ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 51

[EPA–HQ–OAR–2015–0310; FRL–9956–23–OAR]

RIN 2060–AS54

Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches To Address Ozone and Fine Particulate Matter

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: In this action, the Environmental Protection Agency (EPA) promulgates revisions to the *Guideline on Air Quality Models* (''*Guideline*''). The *Guideline* provides EPA's preferred models and other recommended techniques, as well as guidance for their use in estimating ambient concentrations of air pollutants. It is incorporated into the EPA's regulations, satisfying a requirement under the Clean Air Act (CAA) for the EPA to specify with reasonable particularity models to be used in the Prevention of Significant Deterioration (PSD) program. This action includes enhancements to the formulation and application of the EPA's preferred near-field dispersion modeling system, AERMOD (American Meteorological Society (AMS)/EPA Regulatory Model), and the incorporation of a tiered demonstration approach to address the secondary chemical formation of ozone and fine particulate matter (PM$_{2.5}$) associated with precursor emissions from single sources. The EPA is changing the preferred status of and removing several air quality models from appendix A of the *Guideline.* The EPA is also making various editorial changes to update and reorganize information throughout the *Guideline* to streamline the compliance assessment process.

DATES: This rule is effective February 16, 2017. For all regulatory applications covered under the *Guideline,* except for transportation conformity, the changes to the appendix A preferred models and revisions to the requirements and recommendations of the *Guideline* must be integrated into the regulatory processes of respective reviewing authorities and followed by applicants by no later than January 17, 2018. During the 1-year period following promulgation, protocols for modeling analyses based on the 2005 version of the *Guideline,* which are submitted in a timely manner, may be approved at the discretion of the appropriate reviewing authority.

This final rule also starts a 3-year transition period that ends on January 17, 2020 for transportation conformity purposes. Any refined analyses that are started before the end of this 3-year period, with a preferred appendix A model based on the 2005 version of the *Guideline,* can be completed after the end of the transition period, similar to implementation of the transportation conformity grace period for new emissions models. See the discussion in section IV.A.4 of this preamble for details on how this transition period will be implemented.

All applicants are encouraged to consult with their respective reviewing authority as soon as possible to assure acceptance of their modeling protocols and/or modeling demonstration during either of these periods.

ADDRESSES: The EPA has established a docket for this action under Docket ID No. EPA–HQ–OAR–2015–0310. All documents in the docket are listed on the *https://www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.,* Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available electronically through *https://www.regulations.gov.*

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SUPPLEMENTARY INFORMATION:

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The following topics are discussed in this preamble:

I. General Information

A. Does this action apply to me?

This action applies to federal, state, territorial, local, and tribal air quality management agencies that conduct air quality modeling as part of State Implementation Plan (SIP) submittals and revisions, New Source Review (NSR) permitting (including new or modifying industrial sources under Prevention of Significant Deterioration (PSD)), conformity, and other air quality assessments required under EPA regulation. Categories and entities potentially regulated by this action include:

Category	NAICS [a] code
Federal/state/territorial/local/tribal government	924110

[a] North American Industry Classification System.

B. Where can I get a copy of this rule and related information?

In addition to being available in the docket, electronic copies of the rule and related materials will also be available on the Worldwide Web (WWW) through the EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) Web site at *https://www.epa.gov/scram.*

C. Judicial Review

This final rule is nationally applicable, as it revises the *Guideline on Air Quality Models,* 40 CFR part 51, appendix W. Under section 307(b)(1) of the Clean Air Act (CAA), judicial review of this final rule is available by filing a petition for review in the U.S. Court of Appeals for the District of Columbia Circuit by March 20, 2017. Moreover, under section 307(b)(2) of the CAA, the requirements established by this action may not be challenged separately in any civil or criminal proceedings brought by the EPA to enforce these requirements. This rule is also subject to section 307(d) of the CAA.

D. List of Acronyms

AEDT Aviation Environmental Design Tool
AERMET Meteorological data preprocessor for AERMOD
AERMINUTE Pre-processor to AERMET to read 1-minute ASOS data to calculate hourly average winds for input into AERMET
AERMOD American Meteorological Society (AMS)/EPA Regulatory Model
AERSCREEN Program to run AERMOD in screening mode
AERSURFACE Land cover data tool in AERMET
AQRV Air Quality Related Value
AQS Air Quality System
ARM Ambient Ratio Method
ARM2 Ambient Ratio Method 2
ASOS Automated Surface Observing Stations
ASTM American Society for Testing and Materials
B_o Bowen ratio
BART Best available retrofit technology
BID Buoyancy-induced dispersion
BLP Buoyant Line and Point Source model
BOEM Bureau of Ocean Energy Management
BPIPPRM Building Profile Input Program for PRIME
BUKLRN Bulk Richardson Number
CAA Clean Air Act
CAL3QHC Screening version of the CALINE3 model
CAL3QHCR Refined version of the CALINE3 model
CALINE3 CAlifornia LINE Source Dispersion Model
CALMPRO Calms Processor
CALPUFF California Puff model
CALTRANS99 California Department of Transportation Highway 99 Tracer Experiment
CAMx Comprehensive Air Quality Model with Extensions
CFR Code of Federal Regulations
CMAQ Community Multiscale Air Quality
CO Carbon monoxide
CTDMPLUS Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations
CTSCREEN Screening version of CTDMPLUS
CTM Chemical transport model
$d\theta/dz$ Vertical potential temperature gradient
DT Temperature difference
EDMS Emissions and Dispersion Modeling System
EPA Environmental Protection Agency
FAA Federal Aviation Administration
FLAG Federal Land Managers' Air Quality Related Values Work Group Phase I Report
FLM Federal Land Manager
GEP Good engineering practice
GUI Graphical user interface
IBL Inhomogeneous boundary layer
ISC Industrial Source Complex model
IWAQM Interagency Workgroup on Air Quality Modeling
km kilometer
L Monin-Obukhov length
m meter
m/s meter per second
MAKEMET Program that generates a site-specific matrix of meteorological conditions for input to AERMOD
MAR Minimum ambient ratio
MCH Model Clearinghouse
MCHISRS Model Clearinghouse Information Storage and Retrieval System
MERPs Model Emissions Rates for Precursors
METPRO Meteorological Processor for dispersion models
MM5 Mesoscale Model 5
MMIF Mesoscale Model Interface program
MPRM Meteorological Processor for Regulatory Models
NAAQS National Ambient Air Quality Standards
NCEI National Centers for Environmental Information
NH_3 Ammonia
NO Nitric oxide
NOAA National Oceanic and Atmospheric Administration
NO_X Nitrogen oxides
NO_2 Nitrogen dioxide
NSR New Source Review
NTI National Technical Information Service
NWS National Weather Service
OCD Offshore and Coastal Dispersion Model
OCS Outer Continental Shelf
OCSLA Outer Continental Shelf Lands Act
OLM Ozone Limiting Method
PCRAMMET Meteorological Processor for dispersion models
P–G stability Pasquill-Gifford stability
$PM_{2.5}$ Particles less than or equal to 2.5 micrometers in diameter
PM_{10} Particles less than or equal to 10 micrometers in diameter
PRIME Plume Rise Model Enhancements algorithm
PSD Prevention of Significant Deterioration
PVMRM Plume Volume Molar Ratio Method
r Albedo
RHC Robust Highest Concentration
RLINE Research LINE source model for near-surface releases
SCICHEM Second-order Closure Integrated Puff Model
SCRAM Support Center for Regulatory Atmospheric Modeling
SCREEN3 A single source Gaussian plume model which provides maximum ground-level concentrations for point, area, flare, and volume sources
SDM Shoreline Dispersion Model
SILs Significant impact levels
SIP State Implementation Plan
SMAT Software for Model Attainment Test
SO_2 Sulfur dioxide
SRDT Solar radiation/delta-T method
TSD Technical support document
u Values for wind speed
u* Surface friction velocity
VOC Volatile organic compound
w* Convective velocity scale
WRF Weather Research and Forecasting model
z_i Mixing height
Z_o Surface roughness
Z_{ic} Convective mixing height
Z_{im} Mechanical mixing height
σ_v, σ_w Horizontal and vertical wind speeds

II. Background

The *Guideline* is used by the EPA, other federal, state, territorial, local, and tribal air quality agencies, and industry to prepare and review new or modified source permits, SIP submittals or revisions, conformity, and other air quality assessments required under the CAA and EPA regulations. The *Guideline* serves as a means by which national consistency is maintained in air quality analyses for regulatory activities under 40 CFR (Code of Federal Regulations) 51.112, 51.117, 51.150, 51.160, 51.165, 51.166, 52.21, 93.116, 93.123, and 93.150.

The EPA originally published the *Guideline* in April 1978 (EPA–450/2–78–027), and it was incorporated by reference in the regulations for the PSD program in June 1978. The EPA revised the *Guideline* in 1986 (51 FR 32176), and updated it with supplement A in 1987 (53 FR 32081), supplement B in July 1993 (58 FR 38816), and supplement C in August 1995 (60 FR 40465). The EPA published the *Guideline* as appendix W to 40 CFR part 51 when the EPA issued supplement B. The EPA republished the *Guideline* in August 1996 (61 FR 41838) to adopt the CFR system for labeling paragraphs. Subsequently, the EPA revised the *Guideline* on April 15, 2003 (68 FR

18440), to adopt CALPUFF as the preferred model for long-range transport of emissions from 50 to several hundred kilometers (km) and to make various editorial changes to update and reorganize information and remove obsolete models. The EPA further revised the *Guideline* on November 9, 2005 (70 FR 68218), to adopt AERMOD as the preferred model for near-field dispersion of emissions for distances up to 50 km. The publication and incorporation of the *Guideline* into the EPA's PSD regulations satisfies the requirement under CAA section 165(e)(3) for the EPA to promulgate regulations that specify with reasonable particularity models to be used under specified sets of conditions for purposes of the PSD program.

On July 29, 2015, we proposed revisions to the *Guideline* in the **Federal Register** (80 FR 45340). The proposed revisions to the *Guideline* and preferred models are based upon stakeholder input received during the Tenth Conference on Air Quality Modeling. These proposed revisions were presented at the Eleventh Conference on Air Quality Modeling that included the public hearing for the proposed action. The conferences and public hearing are briefly described in section III of this preamble.

Section IV provides a brief discussion of comments received and our responses that support the changes to the *Guideline* being finalized through this action. A more comprehensive discussion of the public comments received and our responses are provided in the Response to Comments document that is included in the docket for this action.

III. The Tenth and Eleventh Conferences on Air Quality Modeling and Public Hearing

To inform the development of our proposed revisions to the *Guideline* and in compliance with CAA section 320, we held the Tenth Conference on Air Quality Modeling in March 2012. The conference addressed updates on: The regulatory status and future development of AERMOD and CALPUFF, review of the Mesoscale Model Interface (MMIF) prognostic meteorological data processing tool for dispersion models, draft modeling guidance for compliance demonstrations of the $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS), modeling for compliance demonstration of the 1-hour nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) NAAQS, and new and emerging models/techniques for future consideration under the *Guideline* to address single-source modeling for ozone and secondary $PM_{2.5}$, as well as long-range transport and chemistry. Based on comments received from stakeholders at the Tenth Modeling Conference, ''Phase 3'' of the Interagency Workgroup on Air Quality Modeling (IWAQM) was formalized in June 2013 to provide additional guidance for modeling single-source impacts on secondarily formed pollutants (*e.g.,* ozone and $PM_{2.5}$) in the near-field and for long-range transport. A transcript of the conference proceedings and a summary of the public comments received are available in the docket for the Tenth Modeling Conference.[1] Additionally, all of the material associated with this conference are available on the EPA's SCRAM Web site at *https://www3.epa.gov/ttn/scram/10thmodconf.htm.*

The Eleventh Conference on Air Quality Modeling was held August 12–13, 2015, in continuing compliance with CAA section 320. The Eleventh Modeling Conference included the public hearing for this action. The conference began with a thorough overview of the proposed revisions to the *Guideline,* including presentations from EPA staff on the formulation updates to the preferred models and the research and technical evaluations that support these and other revisions. Specifically, there were presentations summarizing the proposed updates to the AERMOD modeling system, replacement of CALINE3 with AERMOD for modeling of mobile sources, incorporation of prognostic meteorological data for use in dispersion modeling, the proposed screening approach for long-range transport for NAAQS and PSD increments assessments with use of CALPUFF as a screening technique rather than an EPA-preferred model, the proposed 2-tiered screening approach to address ozone and $PM_{2.5}$ in PSD compliance demonstrations, the status and role of the Model Clearinghouse, and updates to procedures for single-source and cumulative modeling analyses (*e.g.,* modeling domain, source input data, background data, and compliance demonstration procedures).

At the conclusion of these presentations, the public hearing on the proposed revisions to the *Guideline* was convened. The public hearing was held on the second half of the first day and on the second day of the conference. There were 26 presentations by stakeholders and interested parties. The EPA presentations and the presentations from the public hearing are provided in the docket for this action. A transcript of the conference proceedings is also available in the docket. Additionally, all of the material associated with the Eleventh Modeling Conference and the public hearing are available on the EPA's SCRAM Web site at *https://www3.epa.gov/ttn/scram/11thmodconf.htm.*

IV. Discussion of Public Comments on the Proposed Changes to the Guideline

In this action, the EPA is finalizing two types of revisions to the *Guideline.* The first type involves substantive changes to address various topics, including those presented and discussed at the Tenth and Eleventh Modeling Conferences. These revisions to the *Guideline* include enhancements to the formulation and application of the EPA's preferred dispersion modeling system, AERMOD, and the incorporation of a tiered demonstration approach to address the secondary chemical formation of ozone and $PM_{2.5}$ associated with precursor emissions from single sources. The second type of revision involves editorial changes to update and reorganize information throughout the *Guideline.* These latter revisions are not intended to meaningfully change the substance of the *Guideline,* but rather to make the *Guideline* easier to use and to streamline the compliance assessment process.

The EPA recognizes that the scope and extent of the final changes to the *Guideline* may not address all of the current concerns identified by the stakeholder community or emerging science issues. The EPA is committed to ensuring in the future that the *Guideline* and associated modeling guidance reflect the most up-to-date science and will provide appropriate and timely updates. Adhering to the existing procedures under CAA section 320, which requires the EPA to conduct a conference on air quality modeling at least every 3 years, the Twelfth Conference on Air Quality Modeling will occur within the next 2 years to provide a public forum for the EPA and the stakeholder community to engage on technical issues, introduce new air quality modeling research and techniques, and discuss recommendations on future areas of air quality model development and subsequent revisions to the *Guideline.* A formal notice announcing the next Conference on Air Quality Modeling will be published in the **Federal Register** at the appropriate time and will provide information to the stakeholder community on how to register to attend and/or present at the conference.

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[1] *See* Docket ID No. EPA–HQ–OAR–2015–0310.

A. Final Action

In this section, we offer summaries of the substantive comments received and our responses and explain the final changes to the *Guideline* in terms of the main technical and policy concerns addressed by the EPA. A more comprehensive discussion of the public comments received and our responses is provided in the Response to Comments document located in the docket for this action.

Air quality modeling involves estimating ambient concentrations using scientific methodologies selected from a range of possible methods, and should utilize the most advanced practical technology that is available at a reasonable cost to users, keeping in mind the intended uses of the modeling and ensuring transparency to the public. With these revisions, we believe that the *Guideline* continues to reflect scientific advances in the field and balances these important considerations for regulatory assessments. This action amends appendix W of 40 CFR part 51 as detailed below:

1. Clarifications To Distinguish Requirements From Recommendations

We proposed revisions to the *Guideline* to provide clarity in distinguishing requirements from recommendations while noting the continued flexibilities provided within the *Guideline,* including but not limited to use and approval of alternative models. The vast majority of the public comments were supportive of the overall proposed reorganization and revisions to the regulatory text. There were only a few comments specific to the distinction between requirements and recommendations. All but one of these comments commended the EPA for providing this level of clarity of what is required in regulatory modeling demonstrations and where there is appropriate flexibility in the technique or approach. One comment expressed a concern that allowing for flexibility is critical when regulations, standards, and modeling techniques are constantly evolving. In this final action, the EPA reaffirms that significant flexibility and adaptability remain in the *Guideline,* while the revisions we are adopting serve to provide clarity in portions of the *Guideline* that have caused confusion in the past.

As discussed in the preamble to the proposed rule, the EPA's PSD permitting regulations specify that ''[a]ll applications of air quality modeling involved in this subpart shall be based on the applicable models, data bases, and other requirements specified in appendix W of this part (*Guideline on Air Quality Models*).'' 40 CFR 51.166(l)(1); see also 40 CFR 52.21(l)(1). The ''applicable models'' are the preferred models listed in appendix A to appendix W to 40 CFR part 51. However, there was some ambiguity in the past with respect to the ''other requirements'' specified in the *Guideline* that must be used in PSD permitting analysis and other regulatory modeling assessments.

Ambiguity could arise because the *Guideline* generally contains ''recommendations'' and these recommendations are expressed in non-mandatory language. For instance, the *Guideline* frequently uses ''should'' and ''may'' rather than ''shall'' and ''must.'' This approach is generally preferred throughout the *Guideline* because of the need to exercise expert judgment in air quality analysis and the reasons discussed in the *Guideline* that ''dictate against a strict modeling 'cookbook'.'' 40 CFR part 51, appendix W, section 1.0(c).

Considering the non-mandatory language used throughout the *Guideline,* the EPA's Environmental Appeals Board observed:

> Although appendix W has been promulgated as codified regulatory text, appendix W provides permit issuers broad latitude and considerable flexibility in application of air quality modeling. Appendix W is replete with references to ''recommendations,'' ''guidelines,'' and reviewing authority discretion.

In Re Prairie State Generating Company, 13 E.A.D. 1, 99 (EAB 2005) (internal citations omitted).

Although this approach appears throughout the *Guideline,* there are instances where the EPA does not believe permit issuers should have broad latitude. Some principles of air quality modeling described in the *Guideline* must always be applied to produce an acceptable analysis. Thus, to promote clarity in the use and interpretation of the revised *Guideline,* we are finalizing the specific use of mandatory language, as proposed, along with references to ''requirements,'' where appropriate, to distinguish requirements from recommendations in the application of models for regulatory purposes.

