interest (i.e., those new or modified sources subject to New Source Review permitting). In such modeling, these source(s) should be modeled sequentially with these loads for every hour of the year. As part of a cumulative impact analysis, Table 8-1 allows for the model user to account for actual operations in developing the emissions inputs for dispersion modeling of nearby sources, while other sources are best represented by air quality monitoring data. Consultation with the appropriate reviewing authority (paragraph 3.0(b)) is advisable on the establishment of the appropriate emissions inputs for regulatory modeling applications with respect to SIP revisions for stationary point sources.

c. For the purposes of demonstrating NAAQS compliance in a PSD assessment, the regulatory modeling of inert pollutants shall use the emissions input data shown in Table 8-2 for short and long-term NAAQS. The new or modifying stationary point source shall be modeled with "allowable" emission in the regulatory dispersion modeling. As part of a cumulative impact analysis, Table 8-2 allows for the model user to account for actual operations in developing the emissions inputs for dispersion modeling of nearby sources, while other sources are best represented by air quality monitoring data. For purposes of situations involving emissions trading refer to current EPA policy and guidance to establish input data. Consultation with the appropriate reviewing authority (paragraph 3.0(b)) is advisable on the establishment of the appropriate emissions inputs for regulatory modeling applications with respect to PSD assessments for a proposed new or modifying source.

d. For stationary source applications, changes in operating conditions that affect the physical emission parameters (*e.g.*, release height, initial plume volume, and exit velocity) shall be considered to ensure that maximum potential impacts are appropriately determined in the assessment. For example, the load or operating condition for point sources that causes maximum ground-level concentrations shall be established. As a minimum, the source should be modeled using the design capacity (100 percent load). If a source operates at greater than design capacity for periods that could result in violations of the NAAQS or PSD increment, this load should be modeled. Where the source operates at substantially less than design capacity, and the changes in the stack parameters associated with the operating conditions could lead to higher ground level concentrations, loads such as 50 percent and 75 percent of capacity should also be modeled. ~~Malfunctions which may result in excess emissions are not considered to be a normal operating condition. They generally should not be considered in determining allowable emissions. However, if the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions, it may be necessary to consider them in determining source impact.~~ For short-term NAAQS or PSD increments, only emission conditions that are continuous enough or frequent enough to contribute significantly to the annual distribution of the concentrations associated with the form of the NAAQS or PSD increment should be modeled. This would exclude highly intermittent emission cases. A range of operating conditions should be considered in screening analyses; the load causing the highest concentration, in addition to the design load, should be included in refined modeling.

e. Emissions from mobile sources also have physical and temporal characteristics that should be appropriately accounted for, although impacts from existing mobile sources are often accounted for in regional background estimates. For example, an appropriate emissions model shall be used to determine emissions profiles. Such emissions should include speciation specific for the vehicle types used on the roadway (*e.g.*, light duty and heavy duty trucks) and subsequent parameterizations of the physical emissions characteristics (*e.g.*, release height) should reflect those emissions sources. For long-term standards, annual average emissions may be appropriate, but for short-term standards, discrete temporal representation of emissions should be used (*e.g.*, variations in weekday and weekend traffic or the diurnal rush-hour profile typical of many cities). Detailed information and data requirements for modeling mobile sources of pollution are provided in the user's manuals for each of the models applicable to mobile sources.[61, 63]

f. Emissions variability may be considered for New Source Review modeling similar to the consideration provided for SO_2 nonattainment modeling, as outlined in EPA's April 2014 "Guidance for 1-Hour SO2 Nonattainment Area SIP Submissions.

Table 8-1. - Point Source Model Emission Input for SIP Revisions of Inert Pollutants[1]

Averaging time	Emissions limit (lb/MMBtu)[2] X	Operating level (MMBtu/hr)[2] X	Operating factor (e.g., hr/yr, hr/day)
Stationary Point Source(s) Subject to SIP Emissions Limit(s) Evaluation for Compliance with Ambient Standards *(Including Areawide Demonstrations)*			
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.	Actual or design capacity (whichever is greater), or federally enforceable permit condition.	Actual operating factor averaged over the most recent 2 years.[3]
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]			
All averaging times (if hourly emissions data are available)	Actual hourly emissions are input directly into the model		
Otherwise: Annual & quarterly	If available, maximum actual emission rate. Otherwise, m~~M~~aximum allowable emission limit or federally enforceable permit limit.[6]	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)	If available, maximum actual emission rate. Otherwise, m~~M~~aximum allowable emission limit or federally 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] unless non-continuous actual operation can be documented.~~[5]~~
Other Source(s) [6, 9]			

The ambient impacts from Non-nearby or Other Sources (*e.g.* , natural sources, minor sources and ,distant major sources, and unidentified sources) can be represented by air quality monitoring data unless adequate data do not exist.

1 . For purposes of emissions trading, NSR, or PSD, other model input criteria may apply. See Section 8.2 for more information regarding attainment demonstrations of primary PM2.5.
2. Terminology applicable to fuel burning sources; analogous terminology (*e.g.* , lb/throughput) may be used for other types of sources.
3. Unless it is determined that this period is not representative.
4. Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.
5. If operation does not occur for all hours of the time period of consideration (*e.g.* , 3 or 24-hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (*e.g.* , if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating
6. See Section 8.3.3.
7. Temporally representative operating level could be based on Continuous Emissions Monitoring (CEM) data or other information and should be determined through consultation with the appropriate reviewing authority (Paragraph 3.0(b)).
8. For those permitted sources not in operation or that have not established an appropriate factor, continuous operation (i.e., 8760) should be used.
9. See Section 8.3.2.

Table 8-2. - Point Source Model Emission Input for NAAQS Compliance in PSD Demonstrations

Averaging time	Emissions limit (lb/MMBtu)[1]	X	Operating level (MMBtu/hr)[2]	X	Operating factor (e.g., hr/yr, hr/day)
Proposed Major New or Modified Source					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.		Continuous operation (i.e., 8760 hours).[2]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.[3]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database).[2]
Nearby Source(s) [4, 5]					
All averaging times (if hourly emissions data are available)	Actual hourly emissions are input directly into the model				
Otherwise:					
Annual & quarterly	If available, maximum actual emission rate. Otherwise, m~~M~~aximum allowable emission limit or federally enforceable permit limit.[5]		Annual level when actually operating, averaged over the most recent 2 years.[6]		Actual operating factor averaged over the most recent 2 years.[6,8]
Short term (≤ 24 hours)	If available, maximum actual emission rate. Otherwise, m ~~M~~aximum allowable emission limit or federally enforceable permit limit.[6]		~~Annual level when actually operating, averaged over the most recent 2 years.[6,7]~~ **Temporally representative level when actually operating, reflective of the most recent 2 years.[6, 7]**		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database)[2] unless non-continuous actual operation can be documented.
Other Source(s) [5, 9]					

The ambient impacts from Non-nearby or Other Sources (*e.g.* , natural sources, minor sources and ,distant major sources, and unidentified sources) can be represented by air quality monitoring data unless adequate data do not exist.