2. Updates to EPA's AERMOD Modeling System

In our proposed action, we invited comments on the proposed scientific updates to the regulatory version of the AERMOD modeling system, including:

1. A proposed ''ADJ_U*'' option incorporated in AERMET to adjust the surface friction velocity (u*) to address issues with AERMOD model tendency to overprediction from some sources under stable, low wind speed conditions.
2. A proposed ''LOWWIND3'' option in AERMOD to address issues with model tendency to overprediction under low wind speed conditions. The low wind option increases the minimum value of the lateral turbulence intensity (sigma-v) from 0.2 to 0.3 and adjusts the dispersion coefficient to account for the effects of horizontal plume meander on the plume centerline concentration. It also eliminates upwind dispersion, which is incongruous with a straight-line, steady-state plume dispersion model, such as AERMOD.
3. Modifications to AERMOD formulation to address issues with model tendency to overprediction for applications involving relatively tall stacks located near relatively small urban areas.
4. Proposed regulatory options in AERMOD to address plume rise for horizontal and capped stacks based on the July 9, 1993, Model Clearinghouse memorandum,[2] with adjustments to account for the Plume Rise Model Enhancements (PRIME) algorithm for sources subject to building downwash.
5. A proposed buoyant line source option, based on the Buoyant Line and Point Source (BLP) model, incorporated in AERMOD.
6. Proposed updates to the NO_2 Tier 2 and Tier 3 screening techniques coded within AERMOD.

The EPA's final action related to each of these proposed updates is discussed below.

Incorporation of the ADJ_U* Option Into AERMET

The EPA has integrated the ADJ_U* option into the AERMET meteorological processor for AERMOD to address issues with model overprediction of ambient concentrations from some sources associated with underprediction of the surface friction velocity (u*) during light wind, stable conditions. The proposed update to AERMET included separate ADJ_U* algorithms for applications with and without the Bulk Richardson Number (BULKRN) option in AERMET. The ADJ_U* option with BULKRN utilizes measured vertical temperature difference data (*i.e.,* delta-T data) and is based on Luhar and Rayner (2009, BLM v.132). The ADJ_U*

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[2] U.S. Environmental Protection Agency, 1993. Proposal for Calculating Plume Rise for Stacks with Horizontal Releases or Rain Caps for Cookson Pigment, Newark, New Jersey. Memorandum dated July 9, 1993, Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www3.epa.gov/ttn/scram/guidance/mch/new_mch/R1076_TIKVART_9_JUL_93.pdf.*

option without BULKRN does not utilize delta-T data and is based on Qian and Venkatram (2011, BLM v. 138). These studies also include meteorological evaluations of predicted versus observed values of u*, which demonstrate improved skill in predicting u* during stable light wind conditions, and we consider these meteorological evaluations as key components of the overall technical assessment of these model formulation changes.

The majority of public comments supported the adoption of the ADJ_U* option in AERMET, while a few commenters expressed concern regarding the potential for the ADJ_U* option to underestimate ambient concentrations. Some commenters also expressed concern regarding the appropriateness of the field study databases used in the EPA model evaluations. We acknowledge the issues and potential challenges associated with conducting field studies for use in model performance evaluations, especially during stable light wind conditions, given the potentially high degree of variability that may exist across the modeling domain and the increased potential for microscale influences on plume transport and dilution. This variability is one of the reasons that we discourage placing too much weight on modeled versus predicted concentrations paired in time and space in model performance evaluations. This also highlights the advantages of conducting field studies that utilize circular arcs of monitors at several distances to minimize the potential influence of uncertainties associated with the plume transport direction on model-to-monitor comparisons. The 1974 Idaho Falls, Idaho, and 1974 Oak Ridge, Tennessee, field studies,[3] [4] conducted by the National Oceanic and Atmospheric Administration (NOAA), are two of the key databases included in the evaluation of the ADJ_U* option in AERMET (as well as the LOWWIND3 option in AERMOD), and both utilized circular arcs of monitors at 100 meter (m), 200 m, and 400 m downwind of the tracer release point.

Initial evaluations of the ADJ_U* option in AERMET and LOWWIND options in AERMOD were first presented as ''beta'' options in appendix F of the AERMOD User's Guide Addendum for version 12345. This included results for the Idaho Falls and Oak Ridge field studies. Updated evaluations based on these NOAA studies were included in the AERMOD User's Guide Addendum for v15181, along with additional evaluations for the Lovett database involving a tall stack with nearby complex terrain. Additional evaluations of these proposed modifications to AERMET and AERMOD were also presented at the Eleventh Modeling Conference, including an evaluation based on the 1993 Cordero Mine PM_{10} field study in Wyoming, as summarized in the Response to Comments document.

One commenter provided a detailed modeling assessment of the proposed ADJ_U* option in AERMET (as well as the proposed LOWWIND3 option in AERMOD) across a number of field studies to support their position that the proposed model updates will ''reduce model accuracy'' and ''in some cases quite significantly reduce[s] modeled impacts, particularly so in the case of the Tracy validation study data.'' The EPA's review of the modeling results provided by the commenter indicated almost no influence of the ADJ_U* option on those field studies associated with tall stacks in flat terrain, including the Baldwin and Kincaid field studies. These results are expected since the ''worst-case'' meteorological conditions for tall stacks in flat terrain generally occur during daytime convective conditions that are not affected by the ADJ_U* option. In addition, the commenter's modeling results presented for the Lovett field study, a tall stack with nearby complex terrain, appear to show improved performance (with less underprediction) with the ADJ_U* option as compared to the default option in AERMET, thereby supporting use of the ADJ_U* option in appropriate situations.

The commenter also stated that the issue of underprediction with the ADJ_U* option is ''particularly so in the case of the Tracy validation study.'' The Tracy field study involved a tall stack located with nearby terrain similar to the Lovett field study; however, the Tracy field study differs from the Lovett and other complex terrain field studies in that Tracy had the most extensive set of site-specific meteorological data, including several levels of wind speed, wind direction, ambient temperature, and turbulence parameters (*i.e.,* sigma-theta and/or sigma-w), extending from 10 m above ground up to 400 m above ground for some parameters. The Tracy field study also included the largest number of ambient monitors of any complex terrain study used in evaluating AERMOD performance, including 106 monitors extending across a domain of about 75 square kilometers, and used sulfur hexafluoride (SF_6) as a tracer which reduces uncertainty in evaluating model performance by minimizing the influence of background concentrations on the model-to-monitor comparisons. The EPA's review of the commenter's results for the Tracy database confirms their finding of a bias toward underprediction by almost a factor of two with the ADJ_U* option in AERMET, compared to relatively unbiased results with the default option in AERMET based on the full set of meteorological inputs. However, there was no diagnostic performance evaluation included with the commenter's analysis that could provide the necessary clarity regarding the potential connection between the ADJ U* option and cause for the bias to underpredict concentrations.

After proposal, the EPA received several requests through its Model Clearinghouse (MCH) for alternative model approval of the ADJ U* option under section 3.2.2 of the *Guideline.* The EPA issued two MCH concurrences on February 10, 2016, for the Donlin Gold, LLC mining facility in EPA Region 10 (*i.e.,* ground level, fugitive emissions of particulate matter from sources with low release heights during periods of low-wind/stable conditions), and on April 29, 2016, for the Schiller Station facility in EPA Region 1 (*i.e.,* SO_2 emissions from tall stack sources with impacts on distant complex terrain, during low-wind/stable conditions). In both cases, the request memoranda from the EPA Regions to the MCH noted the potential for underprediction by AERMOD with the ADJ U* option in situations where turbulence data from site-specific meteorological data inputs were also used. Through the MCH concurrence for each case, the EPA acknowledged the potential for this underprediction and effectively communicated to the stakeholder community that these turbulence data were not used in the approved alternative model. There was no detailed diagnostic performance evaluation included with the MCH requests to provide insights regarding the potential connection between the ADJ U* option and use of on-site turbulence data.

To evaluate the public comments in light of these MCH concurrences, the EPA has conducted additional meteorological data degradation analyses for the Tracy field study and

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[3] NOAA Technical Memorandum ERL ARL–52, 1974. Diffusion under Low Wind Speed, Inversion Conditions. Sagendorf, J.F., C. Dickson. Air Resources Laboratory, Idaho Falls, Idaho.

[4] NOAA Technical Memorandum ERL ARL–61, 1976. Diffusion under Low Wind Speed Conditions near Oak Ridge, Tennessee. Wilson, R.B., G. Start, C. Dickson, N. Ricks. Air Resources Laboratory, Idaho Falls, Idaho.

the 1972 Idaho Falls field study for a ground-level release in flat terrain to provide a better understanding of the nature of the tendency to underpredict concentrations when applying the ADJ_U* option with site-specific turbulence measurements. The full meteorological dataset available for the Tracy field study provides a robust case study for this assessment because it includes several levels of turbulence data, *i.e.,* sigma-theta (the standard deviation of horizontal wind direction fluctuations) and/or sigma-w (the standard deviation of the vertical wind speed fluctuations), in addition to several levels of wind speed, direction and temperature. The 1972 Idaho Falls field study also included a robust set of meteorological data to assess this potential issue for ground-level sources.

The results of this EPA study confirm good performance for the Tracy field study using the full set of meteorological inputs with the default options (*i.e.,* without the ADJ_U* option in AERMET and without any LOWWIND option in AERMOD). Including the ADJ_U* option in AERMET with full meteorological data results in an underprediction of about 40 percent. On the other hand, AERMOD results without the ADJ_U* option in AERMET and without the observed profiles of temperature and turbulence (*i.e.,* mimicking standard airport meteorological inputs) results in significant overprediction by about a factor of 4. However, using the ADJ_U* option with the degraded meteorological data shows very good agreement with observations, comparable to or slightly better than the results with full meteorological inputs. Full results from this study to assess the use of the ADJ_U* option with various levels of meteorological data inputs are detailed in our Response to Comments document provided in the docket for this action. The Response to Comments document also provides evidence of this potential bias toward underprediction when the ADJ_U* option is applied for applications that also include site-specific meteorological data with turbulence parameters based on the 1972 Idaho Falls study. As with the Tracy field study, the Idaho Falls field study results with site-specific turbulence data do not show a bias toward underprediction without the ADJ_U* option, but do show a bias toward underprediction using turbulence data with the ADJ_U* option.

Based on these detailed findings, the public cannot be assured that the proposed ADJ_U* option, when used with site-specific meteorological inputs including turbulence data (*i.e.,* sigma-theta and/or sigma-w), would not bias model predictions towards underestimation, which would be inconsistent with section 3.2.2 of the *Guideline.* Therefore, the EPA has determined that the ADJ_U* option should not be used in AERMET in combination with use of measured turbulence data because of the observed tendency for model underpredictions resulting from the combined influences of the ADJ_U* and the turbulence parameters within the current model formulation.

While these findings suggest that the ADJ_U* option is not appropriate for use in regulatory applications involving site-specific meteorological data that include measured turbulence parameters, the model performance and diagnostic evaluations strongly support the finding that the ADJ_U* option provides for an appropriate adjustment to the surface friction velocity parameter when standard National Weather Service (NWS) airport meteorological data, site-specific meteorological data without turbulence parameters, or prognostic meteorological input data are used for the regulatory application.

Therefore, based on these findings of improved model performance with the ADJ_U* option for sources where peak impacts are likely to occur during low wind speed and stable conditions, as well as the peer-reviewed studies demonstrating improved estimates of the surface friction velocity (u*) based on these options, the EPA is adopting the proposed ADJ_U* option in AERMET as a regulatory option for use in AERMOD for sources using standard NWS airport meteorological data, site-specific meteorological data without turbulence parameters, or prognostic meteorological inputs derived from prognostic meteorological models.

Incorporation of the LOWWIND3 Option Into AERMOD

In addition to the ADJ_U* option in AERMET, the EPA also proposed the incorporation of LOWWIND3 as a regulatory option in AERMOD to address issues with model overprediction for some sources under low wind speed conditions. Beginning with version 12345 of AERMOD, two LOWWIND ''beta'' options were included in AERMOD (*i.e.,* LOWWIND1 and LOWWIND2), and a third option, LOWWIND3, was incorporated at the time of proposal in version 15181 of AERMOD. The LOWWIND options modify the minimum value of sigma-v, the lateral turbulence intensity, which is used to determine the lateral plume dispersion coefficient (*i.e.,* sigma-y). With respect to the specific issue of setting a minimum value of sigma-v, the LOWWIND options can be considered as empirical options based on applicable parameter specifications from the scientific literature. However, the LOWWIND options go beyond this empirical specification of the minimum sigma-v parameter to address the horizontal meander component in AERMOD that also contributes to lateral plume spread, especially during low wind, stable conditions. Furthermore, since the horizontal meander component in AERMOD is a function of the ''effective'' sigma-v value, lateral plume dispersion may be further enhanced under the LOWWIND3 option by increased meander, beyond the influence of the minimum sigma-v value alone.

The current default option in AERMOD uses a minimum sigma-v of 0.2 meters per second (m/s). Setting a higher minimum value of sigma-v would tend to increase lateral dispersion during low wind conditions and, therefore, could reduce predicted ambient concentrations. It is also worth noting that the values of sigma-v derived in AERMOD are based on the dispersion parameters generated in AERMET (*i.e.,* the surface friction velocity (u*) and the convective velocity scale (w*)), as well as the user-specified surface characteristics (*i.e.,* the surface roughness length, Bowen ratio, and albedo) used in processing the meteorological inputs through AERMET. As a result, application of the ADJ_U* option in AERMET will tend to increase sigma-v values in AERMOD and generally tend to lower predicted peak concentrations, separate from application of the LOWWIND options. Unlike the proposed ADJ_U* option in AERMET that adjusts u* under stable conditions, the LOWWIND options in AERMOD are applied for both stable and unstable/convective conditions. However, since atmospheric turbulence will generally be higher during unstable/convective conditions than for stable conditions, the potential influence of the minimum sigma-v value on plume dispersion is likely to be much less important during unstable/convective conditions.

The majority of commenters supported the EPA's proposal to incorporate the LOWWIND3 option into the regulatory version of AERMOD because they believed it would provide a more realistic treatment of low wind situations and reduce the potential for overprediction of the current regulatory version of AERMOD for such conditions. However, one commenter indicated that the proposed

LOWWIND3 option in AERMOD will ''reduce model accuracy'' along with model results, showing a tendency for underprediction across a number of evaluation databases. As discussed in the Response to Comments document, the influence of the LOWWIND3 option on model performance is mixed, and has shown a tendency toward underprediction with increasing distance in some cases, especially when LOWWIND3 is applied in conjunction with the ADJ_U* option in AERMET. The EPA's reassessment of model performance confirmed this finding of underprediction with increasing distance, in particular for the 1972 Idaho Falls field study database (discussed previously) and the Prairie Grass, Kansas, field study, which involved a near-surface tracer release in flat terrain. As noted above, there is an interaction between the ADJ_U* option and LOWWIND options because the values of sigma-v derived in AERMOD are based on the surface friction velocity (u*) parameter generated in AERMET. As a result, the ADJ_U* option in conjunction with the LOWWIND3 option influences the AERMOD derived sigma-v parameter and, in some cases, may exacerbate the tendency for AERMOD with LOWWIND3 to underpredict at higher concentrations, as shown in the commenter's assessment and the EPA's reassessment.

Another aspect of the AERMOD model formulation that may contribute to an increasing bias toward underprediction with distance is the treatment of the ''inhomogeneous boundary layer'' (IBL) that accounts for changes in key parameters such as wind speed and temperature with height above ground. The IBL approach determines ''effective'' values of wind speed, temperature, and turbulence that are averaged across a layer of the plume between the plume centerline height and the height of the receptor. The extent of this layer depends on the vertical dispersion coefficient (*i.e.,* sigma-z). Therefore, as the plume grows downwind of the source, the extent of the layer used to calculate the effective parameters will increase (up to specified limits). The potential influence of this aspect of AERMOD formulation on modeled concentrations will depend on several factors, including source characteristic, meteorological condition, and the topographic characteristics of the modeling domain.

Several commenters recommended that the EPA's proposed revisions to AERMOD be further evaluated given either the lack or paucity of peer-reviewed literature upon which they are based. Specifically, one commenter noted that ''while this overprediction phenomenon can occur under certain conditions, additional studies produced by a more diverse group of organizations should be evaluated.'' Unlike the situation with the ADJ_U* option, the EPA does not have a published, peer-reviewed model formulation update with supporting model performance evaluations that fully address the complex issues of concern for the LOWWIND options. Therefore, the EPA agrees with commenters that additional study and evaluation is warranted for the proposed LOWWIND3 option, as well as other low wind options, in order to gain the understanding across the modeling community that is necessary to determine whether it would be appropriate to incorporate it into an EPA-preferred model used to inform regulatory decisions. The EPA will continue to work with the modeling community to further assess the theoretical considerations and model performance results under relevant conditions to inform considerations for appropriate adjustments to the default minimum value of sigma-v from 0.2 m/s that, as noted by some commenters, may be considered separate from any specific LOWWIND option.

Based on EPA's review of public comments and further consideration of the issues, the public cannot be assured that the proposed LOWWIND3 option does not have a tendency to bias model predictions towards underestimation (especially in combination with the ADJ_U* option and/or site-specific turbulence parameters), which would be inconsistent with section 3.2.2 of the *Guideline.* Therefore, lacking sufficient evidence to support adoption of LOWWIND3 (or other LOWWIND options) as a regulatory option in AERMOD, we are not incorporating LOWWIND3 as a regulatory option in AERMOD at this time, and we are deferring action on the LOWWIND options in general pending further analysis and evaluation in conjunction with the modeling community.

Modifications to AERMOD Formulation for Tall Stack Applications Near Small Urban Areas

As proposed, the EPA recognized the need to address observed overpredictions by AERMOD when applied to situations involving tall stacks located near small urban areas. The tendency to overpredict concentrations results from an unrealistic limit on plume rise imposed within the dispersion model. The EPA received broad support in the public comments for these proposed modifications to the AERMOD formulation that appropriately address overprediction for applications involving relatively tall stacks located near small urban areas. The EPA is finalizing this model formulation update, as proposed, into the regulatory version of AERMOD.