1. Terminology applicable to fuel burning sources; analogous terminology (*e.g.* , lb/throughput) may be used for other types of sources.
2. If operation does not occur for all hours of the time period of consideration (*e.g.* , 3 or 24-hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (*e.g.* , if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating
3. Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.
4. Includes existing facility to which modification is proposed if the emissions from the existing facility will not be affected by the modification. Otherwise use the same parameters as for major modification.
5. See Section 8.3.3.
6. Unless it is determined that this period is not representative.
7. Temporally representative operating level could be based on Continuous Emissions Monitoring (CEM) data or other information and should be determined through consultation with the appropriate reviewing authority (Paragraph 3.0(b)).

8. For those permitted sources not in operation or that have not established an appropriate factor, continuous operation (*i.e.* , 8760) should be used.
9. See Section 8.3.2.

8.3 Background Concentrations

8.3.1 Discussion

a. Background concentrations are essential in constructing the design concentration, or total air quality concentration, as part of a cumulative impact analysis for NAAQS and PSD increments (section 9.2.4). Background air quality should not include the ambient impacts of the project source under consideration. Instead, it should include:

i. Nearby sources: These are individual sources in the vicinity of the source(s) under consideration for emissions limits that are not adequately represented by ambient monitoring data. Typically, sources that cause a significant concentration gradient in the vicinity of the source(s) under consideration for emissions limits are not adequately represented by background ambient monitoring, although a well-placed monitor could be used for this characterization. The ambient contributions from these nearby sources are usually~~thereby~~ accounted for by explicitly modeling their emissions (section 8.2).

ii. Other sources: That portion of the background attributable to natural sources, other unidentified sources in the vicinity of the project, and regional transport contributions from more distant sources (domestic and international). The ambient contributions from these sources are typically accounted for through use of ambient monitoring data or, in some cases, regional-scale photochemical grid modeling results.

b. The monitoring network used for developing background concentrations is expected to conform to the same quality assurance and other requirements as those networks established for PSD purposes.[91] Accordingly, the air quality monitoring data should be of sufficient completeness and follow appropriate data validation procedures. These data should be adequately representative of the area to inform calculation of the design concentration for comparison to the applicable NAAQS (section 9.2.2)

c. For photochemical grid modeling conducted in SIP attainment demonstrations for ozone, $PM_{2.5}$ and regional haze, the emissions from nearby and other sources are included as model inputs and fully accounted for in the modeling application and predicted concentrations. The concept of adding individual components to develop a design concentration, therefore, do not apply in these SIP applications. However, such modeling results may then be appropriate for consideration in characterizing background concentrations for other regulatory applications. Also, as noted in section 5, this modeling approach does provide for an appropriate atmospheric environment to assess single-sources impacts for ozone and secondary $PM_{2.5}$.

d. For PSD assessments in general and SIP attainment demonstrations for inert pollutants, the development of the appropriate background concentration for a cumulative impact analysis involves proper accounting of each contribution to the design concentration and will depend upon whether the project area's situation consists of either an isolated single source(s) or a multitude of sources.

8.3.2 Recommendations for Isolated Single Source

a. In areas with an isolated source(s), determining the appropriate background concentration should focus on characterization of contributions from all other sources through adequately representative ambient monitoring data.

b. The EPA recommends use of the most recent quality assured air quality monitoring data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. In most cases, the EPA recommends using data from the monitor closest to and upwind of the project area. If several monitors are available, preference should be given to the monitor with the most similar characteristics as the project area. If there are no monitors located in the vicinity of the new or modify source, a "regional site" may be used to determine background concentrations. A regional site is one that is located away from the area of interest but is impacted by similar or adequately representative sources. If a regional site is impacted by local sources, multiple regional sites can be considered to obtain a hybrid site consisting of the minimum concentration observed each hour.

c. Many of the challenges related to cumulative impact analyses arise in the context of defining the appropriate metric to characterize background concentrations from ambient monitoring data and determining the appropriate method for combining this monitor-based background contribution to the modeled impact of the project and other nearby sources. For many cases, the best starting point would be use of the current design value for the applicable NAAQS as a uniform monitored background contribution across the project area. However, there are cases in which the current design value may not be appropriate. Such cases include but are not limited to:

i. For situations involving a modifying source where the existing facility is determined to impact the ambient monitor, the background concentration at each monitor can be determined by excluding values when the source in question is impacting the monitor. In such cases, monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact.

ii. There may be other circumstances which would necessitate modifications to the ambient data record. Such cases could include removal of data from specific days or hours when a monitor is being impacted activities that are not typical or expected to occur again in the future (e.g., construction, roadway repairs, forest fires, or unusual agricultural activities). There may also be cases where scaling (multiplying the monitored concentrations with a scaling factor) or adjusting (adding or subtracting a constant value the monitored concentrations) of data from specific days or hours. Such adjustments would make the monitored background concentrations more temporally and/or spatially representative of area around the new or modifying source for the purposes of the regulator assessment.

iii. For short-term standards, the diurnal or seasonal patterns of the air quality monitoring data may differ significantly from the patterns associated with the modeled concentrations. When this occurs, it may be appropriate to pair the air quality monitoring data in a temporal manner that reflects these patterns (*e.g.*, pairing by season and/or hour of day).[92]

iv. For situations where monitored air quality concentrations vary across the modeling domain, it may be appropriate to consider air quality monitoring data from multiple monitors within the project area.

d. Determination of the appropriate background concentrations should be consistent with appropriate EPA modeling guidance[59, 92] and justified in the modeling protocol that is vetted with the appropriate reviewing authority (paragraph 3.0(b)).

e. Considering the spatial and temporal variability throughout a typical modeling domain on an hourly basis and the complexities and limitations of hourly observations from the ambient monitoring network, the EPA does not recommend hourly or daily pairing of monitored background and modeled concentrations except in rare cases of relatively isolated sources where the available monitor can be shown to be representative of the ambient concentration levels in the areas of maximum impact from the proposed new source. The implicit assumption underlying hourly pairing is that the background monitored levels for each hour are spatially uniform and that the monitored values are fully representative of background levels at each receptor for each hour. Such an assumption clearly ignores the many factors that contribute to the temporal and spatial variability of ambient concentrations across a typical modeling domain on an hourly basis. In most cases, the seasonal (or quarterly) pairing of monitored and modeled concentrations should sufficiently address situations to which the impacts from modeled emissions are not temporally correlated with background monitored levels.

f. In those cases where adequately representative monitoring data to characterize background concentrations are not available, it may be appropriate to use results from a regional-scale photochemical grid model or other representative model application as background concentrations consistent with the considerations discussed above and in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

8.3.3 Recommendations for Multi-Source Areas

a. In multi-source areas, determining the appropriate background concentration involves: (1) identification and characterization of contributions from nearby sources through explicit modeling, and (2) characterization of contributions from other sources through adequately representative ambient monitoring data. A key point here is the interconnectedness of each component in that the question of which nearby sources to include in the cumulative modeling is inextricably linked to the question of what the ambient monitoring data represents within the project area.