Address Plume Rise for Horizontal and Capped Stacks in AERMOD

As proposed, the EPA updated the regulatory options in AERMOD to address plume rise for horizontal and capped stacks based on the July 9, 1993, MCH memorandum,[2] with adjustments to account for the PRIME algorithm for sources subject to building downwash. There was broad-based support for this model update across the public comments. One commenter noted that the use of this proposed option for horizontal stacks, although a better method than the previous version, can lead to extremely high concentrations for sources with building downwash in complex terrain. Despite the noted improved performance of the proposed option in the case of building downwash, the EPA recognizes the ongoing issues with this option in the presence of building downwash and with its inherent complexities and its particular application in such situations with complex terrain. The EPA also recognizes that the appropriateness of this option for that particular situation would be a matter of consultation with the appropriate reviewing authority. However, given the broad support stated in public comments for the improved treatment, the EPA is finalizing this formulation update, as proposed, as a regulatory option within AERMOD.

Incorporation of the BLP Model Into AERMOD

As proposed, the EPA has integrated the BLP model into the AERMOD modeling system and removed BLP from appendix A as a preferred model. The comments received on the BLP integration into AERMOD are summarized in four categories: (1) Strongly supportive of the integration and replacement of BLP; (2) supportive of the integration, but with concerns that the integration of BLP is not fully consistent with the dispersion algorithms in AERMOD; (3) supportive of the integration, but suggestive that more time is needed to evaluate the implementation and that BLP should remain in appendix A until more evaluation can be made of the new code; and (4) concerned that modeled concentrations between the original BLP and BLP integrated in AERMOD are not identical. Despite the concerns expressed, all the comments received were supportive of the concept of integrating the two models and removing BLP from appendix A.

The EPA's integration of BLP into AERMOD was not intended to update the model science within BLP into AERMOD. Thus, while the comments relating to inconsistencies between AERMOD (*e.g.,* based on Monin-Obukhov length and similarity profiling) and BLP (*e.g.,* based on Pasquill-Gifford stability classes) are largely accurate, they do not affect the status of the proposed BLP integration. Many of the comments on the proposal suggested that the EPA needs to more quickly integrate updates to the AERMOD modeling system to address these inconsistencies. However, the EPA does not find it appropriate to delay the release of the integrated model, particularly since the stated purposed of the integration and evaluation is to assure equivalency and not a fundamental update to the BLP model science to be consistent with that of AERMOD, which would require additional time and effort to appropriately inform a possible future EPA action. The EPA appreciates the comments identifying potential issues where model equivalency was not fully demonstrated. These instances have been further evaluated and corrections have been made to the code to sufficiently address these issues. The details of these corrections, along with the comments relating to inconsistencies in underlying dispersion science, are addressed in detail in the Response to Comments document located in the docket for this action.

Therefore, the EPA is integrating the BLP model into the AERMOD modeling system, is removing BLP from appendix A as an EPA-preferred model, and is updating the summary description of the AERMOD modeling system to appendix A of the *Guideline* as proposed.

Updates to the NO_2 Tier 2 and Tier 3 Screening Techniques in AERMOD

In the proposed action, we solicited comments on whether we have reasonably addressed technical concerns regarding the 3-tiered demonstration approach and specific NO_2 screening techniques within AERMOD and whether we were on sound foundation to recommend the proposed updates. Section 5.2.4 of the 2005 version of the *Guideline* details a 3-tiered approach for assessing nitrogen oxides (NO_X) sources, which was recommended to obtain annual average estimates of NO_2 concentrations from point sources for purposes of NSR analyses and for SIP planning purposes. This 3-tiered approach addresses the co-emissions of nitric oxide (NO) and NO_2 and the subsequent conversion of NO to NO_2 in the atmosphere. In January 2010, the EPA promulgated a new 1-hour NO_2 NAAQS (75 FR 6474). Prior to the adoption of the 1-hour NO_2 standard, few PSD permit applications required the use of Tier 3 options, and guidance available at the time did not fully address the modeling needs for a 1-hour standard (*i.e.,* tiered approaches for NO_2 in the 2005 version of the *Guideline* specifically targeted an annual standard). In response to the 1-hour NO_2 standard, the EPA proposed the incorporation of several modifications to the Tier 2 and Tier 3 NO_2 screening techniques as regulatory options in AERMOD, so that alternative model approval would no longer be needed.

The proposed modifications specifically included: (1) Replacing the existing Tier 2 Ambient Ratio Method (ARM)[5] with a revised Ambient Ratio Method 2 (ARM2)[6] approach; and (2) incorporating the existing detailed screening option of the Ozone Limiting Method (OLM)[7] and updated version of the Plume Volume Molar Ratio Method (PVMRM)[8] as regulatory options in AERMOD as preferred Tier 3 screening methods for NO_2 modeling. The vast majority of the public comments supported the proposed changes to these methods. However, there were two subsets of comments that required additional response.

First, several commenters stated that the proposed default NO_2/NO_X minimum ambient ratio (MAR) of 0.5, for use with the ARM2 approach, was too high and that a MAR of 0.2 should be used instead. The MAR is the lowest NO_2/NO_X ratio used in the ARM2 method at the highest NO_X levels. The MAR increases from this minimum level to a maximum NO_2/NO_X ratio of 0.9 at the lowest NO_X levels. While commenters believe that the MAR of 0.2 is more representative of ambient data, the EPA maintains that consistency in the tiered approach for NO_2 modeling, with the Tier 2 methods being more conservative than the Tier 3 methods, is needed and that national default model inputs need to be conservative, in line with the CAA's objective to prevent potential NAAQS violations. The revised text allows for alternative MARs that should not be overly difficult to justify to the appropriate reviewing authority when lower MARs are appropriate. The EPA reaffirms that site-specific data are always preferred, but provides the national default model inputs when these data are unavailable.

Second, several commenters noted that the specific version of PVMRM2 intended for regulatory use was not entirely clear. Version 15181 of AERMOD included both PVMRM and PVMRM2 with the proposal preamble text indicating that we would be promulgating PVMRM2; however, the proposed regulatory text identified PVMRM, which caused confusion. The methodology employed in the ''PVMRM2'' option in AERMOD version 15181 is now the ''PVMRM'' regulatory option in AERMOD, and the methodology employed in the ''PVMRM'' option in AERMOD version 15181 has been removed entirely from the model. The basis for this decision is that the updated PVMRM2 is a more complete implementation of the PVMRM approach outlined by Hanrahan (1999) than the original PVMRM implementation in AERMOD.

Therefore, the EPA is updating the regulatory version of the AERMOD modeling system to reflect these changes for NO_2 modeling and has updated the related descriptions of the AERMOD modeling system in section 4.2.3.4 of the *Guideline* as proposed.

EPA's Preferred Version of the AERMOD Modeling System

As described throughout section IV.A.2 of this preamble, we are revising the summary description of the AERMOD modeling system in appendix A of the *Guideline* to reflect these updates. Model performance evaluation and scientific peer review references for the updated AERMOD modeling system are cited, as appropriate. An updated user's guide and model formulation documents for version 16216 are located in the docket for this action. The essential codes, preprocessors, and test cases have been updated and posted on the EPA's SCRAM Web site at *https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod.*

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[5] Chu, S.H. and E.L. Meyer, 1991. Use of Ambient Ratios to Estimate Impact of NO_X Sources on Annual NO_2 Concentrations. Proceedings, 84th Annual Meeting & Exhibition of the Air & Waste Management Association, June 16–21 1991, Vancouver, B.C.

[6] Podrez, M. 2015. An Update to the Ambient Ratio Method for 1-h NO_2 Air Quality Standards Dispersion Modeling. *Atmospheric Environment,* 103: 163–170.

[7] Cole, H.S. and J.E. Summerhays, 1979. A Review of Techniques Available for Estimation of Short-Term NO_2 Concentrations. *Journal of the Air Pollution Control Association,* 29(8): 812–817.

[8] Hanrahan, P.L., 1999. The Polar Volume Polar Ratio Method for Determining NO_2/NO_X Ratios in Modeling—Part I: Methodology. *Journal of the Air & Waste Management Association,* 49: 1324–1331.

3. Status of AERSCREEN

In our proposed action, we invited comment on the incorporation of AERSCREEN into the *Guideline* as the recommended screening model for AERMOD that may be suitable for applications in all types of terrain and for applications involving building downwash. AERSCREEN uses the EPA's preferred near-field dispersion model AERMOD in screening mode and represents the state of the science versus the outdated algorithms of SCREEN3 that are based on the Industrial Source Complex model (ISC).

We received some comments that SCREEN3 should be retained as it is simpler to use than AERSCREEN. The EPA disagrees with those comments and reminds users that AERSCREEN is already being utilized by much of the stakeholder community and represents the state of the science as stated in the paragraph above. Given the preferred status of AERMOD over ISC and the fact that AERSCREEN is now incorporating fumigation, an option available in SCREEN3, we feel that there are no valid technical reasons to retain SCREEN3 as a recommended screening model.

We also received comments expressing concerns about the fumigation options and conservatism of the fumigation outputs. The fumigation options implemented in AERSCREEN are the same algorithms used in SCREEN3, such that the current capabilities in that screening model are now available in AERSCREEN. However, these fumigation options take advantage of the AERMOD equations for the dispersion parameters sigma-y and sigma-z that are needed for the fumigation calculations. AERSCREEN also takes advantage of the meteorological data generated by MAKEMET to calculate those parameters based on the boundary layer algorithms included in AERMET, as opposed to using standard dispersion curves used by SCREEN3. Some commenters suggested that the Shoreline Dispersion Model (SDM) algorithms be investigated for fumigation calculations. We agree with these commenters and will investigate the incorporation of the SDM algorithms in AERSCREEN for a future release. One commenter noted a bug in building outputs when running AERSCREEN with downwash and user-supplied BPIPPRM input files. The commenter stated that AERSCREEN takes the maximum and minimum dimensions over the 36 directions output by BPIPPRM for use in modeling. For some directions, there may be no building influence and AERSCREEN erroneously takes a zero dimension as a building width. The EPA has determined that this is not a bug in AERSCREEN. Rather, it is a product of the output of BPIPPRM, which may report a value of zero for building widths and, thus, AERSCREEN reports a value of zero as a minimum building width. To address this issue, we have modified AERSCREEN to only output non-zero widths.

Finally, several commenters pointed out a typographical error in the AERSCREEN conversion factors from 1-hour to 3-, 8-, and 24-hour and annual results in section 4.2.1.1 of the *Guideline.* The original text reported the SCREEN3 factors and not the AERSCREEN factors listed in the AERSCREEN user's guide. These factors have been corrected in the final revisions to the *Guideline* to reflect the AERSCREEN factors. Another commenter also found a typographical error in section 4.2.1.1(c) where BPIPPRM was misspelled. This too was corrected. We also received a comment that the term ''unresolvable'' in section 4.2.1.3(c) implies that a problem cannot be solved. Suggested language of ''unforeseen challenges'' was suggested. We agreed that the ''unresolvable'' is erroneous and changed the term to ''unforeseen.''

Therefore, the EPA is incorporating AERSCREEN into the *Guideline* as the recommended screening model for AERMOD that may be used in applications across all types of terrain and for applications involving building downwash.

4. Status of CALINE3 Models

We solicited comment on our proposal to replace CALINE3 [9] with AERMOD as the preferred appendix A model for its intended regulatory applications, primarily determining near-field impacts for primary emissions from mobile sources for $PM_{2.5}$, PM_{10}, and carbon monoxide (CO) hot-spot analyses.[10] This proposed action was based on the importance of reflecting the latest science in AERMOD, its improved model performance over CALINE3, and the availability of more representative meteorological data for use in AERMOD. The EPA's proposal also set forth a 1-year transition period for the adoption of AERMOD for all regulatory applications.

The mobile source modeling applications under the CAA requirements that are most affected by the replacement of CALINE3 with AERMOD are transportation conformity hot-spot analyses for $PM_{2.5}$, PM_{10}, and CO.[11] To date, PM hot-spot analyses have involved a refined analysis that can be accomplished with either AERMOD or CAL3QHCR (a variant of CALINE3).[10] For CO hot-spot analyses, screening analyses are typically conducted with CAL3QHC (a variant of CALINE3).[12]

The EPA received several comments supporting and several comments opposed to the proposed replacement of CALINE3 with AERMOD as the preferred appendix A model for mobile source emissions. The commenters who supported the proposed replacement agreed with the reasons set forth in the proposal, mainly that AERMOD reflects the state-of-the-science for Gaussian plume dispersion models, with on-going updates and enhancements supported by the EPA, has more accurate performance and is more flexible and can be applied to more project types than other dispersion models, can utilize more recent and more representative meteorological data, and that a single model will generally streamline the process of conducting and securing approval of model demonstrations.[13] Alternatively, the commenters who did not support the proposal believed: that the science indicating AERMOD has more accurate performance is unclear; that AERMOD would increase the time required to complete hot-spot analyses, particularly for CO screening; and that a longer transition period, such as a 3-year period, would be needed for the adoption of new models for conformity analyses.

The adverse comments related to the sufficiency of the EPA's technical and scientific basis for the replacement of

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[9] Benson, Paul E., 1979. CALINE3—A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets. Interim Report, Report Number FHWA/CA/TL–79/23. Federal Highway Administration, Washington, DC (NTIS No. PB 80–220841).

[10] U.S. Environmental Protection Agency, 2015, Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas. Publication No. EPA–420–B–15–084, Office of Transportation and Air Quality, Ann Arbor, MI.

[11] Transportation conformity is required under Clean Air Act section 176(c) for federally funded or approved transportation projects in nonattainment and maintenance areas; EPA's transportation conformity regulations can be found at 40 CFR part 93.

[12] U.S. Environmental Protection Agency, 1992, Guideline for Modeling Carbon Monoxide from Roadway Intersections, EPA–454/R–92–005, Office of Air Quality Planning and Standards, RTP, NC.

[13] U.S. Environmental Protection Agency, 2016. Technical Support Document (TSD) for Replacement of CALINE3 with AERMOD for Transportation Related Air Quality Analyses. Publication No. EPA–454/B–16–006. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

CALINE3 with AERMOD included statements that AERMOD does not have an explicit line-source algorithm; that the peer-reviewed literature shows mixed results for model assessments; and that AERMOD performance for roadways has not been as well documented for an array of transportation projects.

First, the EPA notes that, based on implementation of conformity requirements to date, the majority of PM hot-spot analyses have been conducted with AERMOD and its existing algorithms have been used to perform these analyses. While it is true that AERMOD does not have an explicit line-source algorithm, it does have a LINE source input pathway that mimics the input requirements for CALINE3 and simplifies using elongated area sources such as roadways. While roadway sources are often described as ''line sources,'' they are in fact three-dimensional entities. The roadway width is one of the model inputs for CALINE3 and the width of a roadway is frequently many times the distance from the edge of the roadway to the closest receptor. The actual formulation of these source types is not as explicit as the names suggest. For example, LINE source in AERMOD performs an explicit numerical integration of emissions from the LINE source, whereas CALINE uses a rough integration based on a series of finite line segments. Thus, an elongated area source in AERMOD is likely to represent the distribution of roadway emissions more accurately than the approach taken in CALINE3. In fact, the body of literature focused on roadway emissions suggests that the formulation of the Gaussian plume (*i.e.,* line, area or volume) is not as important as the appropriate settings of the source characteristics and the quality of the emissions and meteorological inputs (see discussion in the Response to Comments document in the docket for this action).

These commenters also believed that the Heist (2013) journal article[14] cited primarily as supporting the proposal was too limited in scope. The quality of the emissions inputs, in particular, is one of the reasons the EPA focused on Heist (2013) to support the proposal. The EPA reviewed current model assessments in the literature and found that the majority used traffic counts and an emissions model to estimate emissions (see the Response to Comments document for more details). Although this approach introduces significant uncertainty in the model evaluation, this uncertainty was not addressed in these types of studies. Studies that use tracer emissions rather than traffic counts and emissions models remove this uncertainty and allow an evaluation of the dispersion model itself, rather than a joint evaluation of the emissions model and the dispersion model. The studies based on tracer releases rather than modeled emissions are limited to the CALTRANS99 and the 2008 Idaho Falls field studies examined in Heist (2013), and its robust model performance evaluations of these two studies. Thus, Heist (2013) was the primary literature the EPA considered in making a determination regarding AERMOD replacing CALINE3, rather than the small number of other recent model evaluations available in the peer-reviewed literature. Since the CALTRANS99 field campaign evaluated by Heist (2013) included an emission measurement system attached to vehicles driving on an operational highway, the results are fully representative of operational highways. The Heist (2013) study compared a developmental line-source model, RLINE, to AERMOD with volume and line sources as well as CALINE3 and CALINE4. RLINE showed nearly equivalent performance to the area and volume formulations from AERMOD. CALINE3 was clearly the worst performing model from the six model formulations evaluated. While CALINE4 had better performance than CALINE3, CALINE4 was still the second-worst performing model. It should also be noted that most recent literature only evaluates the CALINE4 model rather than the CALINE3 model, which further highlights that the CALINE3 model is outdated in its science, even within its own class of models.

In terms of regulatory applications, AERMOD has been demonstrated to be useful for a range of transportation applications and is generally relied on over CAL3QHCR for more complicated projects because of its greater flexibility in source types (*e.g.,* CAL3QHCR is unable to model certain types of projects or project features such as intermodal terminals or tunnels) and meteorological processing. Additionally, the Federal Aviation Administration (FAA) replaced CALINE3 with AERMOD in 2005 in its Emissions and Dispersion Modeling System (EDMS) to expand its capability and improve its accuracy in evaluating airport impacts.[15] This, along with the fact that AERMOD has been used for many years already for PM hot-spot analyses for transportation conformity determinations, shows that AERMOD is more than capable of being useful for a wide variety of transportation projects and that the performance has been more than adequate for even the most complicated projects.