b. *Nearby sources:* All sources in the vicinity of the source(s) under consideration for emissions limits that are not adequately represented by ambient monitoring data should be explicitly modeled. Since an ambient monitor is limited to characterizing air quality at a fixed location, sources that causes a significant concentration gradient in the vicinity of the source(s) under consideration for emissions limits are not likely to be adequately characterized by the monitored data due to the high degree of variability of the source's impact. However, a well-placed monitor could be used for this characterization if it is placed in a location of peak impacts from the source(s) under consideration.

i. The pattern of concentration gradients can vary significantly based on the averaging period being assessed. In general, concentration gradients will be smaller and more spatially uniform for annual averages than for short-term averages, especially for hourly averages. The spatial distribution of annual impacts around a source will often have a single peak downwind of the source based on the prevailing wind direction, except in cases where terrain or other geographic effects are important. By contrast, the spatial distribution of peak short-term impacts will typically show several localized concentration peaks with more significant gradient.

ii. Concentration gradients associated with a particular source will generally be largest between that source's location and the distance to the maximum ground-level concentrations from that source. Beyond the maximum impact distance, concentration gradients will generally be much smaller and more spatially uniform. Thus, the magnitude of a concentration gradient will be greatest in the proximity of the source and will generally not be significant at distances greater than 10 times the height of the stack(s) at that source without consideration of terrain influences.

iii. The 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. Owing to both the uniqueness of each modeling situation and the large number of variables involved in identifying nearby sources, no attempt is made here to comprehensively define a "significant concentration gradient." Rather, identification of nearby sources calls for the exercise of professional judgement by the appropriate reviewing authority (paragraph 3.0(b)). This guidance is not intended to alter the exercise of that judgement or to comprehensively prescribe which sources should be included as nearby sources.

c. For cumulative impact analyses of short-term and annual ambient standards, the nearby sources as well as the project source(s) must be evaluated using an appropriate appendix A model or approved alternative model with the emission input data shown in Table 8-1 or 8-2, unless a well-placed monitor is used to provide this information.

i. When modeling a nearby source that does not have a permit and the emissions limits contained in the SIP for a particular source category is greater than the emissions possible given the source's maximum physical capacity to emit, the ''maximum allowable emissions limit'' for such a nearby source may be calculated as the emissions rate representative of the nearby source's maximum physical capacity to emit, considering its design specifications and allowable fuels and process materials. However, the burden is on the permit applicant to sufficiently document what the maximum physical capacity to emit is for such a nearby source.

ii. It is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s). Nearby sources should be modeled using actual hourly emissions if that information is available. Accordingly, it is not necessary to model impacts of a nearby source that does not, by its nature, operate at the same time as the primary source, regardless of an identified significant concentration gradient from the nearby source., The burden is on the permit applicant to adequately justify the exclusion of nearby sources to the satisfaction of the appropriate reviewing authority (paragraph 3.0(b)). The following examples illustrate two cases in which a nearby source may be shown not to operate at the same time as the primary source(s) being modeled:

(1) Seasonal sources (only used during certain seasons of the year). Such sources would not be modeled as nearby sources during times in which they do not operate; and (2) Emergency backup generators, to the extent that they do not operate simultaneously with the sources that they back up. Such emergency equipment would not be modeled as nearby sources.

d. *Other sources*. That portion of the background attributable to all other sources (*e.g.*, natural sources, minor and distance major sources) should be accounted for through use of ambient monitoring data and determined by the procedures found in section 8.3.2 in keeping with eliminating or reducing the source-oriented impacts from nearby sources to avoid potential double-counting of modeled and monitored contributions.

8.4 Meteorological Input Data

8.4.1 Discussion

a. This subsection covers meteorological input data for use in dispersion modeling for regulatory applications and is separate from recommendations made for photochemical grid modeling. Recommendations for meteorological data for photochemical grid modeling applications are outlined in the latest version of EPA's Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze[93]. In cases where Lagrangian models are applied for regulatory purposes, appropriate meteorological inputs should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the measured data is dependent on numerous factors including but not limited to: (1) The proximity of the meteorological monitoring site to the area under consideration; (2) The complexity of the terrain; (3) The exposure of the meteorological monitoring site; and (4) The period of time during which data are collected. The spatial representativeness of the data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area. Temporal representativeness is a function of the year-to-year variations in weather conditions. Where appropriate, data representativeness should be viewed in terms of the appropriateness of the data for constructing realistic boundary layer profiles and, where applicable, three-dimensional meteorological fields, as described in paragraphs (c) and (d) below.

c. The meteorological data should be adequately representative and may be site-specific data, data from a nearby National Weather Service (NWS) or comparable station, or prognostic meteorological data. The implementation of ASOS (automated surface observing stations) in recent years should not preclude the use of NWS-ASOS data if such a station is determined to be representative of the modeled area.[94]

d. Model input data are normally obtained either from the NWS or as part of a site-specific measurement program. State climatology offices, local universities, FAA, military stations, industry and pollution control agencies may also be sources of such data. In specific cases, prognostic meteorological data may be appropriate for use and obtained from similar sources. Some recommendations and requirements for the use of each type of data are included in this subsection.

8.4.2 Recommendations and Requirements

a. AERMET[95] shall be used to preprocess all meteorological data, be it observed or prognostic, for use with AERMOD in regulatory applications. The AERMINUTE[96] processor, in most cases, should be used to process 1-minute ASOS wind data for input into AERMET when processing NWS ASOS sites in AERMET. When processing prognostic meteorological data for AERMOD, the Mesoscale Model Interface Program (MMIF)[93] should be used to process data for input into AERMET. Other methods of processing prognostic meteorological data for input into AERMET should be approved by the appropriate reviewing authority. Additionally, the following meteorological preprocessors are recommended by the EPA: PCRAMMET[97], MPRM[98], and METPRO[99]. PCRAMMET is the recommended meteorological data preprocessor for use in applications of OCD employing hourly NWS data. MPRM is the recommended meteorological data preprocessor for applications of OCD employing site-specific meteorological data. METPRO is the recommended meteorological data preprocessor for use with CTDMPLUS[100].