Comments were also made with respect to potential longer AERMOD model run times and the time necessary to set up model files and obtain meteorological data. These statements are not entirely reflective of the EPA's experience to date in implementing the PM hot-spot requirement. The EPA believes that AERMOD has been used for more complicated projects, since PM hot-spot analyses are completed for projects that are often very large and involve different project components that significantly increase the number of diesel vehicles. By their nature, these types of transportation projects involve more time to set up and complete and few transportation modelers have actually run both CAL3QHCR and AERMOD for equivalent projects.[16] In addition, volume sources have frequently been selected by implementers for AERMOD demonstrations, and this approach involves more time and effort in setting up the model runs, and more sources to be used than would be necessary with area sources. In addition, since AERMOD is already used in all 50 states for NSR purposes, meteorological input data for AERMOD are frequently prepared as a matter of course by the state and local air agencies and often made publicly available for download. Therefore, the EPA's understanding and experience is that the amount of time and resources necessary to create model inputs and complete PM hot-spot model simulations for AERMOD versus CAL3QHCR is not distinguishable from the overall process of running a traffic model, developing design alternatives for multiple purposes beyond conformity, and running the emissions model for the scenarios. In addition, as stated above and in the EPA's existing guidance, AERMOD has several advantages when conducting a PM hot-spot analysis: The ability to model a

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[14] Heist, D., V. Isakov, S. Perry, M. Snyder, A. Venkatram, C. Hood, J. Stocker, D. Carruthers, S. Arunachalam, and R.C. Owen. Estimating near-road pollutant dispersion: A model inter-comparison. Transportation Research Part D: Transport and Environment. Elsevier BV, AMSTERDAM, Netherlands, 25:93–105, (2013).

[15] 70 FR 68218, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, November 9, 2005.

[16] Quantitative PM hot-spot analyses are not required for most new projects in PM nonattainment and maintenance areas, and most state departments of transportation have not been required to complete such an analysis to date for transportation conformity.

variety of different transportation project types; the reliance on existing and more recent AERMET meteorological datasets obtained through the interagency consultation process; and additional capabilities that reduce the number of steps in conducting a PM hot-spot analyses.[17]

In response to the comments received and based on the analysis conducted by the EPA, the following actions are being taken in the final rulemaking:

- The EPA is replacing CALINE3 with AERMOD as the appendix A preferred model for refined modeling for mobile source applications. The EPA has reviewed the available literature and conducted its own analysis[13] that demonstrates AERMOD provides superior performance to that of CALINE3 for refined applications. The EPA emphasizes that AERMOD has been the only model that is applicable to all types of projects, including highway interchanges and intersections; transit, freight, and other terminal projects; intermodal projects; and projects in which nearby sources also need to be modeled.[10]
- The EPA acknowledges that the implementation of AERMOD for all refined modeling may take time, as many state transportation departments are not yet experienced with the AERMOD modeling system. Many states may have attended one of the EPA's multiple trainings but have not been involved in a quantitative PM hot-spot analysis to date. Thus, we are providing an extended 3-year transition period before AERMOD is required as the sole dispersion model for refined modeling in transportation conformity determinations. In addition, any refined analyses for which the air quality modeling was begun before the end of this 3-year period with a CALINE3-based model can be completed after the end of the transition period with that model, similar to the way the transportation conformity grace period for new emissions models is implemented.
- The EPA acknowledges that there are limited demonstrations of using AERMOD for multi-source screening and that additional development work is necessary to develop an AERMOD-based screening approach for CO that satisfies the need for this type of analysis. Thus, we have modified section 4.2.3.1(b) of the *Guideline* to reference the EPA's 1992 CO guidance that employs CAL3QHC for CO screening analysis.[12] This technical guidance will remain in place as the recommended approach for CO screening until such time that the EPA (1) develops a new CO screening approach based on AERMOD or another appropriate model and (2) updates the *Guideline* to include the new CO screening approach. The use of CAL3QHC for CO screening does not need to undergo the review process discussed in the Guideline section 2.2(d). That review process is not necessary for CAL3QHC because its use is already well-established for CO hot-spot analyses and the review criteria have already been met.
- Finally, the EPA has formally recommended the establishment of a standing air quality modeling workgroup with the U.S. Department of Transportation, including the Federal Highway Administration, Federal Transit Administration, and FAA, to continue to evaluate and develop modeling practices for the transportation sector to ensure that future updates to dispersion models and methods reflect the latest available science and implementation.

See the docket for this action for the Response to Comments document for this part of the proposal as well as the EPA's latest technical support document (TSD) for using AERMOD for CO hot-spot screening analyses.

5. Addressing Single-Source Impacts on Ozone and Secondary $PM_{2.5}$

As discussed in our proposed action, on January 4, 2012, the EPA granted a petition submitted on behalf of the Sierra Club on July 28, 2010,[18] which requested that the EPA initiate rulemaking regarding the establishment of air quality models for ozone and $PM_{2.5}$ for use by all major sources applying for a PSD permit. In granting that petition, the EPA committed to engage in rulemaking to evaluate whether updates to the *Guideline* are warranted and, as appropriate, incorporate new analytical techniques or models for ozone and secondarily formed $PM_{2.5}$. This final action completes the rulemaking process described in the EPA's granting of the Sierra Club petition. As discussed in the proposal, the EPA has determined that advances in chemical transport modeling science indicate it is now reasonable to provide more specific, generally-applicable guidance that identifies particular models or analytical techniques that may be used under specific circumstances for assessing the impacts of an individual or single source on ozone and secondary $PM_{2.5}$. For assessing secondary pollutant impacts from single sources, the degree of complexity required to appropriately assess potential impacts varies depending on the nature of the source, its emissions, and the background environment. In order to provide the user community flexibility in estimating single-source secondary pollutant impacts that allows for different approaches to credibly address these different areas, the EPA proposed a two-tiered demonstration approach for addressing single-source impacts on ozone and secondary $PM_{2.5}$.

The first tier involves use of technically credible relationships between precursor emissions and a source's impacts that may be published in the peer-reviewed literature, developed from modeling that was previously conducted for an area by a source, a governmental agency, or some other entity and that is deemed sufficient, or generated by a peer-reviewed reduced form model. The second tier involves application of more sophisticated case-specific chemical transport models (CTMs) (*e.g.,* photochemical grid models) to be determined in consultation with the EPA Regional Offices and conducted consistent with the EPA single-source modeling guidance.[19] The appropriate tier for a given application should be selected in consultation with the appropriate reviewing authority and be consistent with EPA guidance. We invited comments on whether our proposed two-tiered demonstration approach and related EPA technical guidance are appropriately based on sound science and practical application of available models and tools to address single-source impacts on ozone and secondary $PM_{2.5}$.

Multiple commenters expressed support for the two-tiered approach for estimating single-source secondary impacts for permit-related programs, while other commenters did not support

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[17] See Sections 7 and 9 of EPA's 2015 Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas. For example, Exhibit 7–2 in this guidance highlights that AERMOD can be used for all project types that require PM hot-spot analyses under the transportation conformity rule, and Exhibit 7–3 clarifies the number of runs typically necessary for a PM hot-spot analysis with AERMOD (1–5 runs) versus CAL3QHCR (20 runs).

[18] U.S. Environmental Protection Agency, 2012. Sierra Club Petition Grant. Administrative Action dated January 4, 2012, U.S. Environmental Protection Agency, Washington, District of Columbia 20460. *https://www3.epa.gov/ttn/scram/10thmodconf/review_material/Sierra_Club_Petition_OAR-11-002-1093.pdf.*

[19] U.S. Environmental Protection Agency, 2016. Guidance on the use of models for assessing the impacts of emissions from single sources on the secondarily formed pollutants ozone and $PM_{2.5}$. Publication No. EPA 454/R–16–005. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

a multi-tiered approach for this purpose. Commenters also sought flexibility in the first tier to allow for area-specific demonstrations, thereby avoiding the second tier assessments where chemical transport modeling may be part of the demonstration. Most commenters support the idea of developing Model Emissions Rates for Precursors (MERPs) for use as a Tier 1 demonstration tool, as described in the preamble of the proposed rule. However, some commenters expressed the need for more specific information about Tier 1 demonstration tools, particularly MERPs. Furthermore, one commenter expressed concern about the particular use of demonstration tools, such as MERPs, not reflecting the combined ambient impacts across precursors and, in the context of $PM_{2.5}$, in combining primary and secondary ambient impacts.

The EPA has issued draft guidance for use by permitting authorities and permit applicants and deferred rulemaking at this time to address how permitting authorities may develop and use significant impact levels (SILs) for ozone and $PM_{2.5}$. In addition, we are not establishing a single set of national MERPs through rulemaking as we had anticipated in the preamble of the proposed rule. Instead, the EPA developed a draft technical guidance document to provide a framework for permitting authorities to develop area-specific MERPs consistent with the *Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program.*[20] Through this process, the EPA believes it has provided sufficient information regarding Tier 1 demonstration tools, such as MERPs. The draft MERPs technical guidance document[21] illustrates how permitting authorities may appropriately develop MERPs for specific areas and use them as a Tier 1 demonstration tool for permit-related programs. This draft guidance also explicitly addresses the commenter concern regarding the appropriate use of MERPs such that their use reflects the combined ambient impacts across precursors and, in the case of $PM_{2.5}$, the combined primary and secondary ambient impacts. This approach provides the flexibility requested by many commenters with respect to Tier 1 demonstration tools, such as MERPs, to generate information relevant for specific regions or areas rather than a single, national level that may not be representative of secondary formation in a particular region or area.

Specifically, the draft MERPs technical guidance provides information about how to use CTMs to estimate single-source impacts on ozone and secondary $PM_{2.5}$ and how these model simulation results can be used to develop empirical relationships for specific areas that may be appropriate as a Tier 1 demonstration tool. It also provides results from EPA photochemical modeling of multiple hypothetical situations across geographic areas and source types that may be used in developing MERPs consistent with the guidance or with supplemental modeling in situations where the EPA's modeling may not be representative. This flexible and scientifically credible approach allows for the development of area-specific Tier 1 demonstration tools that better represent the chemical and physical characteristics and secondary pollutant formation within that region or area.

The draft MERPs technical guidance[21] and the EPA's draft single-source modeling guidance[19] provide information to stakeholders about how to appropriately address the variety of chemical and physical characteristics regarding a project scenario and key receptor areas that should be addressed in conducting additional modeling to inform development of MERPs. The development of MERPs for ozone and secondary $PM_{2.5}$ precursors is just one example of a suitable Tier 1 demonstration tool. The EPA will continue to engage with the modeling community to identify credible alternative approaches for estimating single-source secondary pollutant impacts, which provide flexibility and are less resource intensive for permit demonstrations.

Commenters also stated that requiring chemical transport modeling as a Tier 2 demonstration tool places undue burden financially on the states, as they do not have the expertise to run or review such models, and that the regulated community does not have the expertise to run such models. Commenters requested a clearer rationale and procedure for applying CTMs for the purposes of estimating single-source secondary impacts for permit-related programs. In response, the EPA believes that its technical guidance on single-source modeling provides both the clarity necessary to conduct such modeling and the flexibility appropriate to address such situations.

First, based on peer-reviewed assessments of models used for estimating ozone and secondary $PM_{2.5}$ for single-source impacts, the EPA continues to recommend that CTMs (including photochemical grid models or Lagrangian models) be used where a more refined Tier 2 demonstration for ozone or secondary $PM_{2.5}$ may be necessary. Given interest in the stakeholder community in different types of CTMs for the purposes of estimating single-source impacts for permit-related programs, and that these models, where applied appropriately, are fit for this purpose, selection of a single model for preferred status under the *Guideline* would impede sources from using a model or technique deemed most appropriate for specific situations, recognizing the diversity in chemical and physical environments across the United States.

Second, as discussed above, the EPA expects that the use of MERPs (or a similarly credible screening approach) as a Tier 1 demonstration tool will be sufficient for most sources to satisfy their compliance demonstration. For those situations where a refined Tier 2 demonstration is necessary, the EPA has provided detailed single-source modeling guidance with clear and credible procedures for estimating single-source secondary impacts from sources doing permit related assessments. The EPA has future plans to provide a module as part of its *Software for Model Attainment Test* (SMAT) tool, a publicly available, Windows-based program, that will allow users to work with output generated from CTMs to provide a consistent approach for estimating single-source ozone or secondary $PM_{2.5}$ impacts consistent with EPA guidance and the *Guideline.*

Multiple commenters do not agree that photochemical grid models can adequately assess single-source impacts. A commenter recognized that photochemical grid model evaluations using in-plume traverses are encouraging as documented in the IWAQM reports, but stated that more work is needed to generate additional confidence in the technique, and further requests that the EPA use newer field study data from 2013 to evaluate CTM performance against in-plume transects of ozone and secondary $PM_{2.5}$.

As referenced in the preamble to the proposal, the EPA has relied upon extensive peer-reviewed literature showing that photochemical grid models have been applied for single-

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[20] U.S. Environmental Protection Agency, 2016. Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[21] U.S. Environmental Protection Agency, 2016. Guidance on the Use of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Permit Related Programs. Publication No. EPA 454/R–16–006. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

source impacts and, compared with near-source downwind in-plume measurements, that the models adequately represent secondary pollutant impacts from a specific facility. The literature shows that these models can clearly differentiate impacts of a specific facility from those of other sources.[22] [23] Other peer-reviewed research has clearly shown that photochemical grid models are able to simulate impacts from single sources on secondarily-formed pollutants.[24] [25] [26] Further, single-source secondary impacts have been provided in technical reports that further support the utility of these tools for single-source scientific and regulatory assessments.[27] [28] [29] The EPA firmly believes that the peer-reviewed science clearly demonstrates that photochemical grid models can adequately assess single-source impacts. The EPA recognizes that ongoing evaluations in this area that will lead to continual improvements in the applicability of these models, such as the work underway to compare photochemical grid model estimates of single-source impacts with in-plume aircraft measurements made as part of the 2013 SENEX field campaign.[30]

Commenters requested that the EPA consider Lagrangian CTMs for use in assessing single-source secondary impacts. A commenter proposed that the Second-order Closure Integrated Puff Model (SCICHEM) can provide an alternative modeling platform for all single-source regulatory applications including ozone and secondary $PM_{2.5}$ impacts. Commenters note that SCICHEM does not suffer from limitations of other Lagrangian puff models with respect to overlapping puffs having similar access to background species as noted in the EPA's single-source modeling guidance.

The proposed revisions to the *Guideline* and EPA's single-source modeling guidance clearly indicate that CTMs are appropriate for estimating single-source impacts on ozone and secondary $PM_{2.5}$ as a Tier 2 demonstration tool or as means to develop a Tier 1 demonstration tool. Both Lagrangian puff models and photochemical grid models may be appropriate for this purpose where those models fulfill alternative model criteria detailed in section 3.2.2 of the *Guideline.* Furthermore, the single-source modeling guidance has been updated to reflect the difference in treatment of overlapping puffs and background in SCICHEM compared to other Lagrangian puff models. However, the EPA believes photochemical grid models are generally most appropriate for addressing ozone and secondary $PM_{2.5}$ because they provide a spatially and temporally dynamic realistic chemical and physical environment for plume growth and chemical transformation.[23] [34] Publicly available and documented Eulerian photochemical grid models such as the Comprehensive Air Quality Model with Extensions (CAMx) [31] and the Community Multiscale Air Quality (CMAQ) [32] model treat emissions, chemical transformation, transport, and deposition using time and space variant meteorology. These modeling systems include primarily emitted species and secondarily formed pollutants such as ozone and $PM_{2.5}$.[33] [34] [35] [36] In addition, these models have been used extensively to support ozone and $PM_{2.5}$ SIPs and to explore relationships between inputs and air quality impacts in the United States and elsewhere.[23] [37] [38]

The EPA is promulgating the two-tiered demonstration approach as described in section 5 of the *Guideline* and updating EPA technical guidance that was released at the time of proposal in response to public comments. These revisions to the *Guideline* and supporting technical guidance are based on sound science and practical application of available models and tools to address single-source impacts on ozone and secondary $PM_{2.5}$. In particular, the EPA has updated its previous $PM_{2.5}$ modeling guidance for permitting [39] to reflect these changes and also incorporated appropriate sections for ozone in releasing its *Guidance for Ozone* and $PM_{2.5}$ Permit Modeling [40] with this final rule.

6. Status of CALPUFF and Assessing Long-Range Transport for PSD Increments and Regional Haze

The EPA proposed a screening approach to address long-range transport for purposes of assessing PSD increments, its decision to remove CALPUFF as a preferred model in appendix A for such long-range transport assessments, and its decision

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[22] Baker, K.R., Kelly, J.T., 2014. Single Source Impacts Estimated with Photochemical Model Source Sensitivity and Apportionment Approaches. Atmospheric Environment 96, 266–274.

[23] Zhou, W., Cohan, D.S., Pinder, R.W., Neuman, J.A., Holloway, J.S., Peischl, J., Ryerson, T.B., Nowak, J.B., Flocke, F., Zheng, W.G., 2012. Observation and Modeling of the Evolution of Texas Power Plant Plumes. Atmospheric Chemistry and Physics 12, 455–468.

[24] Baker, K.R., Kotchenruther, R.A., Hudman, R.C., 2015. Estimating Ozone and Secondary $PM_{2.5}$ Impacts from Hypothetical Single Source Emissions in the Central and Eastern United States. Atmospheric Pollution Research 7, 122–133.

[25] Bergin, M.S., Russell, A.G., Odman, M.T., Cohan, D.S., Chameldes, W.L., 2008. Single-Source Impact Analysis Using Three-Dimensional Air Quality Models. Journal of the Air & Waste Management Association 58, 1351–1359.

[26] Kelly, J.T., Baker, K.R., Napelenok, S.L., Roselle, S.J., 2015. Examining Single-Source Secondary Impacts Estimated from Brute-force, Decoupled Direct Method, and Advanced Plume Treatment Approaches. Atmospheric Environment 111, 10–19.

[27] ENVIRON, 2012a. Comparison of Single-Source Air Quality Assessment Techniques for Ozone, $PM_{2.5}$, other Criteria Pollutants and AQRVs, EPA Contract No: EP–D–07–102. September 2012. 06–20443M6.

[28] ENVIRON, 2012b. Evaluation of Chemical Dispersion Models Using Atmospheric Plume Measurements from Field Experiments, EPA Contract No: EP–D–07–102. September 2012. 06–20443M6.

[29] Yarwood, G., Scorgie, Y., Agapides, N., Tai, E., Karamchandani, P., Duc, H., Trieu, T., Bawden, K., 2011. Ozone Impact Screening Method for New Sources Based on High-order Sensitivity Analysis of CAMx Simulations for NSW Metropolitan Areas.