b. Regulatory application of AERMOD necessitates careful consideration of the meteorological data for input to AERMET. Data representativeness, in the case of AERMOD, means utilizing data of an appropriate type for constructing realistic boundary layer profiles. Of particular importance is the requirement that all meteorological data used as input to AERMOD should be adequately representative of the transport and dispersion within the analysis domain. In this regard, the key meteorological parameters are the wind direction and speed patterns, which govern the plume rise, transport, and dispersion. Where surface conditions vary significantly over the analysis domain, the emphasis in assessing representativeness should be given to adequate characterization of transport and dispersion between the source(s) of concern and areas where maximum design concentrations are anticipated to occur. The EPA recommends that the surface characteristics input to AERMET should be representative of the land cover in the vicinity of the meteorological data, *i.e.*, the location of the meteorological tower for measured data or the representative grid cell for prognostic data. Therefore, the model user should apply the latest version AERSURFACE[101, 102], where applicable, for determining surface characteristics when processing measured meteorological data through AERMET. In areas where it is not possible to use AERSURFACE output, surface characteristics can determined using techniques that apply the same analysis as AERSURFACE. In the case of prognostic meteorological data, the surface characteristics associated with the prognostic meteorological model output for the representative grid cell should be used.[103, 104] Furthermore, since the spatial scope of each variable could be different, representativeness should be judged for each variable separately. For example, for a variable such as wind direction, the data should ideally be collected near plume height to be adequately representative, especially for sources located in complex terrain. Whereas, for a variable such as temperature, data from a station several kilometers away from the source may be considered to be adequately representative. More information about meteorological data, representativeness, and surface characteristics can be found in the AERMOD Implementation Guide[76]. It should be noted that measurement sites at airports or site-specific meteorological towers are inherently less rough than many other sites, including industrial sources. This is due to meteorological siting criteria that limit the obstacles near the instruments, and the predominance of large structures at an industrial site. Due to the fact that the Bowen ratio and albedo are determined over a large 10 km x 10 km area, those surface characteristics are not as sensitive to the changes in surface conditions as the surface roughness is (controlled by land cover within 1 km of the tower). However, since wind profiling is self-consistent at the meteorological site, the winds well above the ground should be reasonably consistent over the modeling domain, so the effect on tall stack releases is reduced over that of low-level sources. For low-level sources, a low roughness usually leads to conservatively high near-field impacts due to minimum turbulence that is parameterized by AERMOD. Therefore, disparities in the surface characteristics between the meteorological tower and the emission source site are likely not to result in model under-predictions.

c. Regulatory application of CTDMPLUS requires the input of multi-level measurements of wind speed, direction, temperature, and turbulence from an appropriately sited meteorological tower. The measurements should be obtained up to the representative plume height(s) of interest. Plume heights of interest can be determined by use of screening procedures such as CTSCREEN.

d. Regulatory application of OCD requires meteorological data over land and over water. The over land or surface data processed through PCRAMMET[97] which provides hourly stability class, wind direction and speed, ambient temperature, and mixing height are required. Data over water requires hourly mixing height, relative humidity, air temperature, and water surface temperature. Missing winds are substituted with the surface winds. Vertical wind direction shear, vertical temperature gradient, and turbulence intensities are optional.

e. The model user should acquire enough meteorological data to ensure that worst-case meteorological conditions are adequately represented in the model results. The use of 5 years of adequately representative NWS meteorological data, at least 1 year of site-specific, or at least 3 years of prognostic meteorological data are required. If 1 year or more, up to 5 years, of site-specific data is available, these data are preferred for use in air quality analyses. Such data should have been subjected to quality assurance procedures as described in section 8.4.4.2.

~~e.~~f. In the case that advanced PGMs are used for predicting single-source impacts on ozone or PM2.5, the use of a single year of quality-assured data is acceptable if approved by the EPA Regional Office.

~~f.~~g. Objective analysis in meteorological modeling is to improve meteorological analyses (the "*first guess field*") used as initial conditions for prognostic meteorological models by incorporating information from meteorological observations. Direct and indirect (using remote sensing techniques) observations of temperature, humidity, and wind from surface and radiosonde reports are commonly employed to improve these analysis fields. For LRT applications, it is recommended that objective analysis procedures using direct and indirect meteorological observations be employed in preparing input fields to produce prognostic meteorological datasets. The length of record of observations should conform to recommendations outlined in paragraph 8.4.2(e) for prognostic meteorological model datasets.

8.4.3 National Weather Service Data

8.4.3.1 Discussion

a. The NWS meteorological data are routinely available and familiar to most model users. Although the NWS does not provide direct measurements of all the needed dispersion model input variables, methods have been developed and successfully used to translate the basic NWS data to the needed model input. Site-specific measurements of model input parameters have been made for many modeling studies, and those methods and techniques are becoming more widely applied, especially in situations such as complex terrain applications, where available NWS data are not adequately representative. However, there are many modeling applications where NWS data are adequately representative, and the applications still rely heavily on the NWS data.

b. Many models use the standard hourly weather observations available from the National Centers for Environmental Information (NCEI)[b]. These observations are then preprocessed before they can be used in the models. Prior to the advent of ASOS in the early 1990's, the "hourly" weather observation was a human observer-based observation reflecting a single 2-minute average generally taken about 10 minutes before the hour. However, beginning with January 2000 for first-order stations and March 2005 for all stations, NCEI has archived the rolling 2-minute average winds at every minute for ASOS sites. The AERMINUTE processor[96] was developed to reduce calm and missing hours by taking advantage of the availability of the 1-minute ASOS wind data to calculate full hourly average winds to replace standard hourly observations and reduce the number of calm and missing winds in AERMET processing.

8.4.3.1 Recommendations

a. The preferred models listed in appendix A all accept as input the NWS meteorological data preprocessed into model compatible form. If NWS data are judged to be adequately representative for a specific modeling application, they may be used. NEIS makes available surface[105, 106] and upper air[107] meteorological data online and in CD-ROM format. Upper air data are also available at the Earth System Research Laboratory Global Systems Divisions website (http://esrl.noaa.gov/gsd)

b. Although most NWS wind measurements are made at a standard height of 10 meters, the actual anemometer height should be used as input to the preferred meteorological processor and model.

c. Standard hourly NWS wind directions are reported to the nearest 10 degrees. A specific set of randomly generated numbers has been developed for use with the preferred EPA models and should be used with standard NWS data to ensure a lack of bias in wind direction assignments within the models.

d. Beginning with year 2000, NCDC began archiving 2-minute winds, reported every minute for NWS ASOS sites. The AERMINUTE processor was developed to read those winds and calculate hourly average winds for input into AERMET. When such data are available for the NWS ASOS site being processed, the AERMINUTE processor should be used in most cases to calculate hourly average wind speed and direction when processing NWS ASOS data for input to AERMOD.[94]

e. Data from universities, FAA, military stations, industry and pollution control agencies may be used if such data are equivalent in accuracy and detail (*e.g.*, siting criteria, frequency of observations, data completeness, etc.) to the NWS data, they are judged to be adequately representative for the particular application and have undergone quality assurance checks.

f. After valid data retrieval requirements have been met,[108] large number of hours in the record having missing data should be treated according to an established data substitution protocol provided that adequately representative alternative data are available. Data substitution guidance is provided in section 5.3 of reference 108. If no representative alternative data are available for substitution, the absent data should be coded as missing using missing data codes appropriate to the applicable meteorological pre-processor. Appropriate model options for treating missing data, if available in the model, should be employed.

[b] Formerly the National Climatic Data Center (NCDC).

8.4.4 Site-specific data

8.4.4.1 Discussion

a. Spatial or geographical representativeness is best achieved by collection of all of the needed model input data in close proximity to the actual site of the source(s). Site-specific measured data are therefore preferred as model input, provided that appropriate instrumentation and quality assurance procedures are followed and that the data collected are adequately representative (free from inappropriate local or microscale influences) and compatible with the input requirements of the model to be used. It should be noted that, while site-specific measurements are frequently made "on-property" (*i.e.*, on the source's premises), acquisition of adequately representative site-specific data does not preclude collection of data from a location off property. Conversely, collection of meteorological data on a source's property does not of itself guarantee adequate representativeness. For help in determining representativeness of site-specific measurements, technical guidance[108] is available. Site-specific data should always be reviewed for representativeness and adequacy by an experienced meteorologist, atmospheric scientist, or other qualified scientist.