[30] National Oceanic & Atmospheric Administration. Southeast Nexus (SENEX) 2013. Studying the Interactions Between Natural and Anthropogenic Emissions at the Nexus of Climate Change and Air Quality. *http://www.esrl.noaa.gov/csd/projects/senex.*

[31] ENVIRON, 2014. User's Guide Comprehensive Air Quality Model with Extensions version 6, *http://www.camx.com.* ENVIRON International Corporation, Novato.

[32] Byun, D., Schere, K.L., 2006. Review of the Governing Equations, Computational Algorithms, and Other Components of the Models-3 Community Multiscale Air Quality (CMAQ) modeling system. *Applied Mechanics Reviews,* 59: 51–77.

[33] Chen, J., Lu, J., Avise, J.C., DaMassa, J.A., Kleeman, M.J., Kaduwela, A.P., 2014. Seasonal Modeling of $PM_{2.5}$ in California's San Joaquin Valley. *Atmospheric Environment,* 92: 182–190.

[34] Civerolo, K., Hogrefe, C., Zalewsky, E., Hao, W., Sistla, G., Lynn, B., Rosenzweig, C., Kinney, P.L., 2010. Evaluation of an 18-year CMAQ Simulation: Seasonal Variations and Long-term Temporal Changes in Sulfate and Nitrate. *Atmospheric Environment,* 44: 3745–3752.

[35] Russell, A.G., 2008. EPA Supersites Program-related Emissions-based Particulate Matter Modeling: Initial Applications and Advances. *Journal of the Air & Waste Management Association,* 58: 289–302.

[36] Tesche, T., Morris, R., Tonnesen, G., McNally, D., Boylan, J., Brewer, P., 2006. CMAQ/CAMx Annual 2002 Performance Evaluation Over the Eastern US. *Atmospheric Environment,* 40: 4906–4919.

[37] Cai, C., Kelly, J.T., Avise, J.C., Kaduwela, A.P., Stockwell, W.R., 2011. Photochemical Modeling in California with Two Chemical Mechanisms: Model Intercomparison and Response to Emission Reductions. *Journal of the Air & Waste Management Association,* 61: 559–572.

[38] Hogrefe, C., Hao, W., Zalewsky, E., Ku, J.-Y., Lynn, B., Rosenzweig, C., Schultz, M., Rast, S., Newchurch, M., Wang, L., 2011. An Analysis of Long-term Regional-scale Ozone Simulations Over the Northeastern United States: Variability and Trends. *Atmospheric Chemistry and Physics,* 11: 567–582.

[39] U.S. Environmental Protection Agency, 2014. Guidance for $PM_{2.5}$ Modeling. May 20, 2014. Publication No. EPA–454/B–14–001. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[40] U.S. Environmental Protection Agency, 2016. Guidance for Ozone and $PM_{2.5}$ Permit Modeling. Publication No. EPA–454/B–16–005. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

to consider CALPUFF as a screening technique along with other Lagrangian models to be used in consultation with the appropriate reviewing authority. In order to provide the user community flexibility in estimating single-source secondary pollutant impacts and given the availability of more appropriate modeling techniques, such as photochemical grid models (which address limitations of models like CALPUFF [41]), the EPA proposed that the *Guideline* no longer contain language that requires the use of CALPUFF or another Lagrangian puff model for long-range transport assessments. The EPA did recognize that long-range transport assessments may be necessary in certain limited situations for PSD increments, particularly for Class I areas. For these situations, the EPA proposed a screening approach where CALPUFF, along with other appropriate screening tools and methods, may be used to support long-range transport assessments of PSD increments.

We received comment that there may also be certain situations where long-range transport assessments of NAAQS compliance may be necessary because either near-field NAAQS compliance is not required or the nearest receptors of concern are greater than 50 km (*e.g.,* many Outer Continental Shelf sources). We agree with this comment and are amending the proposed screening approach in section 4.2 of the *Guideline* to also include a long-range assessment of NAAQS compliance, when appropriate. Specifically, to determine if NAAQS or PSD increments analyses may be necessary beyond 50 km (*i.e.,* long-range transport assessment), the EPA is updating its recommended screening approach to cases where near-field NAAQS compliance is not required or the nearest receptors of concern are greater than 50 km away.

Some commenters also expressed concern about the appropriateness of the EPA's technical basis for establishing the long-range transport screening assessment and, in particular, the appropriateness of the ambient levels used as benchmarks for evaluating the hypothetical source impacts. To support the EPA's proposed approach for long-range transport, we provided a TSD that demonstrated the level of single-source impacts from a variety of facility types.[42] The facility impacts were compared to benchmark ambient values for NO_2, SO_2, PM_{10}, and $PM_{2.5}$ in order to determine which facility types and pollutants might have impacts above these levels at 50 km from the source. The comments on the proposal indicated confusion about which values were applied in the TSD and, in particular, confusion about values used for Class I areas for both NAAQS and PSD increments. The EPA believes that because each NAAQS is uniform throughout the class areas, no class-specific protection is necessary when assessing whether a source causes or contributes to a violation of the NAAQS. Thus, for all NAAQS analyses, a uniform set of benchmark ambient values were used in the TSD across all class areas. However, the EPA recognizes that, historically, Congress has provided special protections to Class I areas, via more protective PSD increments. Thus, for all PSD increments analyses detailed in the TSD, more conservative benchmark ambient values applicable to Class I areas for PSD increments were used. The EPA has updated the TSD to more clearly reflect these conditions and alleviate the confusion on behalf of the commenters. These modifications do not affect the results or conclusions from the analysis or the finalization of the EPA's approach for long-range transport screening.

A number of commenters expressed concern about the EPA's proposed removal of CALPUFF as the preferred long-range transport model in appendix A and do not support its removal without replacement. Other commenters indicated that a lack of an EPA-preferred long-range transport model increases uncertainty in performing Class I PSD increment analyses or could lead to inconsistent modeling approaches for such analyses. Also, many of these same commenters expressed concerns about the need for its approval as an alternative model and the additional time that such a process would entail.

The EPA has presented a well-reasoned and technically sound screening approach for long-range transport assessments for NAAQS and PSD increments that streamlines the time and resources necessary to conduct such analyses and provides for appropriate flexibility in the use of CALPUFF or other Lagrangian models as a screening technique. To address concerns by commenters related to the approval of CALPUFF or other Lagrangian model in this screening approach, the EPA has modified section 4.2.1 of the *Guideline* to specifically recognize the use of Lagrangian models as an appropriate screening technique, for this purpose, that does not need to be approved by the EPA as an alternative model. Rather, the selection of specific model and model parameters must be done in consultation with the appropriate reviewing authority and EPA Regional Office. We consider the flexibility in selection of the appropriate screening technique provided by this long-range screening approach to be critically important for applicants to apply the most suitable technical basis to inform these complex situations. To the extent that a cumulative impact analysis is necessary at distances beyond 50 km, then the use of a Lagrangian or other model is subject to approval under section 3.2.2(e) of the *Guideline.* In response to commenter concerns about the additional time and potential delays associated with such approvals, as discussed in more detail later in this preamble, the EPA disagrees with such contentions and notes that the recently observed average response time of MCH concurrences on alternative models is less than a month.

Some commenters also stated that the EPA had not provided sufficient scientific or technical justification for removal of CALPUFF in appendix A, while other commenters supported the removal of CALPUFF as a preferred model. One commenter provided detailed information documenting the inconsistent nature of CALPUFF performance to more fully support the EPA's proposed action to remove it as a preferred model. As detailed in the Response to Comments document, the EPA has fully documented the past and current concerns related to the regulatory use of the CALPUFF modeling system and believes that these concerns, including the well-documented scientific and technical issues with the modeling system, support the EPA's decision to remove it as a preferred model in appendix A of the *Guideline.* In addition, there was no substantive or technical information submitted in the public comments that would lead the EPA to reconsider its documented concerns about the CALPUFF modeling system and its regulatory use.

In addition, a few commenters recommended that the EPA consider Lagrangian CTMs to address long-range transport from single sources. In this regard, some commenters mentioned the

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[41] U.S. Environmental Protection Agency, 2016. Reassessment of the Interagency Workgroup on Air Quality Modeling Phase 2 Summary Report; Revisions to Phase 2 Recommendations. Publication No. EPA–454/R–16–007. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[42] U.S. Environmental Protection Agency, 2015. Technical Support Document (TSD) for AERMOD-Based Assessments of Long-Range Transport Impacts for Primary Pollutants. Publication No. EPA–454/B–15–003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

more advanced version of CALPUFF for consideration here and specifically proposed that the SCICHEM model can also provide an alternative modeling platform for all single-source regulatory applications including ozone and secondary $PM_{2.5}$ impacts. In addition, they noted that SCICHEM does not suffer from limitations of other Lagrangian puff models with respect to overlapping puffs having similar access to background species as noted in the EPA's single-source modeling guidance. While the information provided by commenters is not sufficient for the EPA to adopt a replacement to CALPUFF as an appendix A model for long-range transport, this information clearly indicates that there are other models available and potentially suitable for use in these situations. Given the EPA's determination regarding the appropriateness of using current models and tools to address single-source impacts on ozone and secondary $PM_{2.5}$, we will continue to work with the modeling community on the development and evaluation of models that may be suitable for future consideration as preferred models to meet long-range assessment needs, as well as broader use in demonstrating compliance with NAAQS and PSD increments. Such developments would further strengthen the scientific credibility of the models and approaches used under the *Guideline* and continue to streamline their regulatory application through use of integrated models with capabilities to address multiple pollutants.

As previously noted in the proposed rule, Phase 3 of the IWAQM process was reinitiated in June 2013 to further the EPA's commitment to update the *Guideline* to address chemically reactive pollutants in near-field and long-range transport applications. This Phase 3 effort included the establishment of a workgroup composed of EPA and Federal Land Managers (FLM) technical staff focused on long-range transport of primary and secondary pollutants with an emphasis on use of consistent approaches to those being developed and applied to meet near-field assessment needs for ozone and secondarily-formed $PM_{2.5}$. The EPA expects that such approaches will be focused on state-of-the-science CTMs as detailed in IWAQM reports [43] [44] and published literature.

To inform future consideration of visibility modeling in regulatory applications consistent with the EPA's guidance for addressing chemistry for single-source impact on ozone and secondary $PM_{2.5}$, the final report [44] of the IWAQM long-range transport subgroup identified that modern CTMs have evolved sufficiently and provide a credible platform for estimating potential visibility impacts from a single or small group of emission sources. Such CTMs are well suited for the purpose of estimating long-range impacts of secondary pollutants, such as $PM_{2.5}$, that contribute to regional haze and other secondary pollutants, such as ozone, that contribute to negative impacts on vegetation through deposition processes. These multiple needs require a full chemistry photochemical model capable of representing gas, particle, and aqueous phase chemistry for $PM_{2.5}$, haze, and ozone.

Photochemical grid models are suitable for estimating visibility and deposition since important physical and chemical processes related to the formation and transport of PM are realistically treated. Source sensitivity and apportionment techniques implemented in photochemical grid models have evolved sufficiently and provide the opportunity for estimating potential visibility and deposition impacts from one or a small group of emission sources using a full science photochemical grid model. Photochemical grid models using meteorology output from prognostic meteorological models have demonstrated skill in estimating source-receptor relationships in the near-field [24] [27] and over long distances.[45]

Photochemical grid models have been shown to demonstrate similar skill to Lagrangian models for pollutant transport when compared to measurements made from multiple mesoscale field experiments.[45] Use of CTMs for Air Quality Related Values (AQRV) analysis requirements, while not subject to specific EPA model approval requirements outlined in 40 CFR 51.166(l)(2) and 40 CFR 52.21(l)(2), should be justified for each application following the general recommendations outlined in section 3.2.2 of the *Guideline,* and concurrence sought with the affected FLM(s).

As proposed, with revisions discussed above, we are taking final action to codify the screening approach to address long-range transport for purposes of assessing NAAQS and/or PSD increments; removing CALPUFF as a preferred model in appendix A for such long-range transport assessments; and confirming our recommendation to consider CALPUFF as a screening technique along with other Lagrangian models that may be used as part of this screening approach without alternative model approval. As detailed in the preamble of the proposed rule, it is important to note that the EPA's final action to remove CALPUFF as a preferred appendix A model in this *Guideline* does not affect its use under the FLM's guidance regarding AQRV assessments (FLAG 2010) nor any previous use of this model as part of regulatory modeling applications required under the CAA. Similarly, this final action does not affect the EPA's recommendation that states use CALPUFF to determine the applicability and level of best available retrofit technology in regional haze implementation plans.[46] It is also important to note that the use of CALPUFF in the near-field as an alternative model for situations involving complex terrain and complex winds is not changed by removal of CALPUFF as a preferred model in appendix A. The EPA recognizes that AERMOD, as a Gaussian plume dispersion model, may be limited in its ability to appropriately address such situations, and that CALPUFF or other Lagrangian model may be more suitable, so we continue to provide the flexibility of alternative model approvals (as has been in place since the 2003 revisions to the *Guideline*).

7. Role of EPA's Model Clearinghouse (MCH)

We proposed to codify our existing practice of requiring consultation and coordination between the EPA Regional Offices and the EPA's MCH on all approvals (under section 3.2.2 of the *Guideline*) of alternative models or techniques. This coordination process has been in practice for almost three decades during which the MCH has served a critical role in helping resolve issues that have arisen from unique situations that were not specifically addressed in the *Guideline* or necessitated the consideration of an alternative model or technique for a

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[43] U.S. Environmental Protection Agency, 2015. Interagency Workgroup on Air Quality Modeling Phase 3 Summary Report: Near-Field Single Source Secondary Impacts. Publication No. EPA 454/P–15–002. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[44] U.S. Environmental Protection Agency, 2015. Interagency Workgroup on Air Quality Modeling Phase 3 Summary Report: Long Range Transport and Air Quality Related Values. Publication No. EPA 454/P–15–003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[45] ENVIRON, 2012. Documentation of the Evaluation of CALPUFF and Other Long Range Transport Models using Tracer Field Experiment Data, EPA Contract No: EP–D–07–102. February 2012. 06–20443M4. *https://www3.epa.gov/ttn/scram/reports/EPA-454_R-12-003.pdf.*

[46] *See* 70 FR 39104, 39122–23 (July 6, 2005).

specific application or range of applications. However, the most comprehensive documentation of this coordination process was a 1988 EPA memorandum to the EPA Regional Offices defining the Model Clearinghouse Operational Plan,[47] which was not widely available to the regulated modeling community until it is was included in the docket for the proposed rule. In response to the proposal and docketed information, the EPA received a wide range of comments regarding the MCH and the related proposed revisions to the *Guideline.*

The majority of the commenters expressed varying levels of concern with the potential for significant delay to the permit review process if all the EPA Regional Office alternative model approvals were required to seek concurrence from the MCH. Several commenters suggested that the current process, as defined in the existing *Guideline,* is appropriate and should not be changed. Other commenters stated that the current MCH process is slow, cumbersome, and in many ways, not needed. Certain industry commenters recommended the establishment of specific timeline requirements for the EPA Regional Office and MCH alternative model approvals. Other industry comments recommended the establishment of an external review committee for alternative model approvals and/or an external advisory group to recommend additional changes to the MCH process. Finally, there were a few comments expressing concern that the MCH process is not well-known and that decisions by the MCH are not widely disseminated.

With regard to comments about possible delay to the approval process for an alternative model, it is important to point out that the revisions to the *Guideline* are only codifying an existing process between the EPA Regional Offices and the Model Clearinghouse. Therefore, the administrative processing time for these approvals should not be affected by codifying the existing process. In fact, we anticipate that this action will further streamline the process by clarifying it for the regulatory modeling community. Additionally, the revisions will ensure fairness, consistency, and transparency in modeling decisions across all EPA Regional Offices. Additional important aspects of these revisions were noted and supported through comment by several state air permitting agencies, an organization representing the state agencies, and a large industrial trade organization.

It is important to note that the EPA's MCH has formally accepted and concurred with five alternative model requests from the EPA Regional Offices since proposal of this rule. The average MCH response time for those five requests was 28 days. There was some variability in the timing of these formal concurrences with one of the concurrences being completed within less than a day; three of the concurrences taking approximately 22 days; and one of the more complex requests taking slightly longer than 2 months. The range of MCH response times over the past year is indicative of applicants that have either engaged early with their respective EPA Regional Office through vetting of a modeling protocol and the identification and coordination of significant issues prior to submittal of their modeling compliance demonstration, or applicants that have performed a substantial amount of modeling work and justification documentation prior to any engagement with the EPA Regional Office or MCH.

When applicants do not engage with the EPA early in the process, additional time is often needed for the justification of the alternative model or options selected and/or remodeling of their facility based on issues realized through review by the EPA. In a few cases, the approach desired by an applicant had to be completely reworked from the beginning, which created significant delays in the permit review and approval process. Early engagement with the EPA will result in the shortest amount of time needed for any alternative model approval by the Agency. However, complex situations involving facilities with unique issues, and requesting a completely new or novel alternative model approach, will require additional time for the applicant, the appropriate reviewing authority, the EPA Regional Office, and the EPA's MCH to collaboratively work together through an informed and iterative process to achieve an approvable alternative model submittal. For these reasons and the recently observed response time of MCH concurrences on alternative models of less than a month, we believe that it is unwarranted to impose a regulatory time limit on the MCH concurrence process. The revised Model Clearinghouse Operational Plan outlines the MCH process by defining the roles and responsibilities of all parties, providing thorough descriptions and flow diagrams, referencing the current databases that store all formal MCH decisions, making available templates for request memoranda and other pertinent information, and providing "best practice" examples of request memoranda that highlight how to best inform the MCH process. We believe these enhancements will increase clarity and understanding of this process and make the imposition of a regulatory time limit unnecessary. This Model Clearinghouse Operational Plan is included in the docket and available on the EPA's SCRAM Web site.