8.4.4.2 Recommendations

a. The EPA guidance[108] provides recommendations on the collection and use of site-specific meteorological data. Recommendations on characteristics, siting, and exposure of meteorological instruments and on data recording, processing, completeness requirements, reporting, and archiving are also included. This publication should be used as a supplement to other limited guidance on these subjects.[5, 91, 109, 110] Detailed information on quality assurance is also available.[111] As a minimum, site-specific measurements of ambient air temperature, transport wind speed and direction, and the variables necessary to estimate atmospheric dispersion should be available in meteorological datasets to be used in modeling. Care should be taken to ensure that meteorological instruments are located to provide an adequately representative characterization of pollutant transport between sources and receptors of interest. The appropriate reviewing authority (paragraph 3.0(b)) is available to help determine the appropriateness of the measurement locations.

b. All processed site-specific data should be in the form of hourly averages for input into the dispersion model. These data include surface wind speed, transport direction, dilution wind speed, and turbulence measurements σ_A and σ_E (for use in stability determinations and direct input into the dispersion model). The hourly average turbulence measurements should be the square root of the arithmetic average of the 15-minute average variances (square of σ_A or σ_E). However, in the case of site-specific wind measurements with a starting threshold speed near 0.5 m/s, the true hourly average of the turbulence measurements for direct input to AERMOD (accounting for intra-hourly wind fluctuations) should be used.

c. *Missing data substitution*. After valid data retrieval requirements have been met,[108] hours in the record having missing data should be treated according to an established data substitution protocol provided that adequately representative alternative data are available. Such protocols are usually part of the approved monitoring program plan. Data substitution guidance is provided in section 5.3 of reference 108. If no representative alternative data are available for substitution, the absent data should be coded as missing using missing data codes appropriate to the applicable meteorological pre-processor. Appropriate model options for treating missing data, if available in the model, should be employed.

d. *Solar radiation measurements*. Total solar radiation or net radiation should be measured with a reliable pyranometer or net radiometer, sited and operated in accordance with established site-specific meteorological guidance.[108, 111]

e. *Temperature measurements*. Temperature measurements should be made at standard shelter height (2m) in accordance with established site-specific meteorological guidance.[108]

f. *Temperature difference measurements.* Temperature difference (DT) measurements should be obtained using matched thermometers or a reliable thermocouple system to achieve adequate accuracy. Siting, probe placement, and operation of DT systems should be based on guidance found in Chapter 3 of reference 108 and such guidance should be followed when obtaining vertical temperature gradient data. AERMET may employ the Bulk Richardson scheme, which requires measurements of temperature difference, in lieu of cloud cover or insolation data. To ensure correct application and acceptance, AERMOD users should consult with the appropriate reviewing authority (paragraph 3.0(b)) before using the Bulk Richardson scheme for their analysis.

g. *Wind measurements*. For simulation of plume rise and dispersion of a plume emitted from a stack, characterization of the wind profile up through the layer in which the plume disperses is desirable. This is especially important in complex terrain and/or complex wind situations where wind measurements at heights up to hundreds of meters above stack base may be required in some circumstances. For tall stacks when site-specific data are needed, these winds have been obtained traditionally using meteorological sensors mounted on tall towers. A feasible alternative to tall towers is the use of meteorological remote sensing instruments (*e.g.*, acoustic sounders or radar wind profilers) to provide winds aloft, coupled with 10-meter towers to provide the near-surface winds. Note that when site-specific wind measurements are used, AERMOD, at a minimum, requires wind observations at a height above ground between seven times the local surface roughness height and 100 meters. (For additional requirements for AERMOD and CTDMPLUS, *see* appendix A.) Specifications for wind measuring instruments and systems are contained in reference 108.

~~g.~~ h. *Turbulence*. There are several dispersion models that are capable of using direct measurements of turbulence (wind fluctuations) in the characterization of the vertical and lateral dispersion (*e.g.*, CTDMPLUS, AERMOD). For specific requirements for CTDMPLUS, AERMOD, *see* appendix A. For technical guidance on measurement and processing of turbulence parameters, *see* reference 108. When turbulence data are used in this manner to directly characterize the vertical and lateral dispersion, the averaging time for the turbulence measurements should be 1 hour. However, since AERMOD incorporates an algorithm to account for horizontal plume meander under low wind conditions, the methodology outlined in paragraph 8.4.4.2(b) should be used to calculate hourly averages of σ_θ, based on four 15-minute values, to minimize "double counting" of plume spread associated with meander. However, in the case of site-specific wind measurements with a starting threshold speed near 0.5 m/s for which the meander component is minimal (especially for tall stack releases where the wind speed will scale with height), the true hourly average of the turbulence measurements for direct input to AERMOD (accounting for intra-hourly wind fluctuations) should be used. The calculation of hourly σ_θ discussed above is automatically applied within AERMET when sub-hourly data are processed. There are other dispersion models that employ P-G stability categories for the characterization of the vertical and lateral dispersion. Methods for using site-specific turbulence data for the characterization of P- G stability categories are discussed in reference 108. When turbulence data are used in this manner to determine the P-G stability category, the averaging time for the turbulence measurements should be 15 minutes, with hourly averaged values based on methodology in paragraph 8.4.4.2(b).

~~h.~~i. *Stability categories*. For dispersion models that employ P-G stability categories for the characterization of the vertical and lateral dispersion, the P-G stability categories, as originally defined, couple near-surface measurements of wind speed with subjectively determined insolation assessments based on hourly cloud cover and ceiling height observations. The wind speed measurements are made at or near 10m. The insolation rate is typically assessed using observations of cloud cover and ceiling height based on criteria outlined by Turner.[72] It is recommended that the P-G stability category be estimated using the Turner method with site- specific wind speed measured at or near 10m and representative cloud cover and ceiling height. Implementation of the Turner method, as well as considerations in determining representativeness of cloud cover and ceiling height in cases for which site-specific cloud observations are unavailable, may be found in section 6 of reference 108. In the absence of requisite data to implement the Turner method, the solar radiation/delta-T (SRDT) method or wind fluctuation statistics (*i.e.*, the σ_E and σ_A methods) may be used.

~~i.~~j. The SRDT method, described in section 6.4.4.2 of reference 108, is modified slightly from that published from earlier work[112] and has been evaluated with three site-specific databases.[113] The two methods of stability classification which use wind fluctuation statistics, the σ_E and σ_A methods, are also described in detail in section 6.4.4 of reference 108 (note applicable tables in section 6). For additional information on the wind fluctuation methods, several references are available.[114, 115, 116, 117]

8.4.5 Prognostic meteorological data

8.4.5.1 Discussion

a. For some modeling applications, there may not be a representative NWS or comparable meteorological station available (*e.g.*, complex terrain), and it may be cost prohibitive or infeasible to collect adequately representative site-specific data. For these cases, it may be necessary to use prognostic meteorological data in a regulatory modeling application.

b. The EPA has developed a processor, the MMIF (Mesoscale Model Interface Program) to process MM5 (Mesoscale Model 5) or WRF (Weather Research and Forecasting) model data for input into various models including AERMOD. MMIF can process data for input into AERMET or AERMOD for a single grid cell or multiple grid cells. MMIF output has been found to compare favorably against observed data (site-specific or NWS).[118] Specific guidance on processing MMIF for AERMOD can be found in reference 104. When using MMIF to process prognostic data for regulatory applications, the data should be processed to generate AERMET inputs and the data subsequently processed through AERMET for input into AERMOD. If an alternative method of processing data for input into AERMET is used, it must be approved by the appropriate reviewing authority (paragraph 3.0(b)).

8.4.5.2 Recommendations

a. *Prognostic model evaluation.* Appropriate effort should be devoted to the process of evaluating the prognostic meteorological data. The modeling data should be compared to NWS observational data in an effort to show that the data are accurately replicating the observed meteorological conditions of the time periods modeled. An operational evaluation of the modeling data for all model years (*i.e.*, statistical, graphical) should be completed.[93] The use of output from prognostic mesoscale meteorological models is contingent upon the concurrence with the appropriate reviewing authority (paragraph 3.0(b)) that the data are of acceptable quality, which can be demonstrated through statistical comparisons with meteorological observations aloft and at the surface at several appropriate locations.[93]

b. *Representativeness.* When processing MMIF data for use with AERMOD, the grid cell used for the dispersion modeling should be adequately spatially representative of the analysis domain. In most cases, this may be the grid cell containing the emission source of interest. Since the dispersion modeling may involve multiple sources and the domain may cover several grid cells, depending on grid resolution of the prognostic model, professional judgement may be needed to select the appropriate grid cell to use. In such cases, the selected grid cell should be adequately representative of the entire domain.

c. *Grid resolution.* The grid resolution of the prognostic meteorological data should be considered and evaluated appropriately, particularly for projects involving complex terrain. The operational evaluation of the modeling data should consider whether a finer grid resolution is needed to ensure that the data are representative. The use of output from prognostic mesoscale meteorological models is contingent upon the concurrence with the appropriate reviewing authority (paragraph 3.0(b)) that the data are of acceptable quality.

8.4.6 Treatment of Near-Calms and Calms

8.4.6.1 Discussion

a. Treatment of calm or light and variable wind poses a special problem in modeling applications since steady-state Gaussian plume models assume that concentration is inversely proportional to wind speed, depending on model formulations. Procedures have been developed to prevent the occurrence of overly conservative concentration estimates during periods of calms. These procedures acknowledge that a steady-state Gaussian plume model does not apply during calm conditions, and that our knowledge of wind patterns and plume behavior during these conditions does not, at present, permit the development of a better technique. Therefore, the procedures disregard hours which are identified as calm. The hour is treated as missing and a convention for handling missing hours is recommended. With the advent of the AERMINUTE processor, when processing NWS ASOS data, the inclusion of hourly averaged winds from AERMINUTE will, in some instances, dramatically reduce the number of calm and missing hours, especially when the ASOS wind are derived from a sonic anemometer. To alleviate concerns about low winds, especially those introduced with AERMINUTE, the EPA implemented a wind speed threshold in AERMET for use with ASOS derived winds.[96] Winds below the threshold will be treated as calms.

b. AERMOD, while fundamentally a steady-state Gaussian plume model, contains algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold. Required input to AERMET for site-specific data, the meteorological processor for AERMOD, includes a threshold wind speed and a reference wind speed. The threshold wind speed is typically the threshold of the instrument used to collect the wind speed data. The reference wind speed is selected by the model as the lowest level of non-missing wind speed and direction data where the speed is greater than the wind speed threshold, and the height of the measurement is between seven times the local surface roughness and 100 meters. If the only valid observation of the reference wind speed between these heights is less than the threshold, the hour is considered calm, and no concentration is calculated. None of the observed wind speeds in a measured wind profile that are less than the threshold speed are used in construction of the modeled wind speed profile in AERMOD.

8.4.6.2 Recommendations

a. Hourly concentrations calculated with steady-state Gaussian plume models using calms should not be considered valid; the wind and concentration estimates for these hours should be disregarded and considered to be missing. Critical concentrations for 3-, 8-, and 24-hour averages should be calculated by dividing the sum of the hourly concentrations for the period by the number of valid or non-missing hours. If the total number of valid hours is less than 18 for 24-hour averages, less than 6 for 8-hour averages or less than 3 for 3-hour averages, the total concentration should be divided by 18 for the 24-hour average, 6 for the 8-hour average and 3 for the 3-hour average. For annual averages, the sum of all valid hourly concentrations is divided by the number of non-calm hours during the year. AERMOD has been coded to implement these instructions. For hours that are calm or missing, the AERMOD hourly concentrations will be zero. For other models listed in appendix A, a post-processor computer program, CALMPRO[119] has been prepared, is available on the EPA's SCRAM website (section 2.3), and should be used.

b. Stagnant conditions that include extended periods of calms often produce high concentrations over wide areas for relatively long averaging periods. The standard steady-state Gaussian plume models are often not applicable to such situations. When stagnation conditions are of concern, other modeling techniques should be considered on a case-by-case basis (*see* also section 7.2.1.2).

c. When used in steady-state Gaussian plume models, measured site-specific wind speeds of less than 1 m/s but higher than the response threshold of the instrument should be input as 1 m/s; the corresponding wind direction should also be input. Wind observations below the response threshold of the instrument should be set to zero, with the input file in ASCII format. For input to AERMOD, no adjustment should be made to the site-specific wind data. For NWS ASOS data, especially data using the 1-minute ASOS winds, a wind speed threshold option is allowed with a recommended speed of 0.5 m/s.[94] When using prognostic data processed by MMIF, a 0.5 m/s threshold is also invoked by MMIF for input into AERMET. Observations with wind speeds less than the threshold are considered calm, and no concentration is calculated. In all cases involving steady-state Gaussian plume models, calm hours should be treated as missing, and concentrations should be calculated as in paragraph (a) of this subsection.

9.0 Regulatory Application of Models

9.1 Discussion

a. Standardized procedures are valuable in the review of air quality modeling and data analyses conducted to support SIP submittals and revisions, NSR, including PSD, or other EPA requirements to ensure consistency in their regulatory application. This section recommends procedures specific to NSR, including PSD, that facilitate some degree of standardization while at the same time allowing the flexibility needed to assure the technically best analysis for each regulatory application. For SIP attainment demonstrations, refer to the appropriate EPA guidance[51, 60] for the recommended procedures.

b. Air quality model estimates, especially with the support of measured air quality data, are the preferred basis for air quality demonstrations. A number of actions have been taken to ensure that the best air quality model is used correctly for each regulatory application and that it is not arbitrarily imposed.