The suggestion by commenters to use an external review committee for alternative model approvals is unnecessary and inappropriate. The CAA requires that air quality models are specified by the EPA Administrator. Any modification or substitution of a regulatory model under the *Guideline* can only be made with written approval of the Administrator. The delegation of this preferred model or alternative model approval process can only occur within the EPA. Also, an external review committee would add another layer of review and coordination to the prerequisite EPA processes and would ultimately result in delays in the overall permit review and approval process. Aside from future regulatory revisions of the *Guideline,* the EPA is required per CAA section 320 to conduct a Conference on Air Quality Modeling at least every 3 years, at which time formal public comment on the MCH process or any other aspect of the *Guideline* can be provided. The EPA believes that the current process demonstrates our continued commitment to provide the regulatory community with scientifically credible models and techniques developed through collaborative efforts, which are provided in updates to the *Guideline.*

In this action, as proposed, we are codifying the long-standing process of the EPA Regional Offices consulting and coordinating with the MCH on all approvals of alternative models or techniques. While the Regional Administrators are the delegated authority to issue such approvals under section 3.2.2 of the *Guideline,* all alternative model approvals will be issued only after consultation with the EPA's MCH and formal documentation through a concurrence memorandum that indicates that the alternative model requirements in section 3.2.2 have been met.

8. Updates to Modeling Procedures for Cumulative Impact Analysis

As discussed in the preamble to our proposed action, based on input from the Tenth Modeling Conference and

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[47] U.S. Environmental Protection Agency, 2016. Model Clearinghouse: Operational Plan. Publication No. EPA–454/B–16–008. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

recent permit modeling experiences under the 1-hour NAAQS for SO_2 and NO_2, we proposed revisions in section 8 of the *Guideline* and associated guidance to provide the necessary clarification in selecting and establishing the model domain and inputs for conducting the regulatory modeling for PSD and SIP applications. In addition to solicited public feedback on section 8, we received numerous public comments with respect to section 9 of the *Guideline,* which is revised to more clearly summarize the general concepts represented throughout the *Guideline* and set the stage for appropriate regulatory application of models and/or, in rare circumstance, air quality monitoring data.

Many of these revisions are based on the EPA clarification memoranda issued since 2010 that were intended to provide the necessary clarification regarding applicability of the *Guideline* to PSD modeling for these new standards.[48] [49] [50] [51] The EPA has specifically cautioned against the literal and uncritical application of very prescriptive procedures for conducting NAAQS and PSD increments modeling compliance demonstrations as described in chapter C of the 1990 draft New Source Review Workshop Manual.[52] Following such procedures in a literal and uncritical manner has led to practices that are overly conservative and unnecessarily complicate the permitting process.

Commenters were supportive of the addition of the definition of the modeling domain, including the appropriate factors to consider, for NAAQS and PSD increments assessments and for SIP attainment demonstrations in section 8 of the *Guideline.* However, several commenters stated that the discussion in the proposed *Guideline* could result in conservatively large modeling domains regularly extending to 50 km. A typographical error was identified in that discussion that may have caused this confusion and is corrected in this final rule. With this correction, it is now clear that the modeling domain or proposed project's impact area is defined as an area with a radius extending from the new or modifying source to: (1) The most distant location 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* [emphasis added]. In most situations, the extent to which a significant ambient impact could occur from a new or modifying source likely will be considerably less than 50 km.

Commenters also were supportive of the expanded discussion of receptor sites in section 9 of the *Guideline.* There were several requests for additional considerations for the potential exclusion of receptors from the modeling domain based on various factors. Along these lines, a few commenters requested that we add a formal definition of ''ambient air'' into the *Guideline* and provide specific exceptions to allow for the exclusion of certain receptors. The definition of ''ambient air'' and related provisions are provided in 40 CFR 50.1(e). Principles for justifying exclusion of particular areas from this definition of ''ambient air'' are discussed in EPA guidance for the PSD program. The EPA has not proposed to revise this definition or how the EPA has interpreted it in guidance. Thus, we do not believe it is necessary to address this topic within the *Guideline.*

There was overwhelming support by the stakeholder community for revisions to the *Guideline* that would bring additional clarity and flexibility concerning the process of determining background concentrations used in constructing the design concentration, or total air quality concentration, as a part of a cumulative impact analysis for NAAQS and PSD increments. There were, however, numerous specific public comments highlighting typographical errors or requesting additional clarifications on particular details of this process. Where appropriate, revisions were made to the *Guideline* to address many of these comments. A few of the public comments identified concerns that we have already addressed within other portions of the *Guideline* or desired more technical detail than is necessary in regulatory text and are best addressed through updates to existing technical guidance.

In particular, there were numerous requests to further clarify the analysis of significant concentration gradients from ''nearby sources,'' as used in the selection of which nearby sources should be explicitly modeled in a cumulative impact assessment under PSD. In the proposed revisions to the *Guideline,* we expanded the concept of significant concentration gradients from the previous version of the *Guideline.* Given the uniqueness of each modeling situation and the large number of variables involved in identifying nearby sources, we continue to believe that comprehensively defining significant concentration gradients in the *Guideline* is inappropriate and could be unintentionally and excessively restrictive. Rather, the identification of nearby sources to be explicitly modeled is regarded as an exercise of professional judgment to be accomplished jointly by the applicant and the appropriate reviewing authority. Following this final action, we will continue to work with the stakeholder community to clarify and improve upon the existing technical guidance and associated approaches that could be used to develop and analyze significant concentrations gradients from nearby sources.

We received numerous comments from the stakeholder community supporting the proposed revisions to Tables 8–1 and 8–2 that allow for the modeling of nearby sources using a representation of average actual emissions based on the most recent 2 years of normal source operation. Typographical errors were noted in the public comments and have subsequently been corrected in both of these tables. The public comments also include additional recommendations for alternate procedures to develop or calculate actual emissions; however, these commenters either did not include substantive technical support for these recommendations or they were inconsistent with the required application of the preferred appendix A model.

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[48] U.S. Environmental Protection Agency, 2010. Applicability of Appendix W Modeling Guidance for the 1-hour NO2 NAAQS. Memorandum dated June 28, 2010, Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www3.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-NO2-NAAQS_FINAL_06-28-2010.pdf.*

[49] U.S. Environmental Protection Agency, 2010. Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 NAAQS. Memorandum dated August 23, 2010, Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www3.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-SO2-NAAQS_FINAL_08-23-2010.pdf.*

[50] U.S. Environmental Protection Agency, 2011. Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS. Memorandum dated March 1, 2011, Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www3.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf.*

[51] U.S. Environmental Protection Agency, 2014. Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard. Memorandum dated September 30, 2014, Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www3.epa.gov/ttn/scram/guidance/clarification/NO2_Clarification_Memo-20140930.pdf.*

[52] U.S. Environmental Protection Agency, 1990. New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting (Draft). Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www.epa.gov/nsr.*

Several commenters from the industrial sector suggested that the *Guideline* should be further amended to allow modeling approaches that account for emissions variability in NSR permitting for new and modifying sources. Additionally, there was public comment that highly intermittent sources should be categorically excluded from NAAQS assessments for statistically-based short-term standards. The emissions variability approaches and exclusion of highly intermittent sources would be a significant departure from long-standing EPA policy in the NSR program and are not addressed in the *Guideline.* If there are future revisions to the NSR program that would allow for such considerations, then appropriate revisions to the *Guideline* would be considered at that time.

A few public comments expressed concern with our recommendation of using the current monitored design value as the background ambient concentration to be included with any explicitly modeled nearby sources and the estimated modeled impact of the source for comparison to the appropriate NAAQS in PSD assessments. The concern expressed in the comments is that this practice is exceedingly conservative and results in very unrealistic characterizations of the design concentration. We agree that certain combinations of monitored background data and modeled concentrations can lead to overly conservative assessments. However, we also point out that section 8.3.2(c) of the *Guideline* clearly states that the best starting point for many cases is the use of the current design value, but there are many cases in which the current design value may not be appropriate. We then provide four example cases where the use of the current monitored design value is not appropriate and further state that this list of examples is not exhaustive such that other cases could be considered on a case-by-case basis with approval by the appropriate reviewing authority.

The modeling protocols discussion at the beginning of section 9 of the *Guideline* received a few public comments. One commenter wanted the discussion to be less prescriptive and not require involvement of the EPA Regional office for every protocol. Another commenter wanted the EPA to establish specific deadlines for approvals (or disapprovals) of modeling protocols. We are aware that the discussion on modeling protocols does not contain any specific requirements for applicants or permit reviewing authorities. Rather, the modeling protocol discussion is provided to recommend best practices to streamline the regulatory modeling process and avoid unnecessary work and additional permit delays. Given the added complexity of the technical issues that arise in the context of demonstrating regulatory compliance through air quality modeling, we strongly encourage the development of comprehensive modeling protocols by the applicants and a thorough vetting of these protocols by the appropriate reviewing authority prior to the start of any work on a project. In circumstances where alternative models or non-*Guideline* procedures are being considered, it is advisable to also include the EPA Regional Office in the initial protocol meeting if it is not the primary permit reviewing authority.

Finally, there were a few general comments on the discussion of NAAQS and PSD increments compliance demonstrations within section 9 of the *Guideline.* Some of those comments offered additional suggestions for revisions to the *Guideline* that are addressed in the Response to Comments document located in the docket for this action. In particular, one commenter criticized the multi-stage process recommended by the EPA, which has been applied in the PSD program for more than 25 years. The commenter argued that a cumulative impact analysis must always be conducted and that there was no other rational way to show that a new or modifying source will not cause or contribute to a violation of the NAAQS or PSD increments. In this context, the commenter argued against the use of ‘‘significant impact levels’’ to show, based on a single-source analysis, that an individual source does not cause or contribute to a violation of the NAAQS or PSD increments. The EPA has revised section 9.2.3 of the proposed *Guideline* to make more clear that this two-stage approach is a recommendation and not a requirement. To the extent this recommendation is followed, interested parties retain the opportunity to comment on the adequacy of a single-source analysis and to call for a cumulative impact analysis to make the required demonstration in the context of individual permits.

Further, the EPA is not establishing SILs in this rulemaking and did not intend to codify the use of these values in the *Guideline.* Our use of the term ‘‘significant impact’’ was intended to carry forward principles previously reflected in sections 10.2.1(b), 10.2.1(c) and 10.2.3.2(a) of the 2005 version of the *Guideline.* To make clear that this rule is not codifying the application of SILs and is only describing the outline of a recommended multi-stage process for making the required demonstration, we have removed the term ‘‘significant impact’’ from many parts of section 9.2.3. In a separate guidance,[20] the EPA has provided a legal and technical rationale that permitting authorities may consider adopting to support the use of ‘‘significant impact levels’’ to quantify a degree of concentration impact below which a source does not have the potential to cause or contribute to a violation. This rationale, which is not adopted by the EPA in this rule, differs in material respects from the basis for a prior EPA rulemaking to adopt SILs that this commenter criticized.

As proposed, we are finalizing revisions to sections 8 and 9 of the *Guideline* to add necessary clarity where requested by public commenters and to correct typographical errors. The EPA fully expects that, by providing more clarity in the *Guideline* of the factors to be considered in conducting both the single-source impact and cumulative impact assessments, permit applicants and permitting authorities will find the proper balance across the various competing factors that contribute to these analyses.

9. Updates on Use of Meteorological Input Data for Regulatory Dispersion Modeling

The EPA solicited comments on the proposed updates regarding use of meteorological input data for regulatory application of dispersion models, including the use of 2-minute Automated Surface Observing Stations (ASOS) for hourly average winds to replace standard hourly observations, and the use of prognostic meteorological data for areas where there is no representative NWS data and it is infeasible or prohibitive to collect site-specific data.

For near-field dispersion modeling applications using NWS ASOS sites, the EPA released a pre-processor to AERMET, called AERMINUTE, in 2011 that calculates hourly averaged winds from 2-minute winds reported every minute at NWS ASOS sites. AERMET substitutes these hourly averaged winds for the standard hourly observations, and thus reduces the number of calms and missing winds for input to AERMOD. The presence of calms and missing winds were due to the METAR reporting methodology of surface observations. In March 2013, the EPA released a memorandum regarding the use of ASOS data in AERMOD,[53] as well as the use of AERMINUTE. When using meteorological data from ASOS sites for input to AERMOD, hourly averaged winds from AERMINUTE should be used in most cases.

For a near-field dispersion modeling application where there is no representative NWS station, and it is prohibitive or not feasible to collect adequately representative site-specific data, it may be necessary to use prognostic meteorological data for the application. The EPA released the MMIF program that converts the prognostic meteorological data into a format suitable for dispersion modeling applications. The most recent 3 years of prognostic data are preferred. Use of the prognostic data are contingent on the concurrence of the appropriate reviewing authority and collaborating agencies that the data are of acceptable quality and representative of the modeling application.

We received many comments favorable to the use of prognostic meteorological data. While supporting the use of prognostic meteorological data, many commenters also requested additional guidance on running the prognostic meteorological models, assessing the suitability of the model output, and the use of MMIF to generate the meteorological data needed for AERMET and AERMOD. Based on the comments received, the EPA has updated the guidance[54] on use of the prognostic meteorological data.

Therefore, as proposed, the EPA is updating the *Guideline* to recommend that AERMINUTE output should be routinely used in most cases when meteorological data from NWS ASOS sites are used for input to AERMOD and that representative prognostic meteorological data are appropriate for use in dispersion modeling within areas where there is no representative NWS data, or it is infeasible or prohibitive to collect site-specific meteorological data.

B. Final Editorial Changes

In this action, the EPA is making editorial changes to update and reorganize information throughout the *Guideline.* These revisions are intended to make the *Guideline* easier to use, without meaningfully changing the substance of the *Guideline,* by grouping topics together in a more logical manner to make related content easier to find. This in turn should streamline the compliance assessment process.

We describe these editorial changes below for each affected section of the *Guideline,* as well as changes associated with the resolution of the comments and issues discussed in section IV.A. of this preamble and the correction of typographical errors identified in our proposal. For ease of reference, we are publishing the entire text of appendix W and its appendix A, as revised through today's action.

1. Preface

As proposed, the preface is updated to reflect minor text revisions for consistency with the remainder of the *Guideline.*

2. Section 1

The introduction section is updated to reflect the reorganized nature of the revised *Guideline* as proposed. Additional information is provided regarding the importance of CAA section 320 to amendments of the *Guideline.*

3. Section 2

As proposed, section 2 is revised to more appropriately discuss the process by which models are evaluated and considered for use in particular applications. Information from the previous section 9 pertaining to model accuracy and uncertainty is incorporated within this section to clarify how model performance evaluation is critical in determining the suitability of models for particular application.

A discussion is provided in section 2.1 of the three types of models historically used for regulatory demonstrations. For each type of model, some strengths and weaknesses are listed to assist readers in understanding the particular regulatory applications to which they are most appropriate.

In addition, we revised section 2.2 with respect to the recommended practice of progressing from simplified and conservative air quality analysis toward more complex and refined analysis. In this section, we clarify distinctions between various types of models that have previously been described as screening models. In addition, this section clarifies distinctions between models used for screening purposes and screening techniques and demonstration tools that may be acceptable in certain applications.

A few typographical corrections were made in this section based on public comment and additional review of the proposed regulatory text. Also, based on public comment, clarity was added to the description of the modeling process to indicate that an applicant may choose to implement controls or operational limits based on screening modeling rather than performing additional refined modeling.

4. Section 3

There were minor modifications, including a few typographical corrections, made to section 3 based on public comment to more accurately reflect current EPA practices. As proposed, the discussion of the EPA's MCH is moved to a revised section 3.3 for ease of reference and prominence within the *Guideline.* With this action, EPA Regional Office consultation with and concurrence by the MCH is required on all alternative model approvals. Previously, section 3 included various requirements under a recommendation subheading that were not clearly identified as requirements. Accordingly, we modified section 3 with the incorporation of requirement subsections to eliminate any ambiguity. Finally, the metric used to demonstrate equivalency of models (section 3.2.2) is modified based on public comment to be more appropriate for both deterministic and probabilistic based standards.

5. Section 4

As proposed, section 4 is revised to incorporate the modeling approaches recommended for air quality impact analyses for the following criteria pollutants: CO, lead, SO_2, NO_2, and primary $PM_{2.5}$ and PM_{10}. The revised section 4 is now a combination of the previous sections 4 and 5, reflecting inert criteria pollutants only. We also modified section 4 to incorporate requirement subsections that provide clarity to the various requirements where, previously, sections 4 and 5 included various requirements under recommendation subheadings.

Section 4 now provides an in-depth discussion of screening and refined models, including the introduction of AERSCREEN as the recommended screening model for simple and complex terrain for single sources. We included a clear discussion of each appendix A preferred model in section 4.3. We modified the discussion for each preferred model (*i.e.,* AERMOD Modeling System, CTDMPLUS, and OCD) from the previous section 4 with

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[53] U.S. Environmental Protection Agency, 2013. Use of ASOS Meteorological Data in AERMOD Dispersion Modeling. Memorandum dated March 8, 2013, Office of Air Quality Planning and Standards, Research Triangle Park, NC. *https://www3.epa.gov/ttn/scram/guidance/clarification/20130308_Met_Data_Clarification.pdf.*

[54] U.S. Environmental Protection Agency, 2016 Guidance on the Use of the Mesoscale Model Interface Program (MMIF) for AERMOD Applications. Publication No. EPA–454/B–16–003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

appropriate edits and some streamlining based on information available in the respective model formulation documentation and user's guides.

We added a subsection specifically addressing the modeling recommendations for SO_2 where, previously, section 4 of the *Guideline* was generally understood to be applicable for SO_2. We made minor updates with respect to the modeling recommendations for each of the other inert criteria pollutants that were previously found in section 5. For NO_2, the ARM2 is added as a Tier 2 option, and the Tier 3 options of OLM and PVMRM are now regulatory options in AERMOD. For refined modeling of mobile sources, we have revised our previous language regarding the use of the CALINE3 models and are now listing AERMOD, where appropriate. As previously discussed in section IV.A.4 of this preamble, the section on CO modeling has been revised to reference existing guidance for CO screening rather than discussing screening approaches with AERMOD.

Throughout section 4, typographical errors in our proposal were noted by commenters. We have corrected those errors and made some minor revisions for additional clarity addressing some confusion that was expressed in several public comments. Of note, modifications to the requirements discussion of section 4.2 from our proposal were made to account for the potential need for a NAAQS compliance demonstration for long-range transport situations where a near-field assessment for NAAQS is not available or indicates a significant ambient impact at or about 50 km.

6. Section 5

As stated above, much of the previous section 5 (*i.e.,* the portions pertaining to the inert criteria pollutants) is now incorporated into the revised section 4. As proposed, the revised section 5 focuses only on the modeling approaches recommended for ozone and secondary $PM_{2.5}$. Other than addressing a few typographical errors based on public comment, the only additions to section 5 from proposal are a few transitional statements that were added for additional clarity.