- First, the *Guideline* clearly recommends that the most appropriate model be used in each case. Preferred models are identified, based on a number of factors, for many uses.
- Second, the preferred models have been subjected to a systematic performance evaluation and a peer scientific review. Statistical performance measures, including measures of difference (or residuals) such as bias, variance of difference and gross variability of the difference, and measures of correlation such as time, space, and time and space combined as described in section 2.1.1, were generally followed.
- Third, more specific information has been provided for considering the incorporation of new models into the *Guideline* (section 3.1) and the *Guideline* contains procedures for justifying the case-by-case use of alternative models and obtaining EPA approval (section 3.2).

The *Guideline*, therefore, provides objective methods that allow a determination to be made as to what air quality model or technique is most appropriate for a particular application.

c. Air quality modeling is the preferred basis for air quality demonstrations. Nevertheless, there are rare circumstances where the performance of the preferred air quality model may be shown to be less than reasonably acceptable or where no preferred air quality model, screening model or technique, or alternative model are suitable for the situation. In these unique instances, there is the possibility of assuring compliance and establishing emissions limits for an existing source solely on the basis of observed air quality data in lieu of an air quality modeling analysis. Comprehensive air quality monitoring in the vicinity of the existing source with proposed modifications will be necessary in these cases. The same attention should be given to the detailed analyses of the air quality data as would be applied to a model performance evaluation.

d. The current levels and forms of the NAAQS for the six criteria pollutants can be found on the EPA's NAAQS website at http://www.epa.gov/air/criteria.html. Under the CAA, the NAAQS are subjected to extensive review every 5 years and the standards, including the level and the form, may be revised as part of that review. The criteria pollutants have either long-term (annual or quarterly) and/or short-term (24-hour or less) forms that are not to be exceeded more than a certain frequency over a period of time (*e.g.*, no exceedance on a rolling 3-month average, no more than once per year, or no more than once per year averaged over 3 years), are averaged over a period of time (*e.g.*, an annual mean or an annual mean averaged over 3 years), or are some percentile that is averaged over a period of time (*e.g.*, annual 99th or 98th percentile averaged over 3 years). The 3-year period for ambient monitoring design values does not dictate the length of the data periods recommended for modeling (*i.e.*, 5 years of NWS meteorological data, at least 1 year of site-specific, or at least 3 years of prognostic meteorological data).

e. This section discusses general recommendations on the regulatory application of models for the purposes of NSR, including PSD permitting, and particularly for estimating design concentration(s), appropriately comparing these estimates to NAAQS and PSD increment, and developing emissions limits. Lastly, this section provides the criteria necessary for considering use of analysis based on measured ambient data in lieu of modeling as the sole basis for demonstrating compliance with NAAQS and PSD increments.

9.2 Recommendations

9.2.1 Modeling Protocol

a. Every effort should be made by the appropriate reviewing authority (paragraph 3.0(b)) to meet with all parties involved in either a SIP submission or revision or a PSD permit application prior to the start of any work on such a project. During this meeting, a protocol should be established between the preparing and reviewing parties to define the procedures to be followed, the data to be collected, the model to be used, and the analysis of the source and concentration data to be performed. An example of the content for such an effort is contained in the Air Quality Analysis Checklist posted on the EPA's SCRAM website (section 2.3). This checklist suggests the appropriate level of detail to assess the air quality resulting from the proposed action. Special cases may require additional data collection or analysis and this should be determined and agreed upon at this pre-application meeting. The protocol should be written and agreed upon by the parties concerned, although it is not intended that this protocol be a binding, formal legal document. Changes in such a protocol or deviations from the protocol are often necessary as the data collection and analysis progresses. However, the protocol establishes a common understanding of how the demonstration required to meet regulatory requirements will be made. 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.

9.2.2 Design Concentration and Receptor Sites

a. Under the PSD permitting program, an air quality analysis for criteria pollutants is required to demonstrate that emissions from the construction or operation of a proposed new source or modification will not cause or contribute to a violation of the NAAQS or PSD increments.

i. For a NAAQS assessment, the design concentration is the combination of the appropriate background concentration (section 8.3) with the estimated modeled impact of the source. The NAAQS design concentration is then compared to the applicable NAAQS.

ii. For a PSD increment assessment, the design concentration includes impacts after the appropriate baseline date from all increment consuming and increment expanding sources. The PSD increment design concentration is then compared to the applicable PSD increment.

b. The specific form of the NAAQS for the pollutant(s) of concern will also influence how the background and modeled data should be combined for appropriate comparison with the respective NAAQS in such a modeling demonstration. Given the potential for revision of the form of the NAAQS and the complexities of combining background and modeled data, specific details on this process can be found in applicable modeling guidance available on the EPA's SCRAM website (section 2.3). Modeled concentrations should not be rounded before comparing the resulting design concentration to the NAAQS or PSD increments. Ambient monitoring and dispersion modeling address different issues and needs relative to each aspect of the overall air quality assessment. For the NAAQS and PSD increment modeling assessments, receptors should be excluded from areas to which the public does not have physical or legal access at a given location for the time periods or frequencies associated with the NAAQS of interest.

c. The PSD increments for criteria pollutants are listed in 40 CFR 52.21(c) and 40 CFR 51.166(c). For short-term increments, these maximum allowable increases in pollutant concentrations may be exceeded once per year at each site, while the annual increment may not be exceeded. The highest, second-highest increase in estimated concentrations for the short-term averages as determined by a model should be less than or equal to the permitted increment. The modeled annual averages should not exceed the increment.

d. Receptor sites for refined dispersion modeling should be located within the modeling domain (section 8.1). In designing a receptor network, the emphasis should be placed on receptor density and location, not total number of receptors. Typically, the density of receptor sites should be progressively more resolved near the new or modifying source, areas of interest, and areas with the highest concentrations with sufficient detail to determine where possible violations of a NAAQS or PSD increment are most likely to occur. The placement of receptor sites should be determined on a case-by-case basis, taking into consideration the source characteristics, topography, climatology, and monitor sites. Locations of particular importance include: (1) the area of maximum impact of the point source; (2) the area of maximum impact of nearby sources; and (3) the area where all sources combine to cause maximum impact. Depending on the complexities of the source and the environment to which the source is located, a dense array of receptors may be required in some cases. In order to avoid unreasonably large computer runs due to an excessively large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors more resolved nearby the new or modifying source and over areas of interest. The second model run would modify the receptor network from the first model run with a denser array of receptors in areas showing potential for high concentrations and possible violations, as indicated by the results of the first model run. Accordingly, the EPA neither anticipates nor encourages that numerous iterations of modeling runs be made to continually refine the receptor network.

9.2.3 NAAQS and PSD Increments Compliance Demonstrations for New or Modified Sources

a. As described in this subsection, the recommended procedure for conducting either a NAAQS or PSD increment assessment under PSD permitting is a multi-stage approach that includes the following two stages:

i. The first stage is referred to as a single-source impact analysis, since only the new or modifying source is considered in the analysis. There are two possible levels of detail in conducting a single-source impact analysis with the model user beginning with use of a screening model and proceeding to use of a refined model as necessary.

ii. The second stage is referred to as a cumulative impact analysis, since it takes into account all sources affecting the air quality in an area. In addition to the project source impact, it includes consideration of background, which includes contributions from natural, nearby, and unknown sources.

b. Each stage involves increasing complexity and details, as required to fully demonstrate a new or modifying source will not cause of contribution to a violation of any NAAQS or PSD increment. As such, starting with a single-source impact analysis may alleviate the need for a more time consuming and comprehensive cumulative modeling analysis.

c. The single-source impact analysis, or first stage of an air quality analysis, begins by determining the potential of a proposed new or modifying source to cause or contribute to a NAAQS or PSD increment violation. In certain circumstances, a screening model or technique may be used instead of the preferred model because it will provide estimated worst-case ambient impacts from the proposed new or modifying source. If these worst case ambient concentration estimates indicate that there will not be a significant impact, then the analysis is sufficient for the required demonstration under PSD. If the ambient concentration estimates indicate that significant impacts may occur, then the use of a refined model to estimate the source's impact should be pursued. The refined modeling analysis should use a model or technique consistent with the *Guideline* (either a preferred model or technique or an alternative model or technique) and follow the requirements and recommendations for model inputs outlined in section 8. If the estimated ambient concentrations indicate that there will not be a significant impact, then the analysis is generally sufficient to demonstrate that the source will not cause or contribute to an exceedance. However, if the concentration estimates from the refined modeling analysis indicate that significant impacts may occur, then a cumulative impact analysis should be undertaken. The receptors that indicate the location of significant impacts should be used to define the modeling domain for use in the cumulative impact analysis (section 8.2.2).

d. The cumulative impact analysis, or the second stage of an air quality analysis, should be conducted with the same refined model or technique to characterize the project source and then include the appropriate background concentrations (section 8.3). The resulting design concentrations are used to determine whether the source will cause or contribute to a NAAQS or PSD increment violation. This determination should be based on: (1) The appropriate design concentration for each applicable NAAQS (and averaging period); and (2) the significance of the source's contribution, in a temporal and spatial sense, to any modeled violation, *i.e.*, where and when the predicted design concentration is greater than the NAAQS. For PSD increment, the cumulative impact analysis should also consider the amount of the air quality increment that has already been consumed by other sources, or, conversely, whether increment has expanded relative to the baseline concentration. Therefore, the applicant should model the existing or permitted nearby increment-consuming and increment-expanding sources, rather than using past modeling analyses of those sources as part of background concentration. This would permit the use of newly acquired data or improved modeling techniques if such data and/or techniques have become available since the last source was permitted.

9.2.3.1 Considerations in Developing Emissions Limits

a. Emissions limits and resulting control requirements should be established to provide for compliance with each applicable NAAQS (and averaging period) and PSD increment. It is possible that multiple emissions limits will be required for a source to demonstrate compliance with several criteria pollutants (and averaging periods) and PSD increments. Case-by-case determinations must be made as to the appropriate form of the limits, *i.e.*, whether the emissions limits restrict the emission factor (*e.g.*, limiting lb/MMBTU), the emission rate (*e.g.*, lb/hr), or both. The appropriate reviewing authority (paragraph 3.0(b)) and appropriate EPA guidance should be consulted to determine the appropriate emissions limits on a case-by-case basis. As discussed in Section 8.2.2(f), there are approaches available to accommodate emissions variability in developing emission limits.

~~9.2.4~~9.2.5 Use of Measured Data in Lieu of Model Estimates

a. As described throughout the *Guideline*, modeling is the preferred method for demonstrating compliance with the NAAQS and PSD increments and for determining the most appropriate emissions limits for new and existing sources. When a preferred model or adequately justified and approved alternative model is available, model results, including the appropriate background, are sufficient for air quality demonstrations and establishing emissions limits, if necessary. In instances when the modeling technique available is only a screening technique, the addition of air quality monitoring data to the analysis may lend credence to the model results. However, air quality monitoring data alone will normally not be acceptable as the sole basis for demonstrating compliance with the NAAQS and PSD increments or for determining emissions limits.

b. There may be rare circumstances where the performance of the preferred air quality model will be shown to be less than reasonably acceptable when compared with air quality monitoring data measured in the vicinity of an existing source. There may also be a monitor that represents the impact of a nearby source, such that the source being permitted is modeled, but the nearby source impact is more accurately accounted for by the data from the monitor than through modeling. Additionally, there may not be an applicable preferred air quality model, screening technique, or justifiable alternative model suitable for the situation. In these unique instances, there may be the possibility of establishing emissions limits and demonstrating compliance with the NAAQS and PSD increments solely on the basis of analysis of observed air quality data in lieu of an air quality modeling analysis. However, only in the case of a modification to an existing source should air quality monitoring data alone be a basis for determining adequate emissions limits or for demonstration that the modification will not cause or contribute to a violation of any NAAQS or PSD increment.

c. The following items should be considered prior to the acceptance of an analysis of measured air quality data as the sole basis for an air quality demonstration or determining an emissions limit:

i. Does a monitoring network exist for the pollutants and averaging times of concern in the vicinity of the existing source?
ii. Has the monitoring network been designed to locate points of maximum concentration?
iii. Do the monitoring network and the data reduction and storage procedures meet EPA monitoring and quality assurance requirements?
iv. Do the dataset and the analysis allow impact of the most important individual sources to be identified if more than one source or emission point is involved?
v. Is at least one full year of valid ambient data available?
vi. Can it be demonstrated through the comparison of monitored data with model results that available air quality models and techniques are not applicable?

d. Comprehensive air quality monitoring in the area affected by the existing source with proposed modifications will be necessary in these cases. Additional meteorological monitoring may also be necessary. The appropriate number of air quality and meteorological monitors from a scientific and technical standpoint is a function of the situation being considered. The source configuration, terrain configuration, and meteorological variations all have an impact on number and optimal placement of monitors. Decisions on the monitoring network appropriate for this type of analysis can only be made on a case-by-case basis.

e. Sources should obtain approval from the appropriate reviewing authority (paragraph 3.0(b)) and the EPA Regional Office for the monitoring network prior to the start of monitoring. A monitoring protocol agreed to by all parties involved is necessary to assure that ambient data are collected in a consistent and appropriate manner. The design of the network, the number, type, and location of the monitors, the sampling period, averaging time as well as the need for meteorological monitoring or the use of mobile sampling or plume tracking techniques, should all be specified in the protocol and agreed upon prior to start-up of the network.

f. Given the uniqueness and complexities of these rare circumstances, the procedures can only be established on a case-by-case basis for analyzing the source's emissions data and the measured air quality monitoring data and for projecting with a reasoned basis the air quality impact of a proposed modification to an existing source in order to demonstrate that emissions from the construction or operation of the modification will not cause or contribute to a violation of the applicable NAAQS and PSD increment, and to determine adequate emissions limits. The same attention should be given to the detailed analyses of the air quality data as would be applied to a comprehensive model performance evaluation. In some cases, the monitoring data collected for use in the performance evaluation of preferred air quality models, screening technique, or existing alternative models may help inform the development of a suitable new alternative model. Early coordination with the appropriate reviewing authority (paragraph 3.0(b)) and the EPA Regional Office is fundamental with respect to any potential use of measured data in lieu of model estimates.