Both ozone and secondary $PM_{2.5}$ are formed through chemical reactions in the atmosphere and are not appropriately modeled with traditional steady-state Gaussian plume models, such as AERMOD. Chemical transport models are necessary to appropriately assess the single-source air quality impacts of precursor pollutants on the formation of ozone or secondary $PM_{2.5}$.

While the revisions to section 5 do not specify a particular EPA-preferred model or technique for use in air quality assessments, we have established a two-tiered screening approach for ozone and secondary $PM_{2.5}$ with appropriate references to the EPA's new single-source modeling guidance. The first tier consists of technically credible and appropriate relationships between emissions and the impacts developed from existing modeling simulations. If existing technical information is not available or appropriate, then a second tier approach would apply, involving use of sophisticated CTMs (*e.g.,* photochemical grid models) as determined in consultation with the appropriate EPA Regional Office on a case-by-case basis based upon the EPA's new single-source modeling guidance.

7. Section 6

As proposed, section 6 is revised to more clearly address the modeling recommendations of other federal agencies, such as the FLMs, that have been developed in response to EPA rules or standards. Based on public comment from a tribal association and several tribes, we have added clarifying language that indicates that other state, local, or tribal agencies with air quality and land management responsibilities may also have specific modeling approaches for their own regulatory or other requirements. While no attempt was made to comprehensively discuss each topic, we provide appropriate references to the respective federal agency guidance documents.

The revisions to section 6 focus primarily on AQRVs, including near-field and long-range transport assessments for visibility impairment and deposition. The interests of the Bureau of Ocean Energy and Management (BOEM) for Outer Continental Shelf (OCS) permitting situations and the FAA for airport and air base permitting situations are represented in section 6.3.

The discussion of Good Engineering Practices (GEP) for stack height consideration is modified and moved to section 7. We have removed the discussion of long-range transport for PSD Class I increments and the references to the previously preferred long-range transport model, CALPUFF, in accordance with the more detailed discussion in section IV.A.6 of this preamble.

8. Section 7

As proposed, we revised section 7 to be more streamlined and appropriate to the variety of general modeling issues and considerations that are not covered in sections 4, 5, and 6 of the *Guideline.* Information concerning design concentrations and receptor sites is moved to section 9. The discussion of stability categories has been removed from section 7 because it is specifically addressed in the model formulation documentation and guidance for the dispersion models that require stability categories to be defined. As stated above, the GEP discussion from the previous section 6 is now incorporated into this section. Based on public comment, we added a statement to the plume rise discussion to clarify that refinements to the preferred model may be considered for plume rise and downwash effects only with agreement from the appropriate reviewing authority and approval by the EPA Regional Office.

We expanded the recommendations for determining rural or urban dispersion coefficients to provide more clarity with respect to appropriate characterization within AERMOD, including a discussion on the existence of highly industrialized areas where population density is low, which may be best treated with urban rather than rural dispersion coefficients. References to CALPUFF in the Complex Winds subsection have been removed in keeping with our approach to not explicitly name models that are not listed in appendix A, so as to not imply any preferential status vis-a-vis other available models. If necessary for special complex wind situations, the setup and application of an alternative model should now be determined in consultation with the appropriate reviewing authority. Finally, we revised section 7, as proposed, to include a new discussion of modeling considerations specific to mobile sources.

9. Section 8

We made extensive updates and modifications to section 8, as proposed, to reflect current EPA practices, requirements, and recommendations for determining the appropriate modeling domain and model input data from new or modifying source(s) or sources under consideration for a revised permit limit, from background concentrations (including air quality monitoring data and nearby and others sources), and from meteorology. As with earlier sections, we modified section 8 to incorporate requirement subsections where previously section 8 ambiguously included various requirements under recommendation subheadings. Commenters identified typographical errors that have been corrected along with appropriate clarifications in this section.

The Background Concentration subsection has been significantly modified from the existing *Guideline* to include a clearer and more comprehensive discussion of ''nearby'' and ''other'' sources. This is intended to eliminate confusion over how to identify nearby sources that should be explicitly modeled and all other sources that should be generally represented by air quality monitoring data. In addition, a brief discussion on the use of photochemical grid modeling to appropriately characterize background concentrations has been included in this section. Updates to Tables 8–1 and 8–2 are made per changes in the considerations for nearby sources, as discussed in section IV.A.8 of this preamble. Based on several public comments, Table 8–2 was further updated to correctly state that the operational level for nearby sources for short-term average times is the ''temporally representative level when actually operating, reflective of the most recent 2 years.''

The use of prognostic mesoscale meteorological models to provide meteorological input for regulatory dispersion modeling applications has been incorporated throughout the ''Meteorological Input Data'' subsection, including the introduction of the MMIF as a tool to inform regulatory model applications. We made additional minor modifications to the recommendations in this subsection based on current EPA practices, of which the most substantive edit was the recommendation to use the AERMINUTE meteorological data processor to calculate hourly average wind speed and direction when processing NWS ASOS data for developing AERMET meteorological inputs to the AERMOD dispersion model.

10. Section 9

As proposed, we moved all of the information previously in section 9 related to model accuracy and evaluation into other sections in the revised *Guideline* (primarily to the revised section 2 and some to the revised section 4). This provides greater clarity in those topics as applied to selection of models under the *Guideline.* We removed a subsection on the ''Use of Uncertainty in Decision Making.'' Also, we revised section 9 to focus on the regulatory application of models, which includes the majority of the information found previously in section 10.

We revised the discussion portion of section 9 to more clearly summarize the general concepts presented in earlier sections of the *Guideline* and to set the stage for the appropriate regulatory application of models and/or, in rare circumstances, air quality monitoring data in lieu of modeling. The importance of developing and vetting a modeling protocol is more prominently presented in a separate subsection.

The information related to design concentrations is updated and unified from previous language found in sections 7 and 10. An expanded discussion of receptor sites is based on language from the previous section 7 and new considerations given past practices of model users tending to define an excessively large and inappropriate number of receptors based on vague guidance.

We added the recommendations for NAAQS and PSD increments compliance demonstrations that had been in section 10. In additions, we updated the recommendations to more clearly and accurately reflect the long-standing practice of performing a single-source impact analysis as a first stage of the NAAQS and PSD increments compliance demonstration and, as necessary, conducting a more comprehensive cumulative impact analysis as the second stage. The appropriate considerations and applications of screening and/or refined model are described in each stage.

Finally, we revised the ''Use of Measured Data in Lieu of Model Estimates'' subsection to provide more details on the process for determining the rare circumstances in which air quality monitoring data may be considered for determining the most appropriate emissions limit for a modification to an existing source. As with other portions of the revised section 9, the language throughout this subsection is updated to reflect current EPA practices, as appropriate.

11. Section 10

As proposed, we incorporated the majority of the information found previously in section 10 into the revised section 9. Section 10 now consists of the references that were in the previous section 12. Each reference is updated, as appropriate, based on the text revisions throughout the *Guideline.*

12. Section 11

In a streamlining effort, we removed the bibliography section from the *Guideline* as proposed.

13. Section 12

As stated earlier, this references section is now section 10 with appropriate updates.

14. Appendix A to the *Guideline*

As proposed, we revised appendix A to the *Guideline* to remove the BLP model, CALINE3, and CALPUFF as refined air quality models preferred for specific regulatory applications. The rationale for the removal of these air quality models from the preferred status can be found in section IV.A.2, section IV.A.4, and section IV.A.6 of this preamble. Finally, we made minor modifications, including a few typographical corrections, to appendix A based on public comment and additional review of the proposed regulatory text.

V. Statutory and Executive Order Reviews

A. Executive Order 12866: Regulatory Planning and Review and Executive Order 13563: Improving Regulation and Regulatory Review

This action is a significant regulatory action that was submitted to the Office of Management and Budget (OMB) for review. The OMB determined that this regulatory action could potentially interfere with an action taken or planned by another agency. Any changes made in response to OMB recommendations have been documented in the docket.

B. Paperwork Reduction Act (PRA)

This final action does not impose an information collection burden under the PRA. This action does not contain any information collection activities, nor does it add any information collection requirements beyond those imposed by existing NSR requirements.

C. Regulatory Flexibility Act (RFA)

I certify that this action will not have a significant economic impact on a substantial number of small entities under the RFA. In making this determination, the impact of concern is any significant adverse economic impact on small entities. An agency may certify that a rule will not have a significant economic impact on a substantial number of small entities if the rule relieves regulatory burden, has no net burden or otherwise has a positive economic effect on the small entities subject to the rule.

The modeling techniques described in this action are primarily used by air agencies and by industries owning major sources subject to NSR permitting requirements. To the extent that any small entities would have to conduct air quality assessments, using the models and/or techniques described in this action are not expected to pose any additional burden on these entities. The revisions to the existing EPA-preferred model, AERMOD, serve to increase efficiency and accuracy by changing only mathematical formulations and specific data elements. Also, this action will streamline resources necessary to conduct modeling with AERMOD by incorporating model algorithms from the BLP model. Although this final action calls for new models and/or techniques for use in addressing ozone and secondary $PM_{2.5}$, we expect most small entities will generally be able to rely on existing modeling simulations. We have, therefore, concluded that this action will have no net regulatory burden for all directly regulated small entities.

D. Unfunded Mandates Reform Act (UMRA)

This action does not contain an unfunded mandate of $100 million or more as described in UMRA, 2 U.S.C. 1531–1538 and does not significantly or uniquely affect small governments. This action imposes no enforceable duty on any state, local or tribal governments or the private sector beyond those imposed by the existing NSR requirements.

E. Executive Order 13132: Federalism

This action does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

This action does not have tribal implications, as specified in Executive Order 13175. The final rule provides revisions to the *Guideline* which is used by the EPA, other federal, state, territorial, local, and tribal air quality agencies, and industry to prepare and review new source permits, source permit modifications, SIP submittals and revisions, conformity, and other air quality assessments required under EPA regulation. The Tribal Air Rule implements the provisions of section 301(d) of the CAA authorizing eligible tribes to implement their own tribal air program. Thus, Executive Order 13175 does not apply to this action. In the spirit of Executive Order 13175, the EPA provided an informational webinar with the National Tribal Air Association (NTAA) on September 10, 2015, and also received comment on the proposed action from the NTAA and several individual tribes. These comments and our responses are included in the docket for this action.

G. Executive Order 13045: Protection of Children From Environmental Health and Safety Risks

The EPA interprets Executive Order 13045 as applying only to those regulatory actions that concern environmental health or safety risks that the EPA has reason to believe may disproportionately affect children, per the definition of ''covered regulatory action'' in section 2–202 of the Executive Order. This action is not subject to Executive Order 13045 because it does not concern an environmental health risk or safety risk.

H. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use

This action is not a ''significant energy action'' as defined in Executive Order 13211 (66 FR 28355, May 22, 2001), because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. Further, we have concluded that this action is not likely to have any adverse energy effects because its purpose is to streamline the procedures by which stakeholders apply air quality modeling and technique in conducting their air quality assessments required under the CAA and, also, increases the scientific credibility and accuracy of the models and techniques used for conducting these assessments.

I. National Technology Transfer and Advancement Act

This rulemaking does not involve technical standards.

J. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

The EPA believes that this action is not subject to Executive Order 12898 (59 FR 7629, February 16, 1994) because it does not establish an environmental health or safety standard. This regulatory action provides updates and clarifications to the *Guideline* and does not have any impact on human health or the environment.

K. Congressional Review Act (CRA)

This action is subject to the Congressional Review Act (CRA), and the EPA will submit a rule report to each House of the Congress and to the Comptroller General of the United States. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2).

List of Subjects in 40 CFR Part 51

Environmental protection, Administrative practice and procedure, Air pollution control, Carbon monoxide, Intergovernmental relations, Nitrogen oxides, Ozone, Particulate matter, Reporting and recordkeeping requirements, Sulfur oxides.

Dated: December 20, 2016.

Gina McCarthy,

Administrator.

For the reasons stated in the preamble, the Environmental Protection Agency is amending title 40, chapter I of the Code of Federal Regulations as follows:

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 the EPA's Regional Offices.

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1.0 Introduction

a. The *Guideline* provides 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 Offices, 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 the EPA to conduct a Conference on Air Quality Modeling at least every 3 years (CAA 320, 42 U.S.C. 7620). 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. Ample opportunity for public comment will be provided for each proposed change and public hearings scheduled.

h. 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.

i. 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.

2.0 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. 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. At coarse grid resolutions, Eulerian models have difficulty with fine scale resolution of individual plumes. 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 grid 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 sophisticated models are used or the area 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, error, 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 data 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 and conservative methods 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 and 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 increase in concentration attributable to 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 unless appropriate controls or operational restrictions are implemented based on the screening modeling.

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) Web site at *https://www.epa.gov/scram.* This is a Web site 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 be available from the National Technical Information Service (NTIS), *http://www.ntis.gov*, and, when available, is referenced with the appropriate NTIS accession number.

3.0 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 Web site (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 permitting under programs approved into SIPs. In some EPA regions, federal authority to administer NSR 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 Region. 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, the EPA Regional Office will coordinate and shall seek concurrence with the EPA's Model Clearinghouse. If there is any question as to the appropriate reviewing authority, you should contact the EPA Regional Office modeling contact (*https://www3.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. 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, 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 preferred model code 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 for its intended regulatory application. If the regulatory options are not applied, 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 have delegated authority to issue such approvals under section 3.2 of the *Guideline,* provided that such approval is issued after consultation with the EPA's Model Clearinghouse and formally documented in a concurrence memorandum from the 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 the 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 Web site (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 appropriate regulatory metric(s) 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 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 that 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 EPA 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 Offices, and state, local, and tribal agency modeling representatives.

b. The appropriate 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.

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 not 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, beyond which, modeled predictions of plume impact are likely conservative. The locations of these impacts 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 is considered to be an area where terrain features are all lower in elevation than the top of the stack(s) of the source(s) in question. Complex terrain is defined as terrain exceeding the height of the stack(s) 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. Thus, the Cox-Tikvart model evaluation approach, 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 contribute to ambient concentrations in excess of a NAAQS. In most cases, maximum source impacts of inert pollutants will occur within the first 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 if a near-field NAAQS compliance demonstration is required.[36]

b. For assessment of PSD increments within the near-field 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 compliance demonstration for NAAQS and/or PSD increments may be necessary beyond 50 km (*i.e.,* long-range transport assessment), the following screening approach shall be used to determine if a significant ambient impact will occur with particular focus on Class I areas and/or the applicable receptors 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 or about 50 km from the new or modifying source. If a near-field assessment is not available or this initial analysis indicates there may be significant ambient impacts at that distance, then further assessment is necessary.

ii. For assessment of the significance of ambient impacts for NAAQS and/or PSD increments, there is not a preferred model or screening approach for distances beyond 50 km. Thus, the appropriate reviewing authority (paragraph 3.0(b)) and the EPA Regional Office shall be consulted in determining the appropriate and agreed upon screening technique to conduct the second level assessment. Typically, a Lagrangian model is most appropriate to use for these second level assessments, but applicants shall reach agreement on the specific model and modeling parameters on a case-by-case basis in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and EPA Regional Office. When Lagrangian models are used in this manner, they shall not include plume-depleting processes, such that model estimates are considered conservative, as is generally appropriate for screening assessments.

d. In those situations where a cumulative impact analysis for NAAQS and/or PSD increments analysis beyond 50 km is necessary, the selection and use of 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 recommended screening model for most applications in all types of terrain and for applications involving building downwash. 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. As discussed in section 4.2(c)(ii), there are screening techniques needed for long-range transport assessments that will typically involve the use of a Lagrangian model. Based on the long-standing practice and documented capabilities of these models for long-range transport assessments, the use of a Lagrangian model as a screening technique for this purpose does not need to be approved as an alternative model. However, their usage shall occur in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and EPA Regional Office.

f. 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 to 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 for surface roughness (Z_o), Bowen ratio (B_o), and albedo (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 BPIPPRM to provide the necessary building parameters for applications involving building downwash using the Plume Rise Model Enhancements (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 1.0 for 3-hour, 0.9 for 8-hour, 0.60 for 24-hour, and 0.10 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]

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 ($d\theta/dz$), 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. Under such conditions, the plume 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 receptor locations either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptor locations 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 unforeseen 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 required 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 versus 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(e)).

c. AERMOD incorporates the 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 utilizes the standard meteorological inputs provided by the AERMET meteorological processor.

e. The state-of-the-science for modeling atmospheric deposition is evolving, 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 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 4.2.1 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. In applying these recommendations and requirements, the existing 1992 EPA guidance for screening CO impacts from highways may be consulted.[47]

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 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 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 gases 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 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 screening approach is required to obtain hourly and annual average estimates of NO_2.[54] Since these methods are considered screening techniques, 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, modeling of negative emissions rates should only be done after consultation with the EPA Regional Office to ensure that decreases in concentrations would not be overestimated. Each tiered approach (*see* Figure 4–1) accounts for increasingly complex considerations of NO_2 chemistry and is described in paragraphs c through e 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 refined model (section 4.2.2) to estimate nitrogen oxides (NO_X) concentrations and assume a total conversion of NO to NO_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 includes a minimum ambient NO_2/NO_X ratio of 0.5 and a maximum ambient ratio of 0.9. The reviewing agency may establish alternative minimum ambient NO_2/NO_X values based on the source's in-stack emissions ratios, with alternative minimum ambient ratios reflecting the source's in-stack NO_2/NO_X ratios. Preferably, alternative minimum ambient NO_2/NO_X ratios 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, and/or 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 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 roadway 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 models or 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 considered as an alternative model to estimate ambient impacts of NO_X sources.

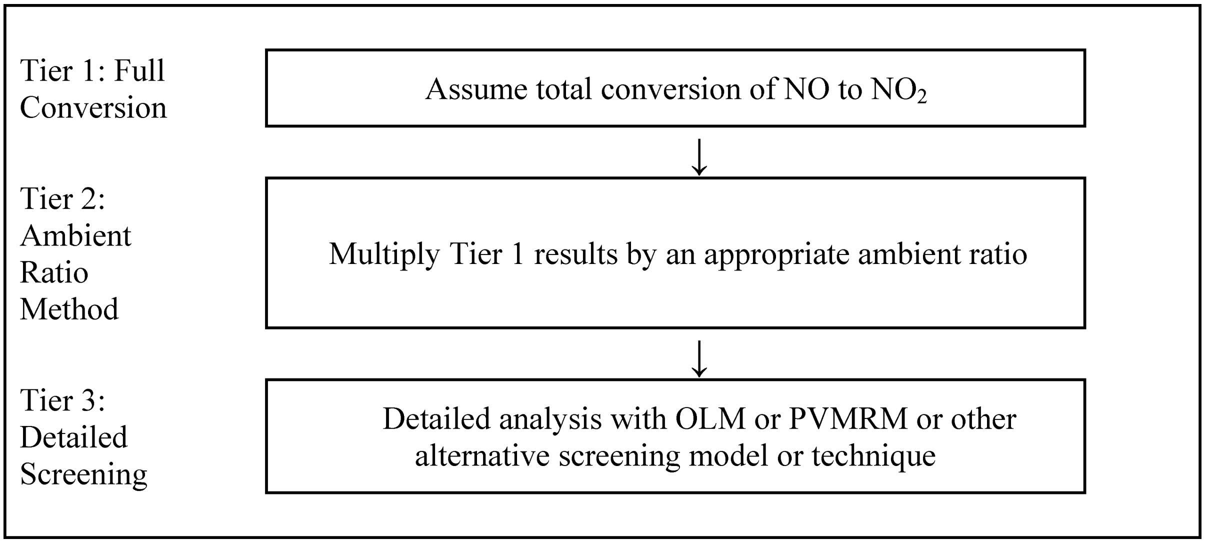

Figure 4-1: Multi-tiered Approach for Estimating NO2 Concentrations

4.2.3.5 Models for $PM_{2.5}$

a. $PM_{2.5}$ is a mixture consisting of several diverse components.[58] Ambient $PM_{2.5}$ generally consists of two components: (1) The primary component, emitted directly from a source; and (2) the secondary component, formed in the atmosphere from other pollutants emitted from the source. Models for $PM_{2.5}$ are needed to meet NSR requirements to address compliance with the $PM_{2.5}$ NAAQS and PSD increments and for SIP attainment demonstrations.

b. For NSR modeling assessments, the general modeling requirements for screening models in section 4.2.1 and refined models in section 4.2.2 are applicable for the primary component of $PM_{2.5}$, while the methods in section 5.4 are applicable 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 shall be applied for $PM_{2.5}$ hot-spot modeling for mobile sources. Specific guidance is available for analyzing direct $PM_{2.5}$ impacts from highways, terminals, and other transportation projects.[61]

4.2.3.6 Models for PM_{10}

a. Models for PM_{10} are needed to meet NSR requirements 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 on a case-by-case basis and their usage shall be coordinated with the appropriate reviewing authority. A SIP development guide[62] is also available to assist in PM_{10} analyses and control strategy development.

c. Fugitive dust 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, recommended dispersion models may not be suitable to appropriately address the nature of ambient PM_{10}. In these circumstances, the alternative modeling approach shall be approved by the EPA Regional Office (section 3.2).

e. The general modeling requirements for the refined models discussed in section 4.2.2 shall be applied for PM_{10} hot-spot modeling for mobile sources. Specific guidance is available for analyzing direct PM_{10} impacts from highways, terminals, and other transportation 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 $PM_{2.5}$ 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 and 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 mass, elemental carbon, 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 SO_2 and NO_X emissions with direct ammonia emissions.[64]

d. Control measures reducing ozone and $PM_{2.5}$ precursor emissions may not lead to proportional reductions in ozone and $PM_{2.5}$. Modeled strategies designed to reduce ozone or $PM_{2.5}$ levels typically need to consider the chemical coupling between these pollutants. 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 comprising $PM_{2.5}$.

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, ideally 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 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. [59] [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 ambient ozone is necessary for obtaining a permit. The simulation of ozone formation and transport requires realistic treatment of atmospheric chemistry and deposition. Models (*e.g.,* Lagrangian and photochemical grid models) that integrate chemical and physical processes important in the formation, decay, and transport of ozone and important precursor species should be applied. 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 or a first tier demonstration indicates a more refined assessment is needed. For these situations, chemical transport 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 guidance 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 the guidance in consultation with the appropriate reviewing authority (paragraph 3.0(b)) to determine the most suitable refined approach for single-source ozone modeling on a case-by-case basis.

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

a. Models that estimate $PM_{2.5}$ concentrations are needed to guide the choice of strategies for the purposes of a nonattainment area demonstrating future year attainment of the $PM_{2.5}$ NAAQS. Additionally, models that estimate $PM_{2.5}$ concentrations are needed to assess impacts from specific sources or source complexes to satisfy requirements for NSR 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 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 that 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 may be necessary for obtaining a permit. Primary $PM_{2.5}$ components shall be simulated using the general modeling requirements in section 4.2.3.5. 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 that 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] For situations where a project source emits both primary $PM_{2.5}$ and $PM_{2.5}$ precursors, the contribution from both should be combined for use in determining the source's ambient impact. Approaches for combining primary and secondary impacts are provided in appropriate guidance for single source permit related demonstrations. [66]

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 or a first tier demonstration indicates a more refined assessment is needed. For these situations, chemical transport 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 guidance 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 government agencies and state, local, and tribal agencies with air quality and land management responsibilities 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, state, local, or tribal agency to ensure the proper application and use of the models and/or techniques. These 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.

6.2 Air Quality Related Values

a. The 1990 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 CAA 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. Where state or tribal agencies have successfully petitioned the EPA and lands have been redesignated to Class I status, these agencies may have equivalent responsibilities to that of the FLMs for these non-federal Class I areas as described throughout the remainder of section 6.2.

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, that 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 through 51.309) 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 through 51.309). The state of relevant scientific knowledge has expanded significantly since that time. 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. Section 169A of the CAA 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]

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 that 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 may 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 BOEM's Web site: *https://www.boem.gov/GOMR-Environmental-Compliance.*

b. The Federal Aviation Administration (FAA) is the appropriate reviewing authority for air quality assessments of primary pollutant impacts at airports and air bases. The Aviation Environmental Design Tool (AEDT) is developed and 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 change in emissions for aircraft operations, point source, and mobile source emissions on airport property and quantify the associated pollutant level- concentrations. AEDT 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 the FAA at: *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 (of the two methods, the land use procedure is considered more definitive.):

i. Land Use Procedure: (1) Classify the land use within the total area, A_o, circumscribed by a 3 km 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 per square kilometer, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

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]

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)) and the latest version of the AERMOD Implementation Guide[76] when evaluating this situation.

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. Typically, geographic effects are more apparent when the ambient winds are light or calm, as stronger synoptic or mesoscale winds can modify, or even eliminate the weak geographic circulations.[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 characteristics of the winds are 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 approximate the 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. The 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, use professional judgment along with 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] that 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, AERMOD should be used (section 4.2.2).

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 in 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.

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 paragraph (a) of this subsection. 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, refinements to the preferred model may be considered for plume rise and downwash effects and 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 section 3.2.2.

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, *e.g.,* worst-case meteorological conditions. Maximum hourly concentrations computed from screening modeling can be converted to longer averaging periods using the scaling ratios specified 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 (m) of the roadway), the results can be highly sensitive to the characterization of the mobile emissions. Important characteristics for both line/area and volume sources include the plume release height, source width, and initial dispersion characteristics, and should also take into account the impact of traffic-induced turbulence that 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. Area, line or volume sources may be used for modeling mobile sources. However, experience in the field has shown that area sources may be easier to characterize correctly compared to volume sources. If volume sources are used, it is particularly important to ensure 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 that 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.

8.0 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 user's 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 increments 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 location 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 that 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 the appropriate reviewing authority (paragraph 3.0(b)) for any application specific guidance that 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, $PM_{2.5}$, 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. 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’’ emissions 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 increments, 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. 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 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]

Table 8-1. - Point Source Model Emission Inputs 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]					
Annual & quarterly	Maximum 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)	Maximum 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]
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.					

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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 time periods.)

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 Inputs 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]					
Annual & quarterly	Maximum 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)	Maximum allowable emission limit or federally enforceable permit limit.[5]		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]
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 time periods.
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 9.2.3). 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 located 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. The ambient contributions from these nearby sources are 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-source impacts for ozone and secondary $PM_{2.5}$.

d. For NAAQS assessments 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. For PSD increment assessments, all impacts after the appropriate baseline dates (*i.e.,* trigger date, major source baseline date, and minor source baseline date) from all increment-consuming and increment-expanding sources should be considered in the design concentration (section 9.2.2).

8.3.2 Recommendations for Isolated Single Sources

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 characteristics that are most similar to the project area. If there are no monitors located in the vicinity of the new or modifying 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.

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 by activities that are not typical or not expected to occur again in the future (*e.g.,* construction, roadway repairs, forest fires, or unusual agricultural activities). There may also be cases where it may be appropriate to scale (multiplying the monitored concentrations with a scaling factor) or adjust (adding or subtracting a constant value the monitored concentrations) data from specific days or hours. Such adjustments would make the monitored background concentrations more temporally and/or spatially representative of the area around the new or modifying source for the purposes of the regulatory 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 60] 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 cause 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.

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 the first 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 judgment by the appropriate reviewing authority (paragraph 3.0(b)). This guidance is not intended to alter the exercise of that judgment 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.

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) or could have impact on the averaging period of concern. 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 or could have impact on the averaging period of concern, 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 distant 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 *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$,* and *Regional Haze.*[60] 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) of this subsection.

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 NWS Automated Surface Observing Stations (ASOS) in the early 1990's should not preclude the use of NWS ASOS data if such a station is determined to be representative of the modeled area.[93]

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 [94] shall be used to preprocess all meteorological data, be it observed or prognostic, for use with AERMOD in regulatory applications. The AERMINUTE [95] processor, in most cases, should be used to process 1-minute ASOS wind data for input to AERMET when processing NWS ASOS sites in AERMET. When processing prognostic meteorological data for AERMOD, the Mesoscale Model Interface Program (MMIF) [103] should be used to process data for input to AERMET. Other methods of processing prognostic meteorological data for input to AERMET should be approved by the appropriate reviewing authority. Additionally, the following meteorological preprocessors are recommended by the EPA: PCRAMMET,[96] MPRM,[97] and METPRO.[98] 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.[99]

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. 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,[100 101] 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 be 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.[102 103] 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]

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[96] or MPRM,[97] that 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 or comparable 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 are available, these data are preferred for use in air quality analyses. Depending on completeness of the data record, consecutive years of NWS, site-specific, or prognostic data are preferred. Such data must be subjected to quality assurance procedures as described in section 8.4.4.2.

f. 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 long-range transport 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 standard ''hourly'' weather observation was a human-based observation reflecting a single 2-minute average generally taken about 10 minutes before the hour. However, beginning in January 2000 for first-order stations and in March 2005 for all stations, the NCEI has archived the 1-minute ASOS wind data (*i.e.,* the rolling 2-minute average winds) for the NWS ASOS sites. The AERMINUTE processor[95] was developed to reduce the number of calm and missing hours in AERMET processing by substituting standard hourly observations with full hourly average winds calculated from 1-minute ASOS wind data.

8.4.3.2 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. The NCEI makes available surface[104] [105] and upper air[106] meteorological data online and in CD–ROM format. Upper air data are also available at the Earth System Research Laboratory Global Systems Divisions Web site (*http://esrl.noaa.gov/gsd*).

b. Although most NWS wind measurements are made at a standard height of 10 m, 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. Due to the coarse resolution of these data, a specific set of randomly generated numbers has been developed by the EPA and should be used when processing standard hourly NWS data for use in the preferred EPA models to ensure a lack of bias in wind direction assignments within the models.

d. Beginning with year 2000, NCEI began archiving 2-minute winds, reported every minute to the nearest degree for NWS ASOS sites. The AERMINUTE processor was developed to read those winds and calculate hourly average winds for input to 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.[93]

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,[107] 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.[107] 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.

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[107] is available. Site-specific data should always be reviewed for representativeness and adequacy by an experienced meteorologist, atmospheric scientist, or other qualified scientist in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

8.4.4.2 Recommendations

a. The EPA guidance[107] 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] [108] [109] Detailed information on quality assurance is also available.[110] 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.

i. *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.[107] [110]

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

ii. *Temperature measurements.* Temperature measurements should be made at standard shelter height (2m) in accordance with established site-specific meteorological guidance.[107]

iii. *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 107 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.

iv. *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 m. (For additional requirements for AERMOD and CTDMPLUS, *see* appendix A.) Specifications for wind measuring instruments and systems are contained in reference 107.

b. All processed site-specific data should be in the form of hourly averages for input to the dispersion model.

i. *Turbulence data.* 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 or AERMOD). When turbulence data are used to directly characterize the vertical and lateral dispersion, the averaging time for the turbulence measurements should be 1 hour. For technical guidance on processing of turbulence parameters for use in dispersion modeling, refer to the user's guide to the meteorological processor for each model (*see* section 8.4.2(a)).

ii. *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 10 m. 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 10 m 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 107. 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.

iii. The SRDT method, described in section 6.4.4.2 of reference 107, is modified slightly from that published from earlier work[111] and has been evaluated with three site-specific databases.[112] The two methods of stability classification that use wind fluctuation statistics, the σ_E and σ_A methods, are also described in detail in section 6.4.4 of reference 107 (note applicable tables in section 6). For additional information on the wind fluctuation methods, several references are available.[113] [114] [115] [116]

c. *Missing data substitution.* After valid data retrieval requirements have been met,[107] 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 107. 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.

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 appropriate to use prognostic meteorological data, if deemed adequately representative, in a regulatory modeling application. However, if prognostic meteorological data are not representative of transport and dispersion conditions in the area of concern, the collection of site-specific data is necessary.

b. The EPA has developed a processor, the MMIF,[102] to process MM5 (Mesoscale Model 5) or WRF (Weather Research and Forecasting) model data for input to various models including AERMOD. MMIF can process data for input to 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).[117] Specific guidance on processing MMIF for AERMOD can be found in reference 103. 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 to AERMOD. If an alternative method of processing data for input to 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 by the applicant should be devoted to the process of evaluating the prognostic meteorological data. The modeling data should be compared to NWS observational data or other comparable data in an effort to show that the data are adequately 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.[60] 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.[60]

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 judgment may be needed to select the appropriate grid cell to use. In such cases, the selected grid cells 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 that 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 these issues, especially those introduced with AERMINUTE, the EPA implemented a wind speed threshold in AERMET for use with ASOS derived winds.[93] [94] 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 the greater of the threshold of the instrument used to collect the wind speed data or wind direction sensor.[107] 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 length and 100 m. 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. Model predicted 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 [118] has been prepared, is available on the EPA's SCRAM Web site (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 other than AERMOD, 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 such adjustment should be made to the site-specific wind data, as AERMOD has algorithms to account for light or variable winds as discussed in section 8.4.6.1(a). 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.[93] When using prognostic data processed by MMIF, a 0.5 m/s threshold is also invoked by MMIF for input to 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, or other EPA requirements to ensure consistency in their regulatory application. This section recommends procedures specific to NSR 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 scientific peer 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).

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 Web site at *https://www.epa.gov/criteria-air-pollutants*. As required by 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 increments, and developing emissions limits. This section also provides the criteria necessary for considering use of an 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 Web site (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 the 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.

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 proposed source. The NAAQS design concentration is then compared to the applicable NAAQS.

ii. For a PSD increment assessment, the design concentration includes impacts occurring 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 the applicable modeling guidance available on the EPA's SCRAM Web site (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.

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, must be less than or equal to the permitted increment. The modeled annual averages must 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 increments 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 near 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 Modifying Sources

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

i. The EPA describes the first stage as a single-source impact analysis, since this stage involves considering only the impact of the new or modifying source. 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 EPA describes the second stage 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, this stage includes consideration of background, which includes contributions from nearby sources and other sources (*e.g.,* natural, minor, and distant major sources).

b. Each stage should involve increasing complexity and details, as required, to fully demonstrate that a new or modifying source will not cause or contribute to a violation of any NAAQS or PSD increment. As such, starting with a single-source impact analysis is recommended because, where the analysis at this stage is sufficient to demonstrate that a source will not cause or contribute to any potential violation, this 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, should begin 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 the source will not cause or contribute to any potential violation of a NAAQS or PSD increment, then the screening analysis should generally be sufficient for the required demonstration under PSD. If the ambient concentration estimates indicate that the source's emissions have the potential to cause or contribute to a violation, 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 ambient concentration increase predicted with refined modeling indicates that the source will not cause or contribute to any potential violation of a NAAQS or PSD increment, then the refined analysis should generally be sufficient for the required demonstration under PSD. However, if the ambient concentration estimates from the refined modeling analysis indicate that the source's emissions have the potential to cause or contribute to a violation, then a cumulative impact analysis should be undertaken. The receptors that indicate the location of significant ambient 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 should be 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) whether the source's emissions cause or contribute to a violation at the time and location of any modeled violation (*i.e.,* when and where the predicted design concentration is greater than the NAAQS). For PSD increments, 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.

9.2.4 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. 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.

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Appendix A to Appendix W of Part 51—Summaries of Preferred Air Quality Models

Table of Contents

A.0 Introduction and Availability

(1) This appendix summarizes key features of refined air quality models preferred for specific regulatory applications. For each model, information is provided on availability, approximate cost (where applicable), regulatory use, data input, output format and options, simulation of atmospheric physics, and accuracy. These models may be used without a formal demonstration of applicability provided they satisfy the recommendations for regulatory use; not all options in the models are necessarily recommended for regulatory use.

(2) Many of these models have been subjected to a performance evaluation using comparisons with observed air quality data. Where possible, several of the models contained herein have been subjected to evaluation exercises, including: (1) Statistical performance tests recommended by the American Meteorological Society, and (2) peer scientific reviews. The models in this appendix have been selected on the basis of the results of the model evaluations, experience with previous use, familiarity of the model to various air quality programs, and the costs and resource requirements for use.

(3) Codes and documentation for all models listed in this appendix are available from the EPA's Support Center for Regulatory Air Models (SCRAM) Web site at *https://www.epa.gov/scram.* Codes and documentation may also available from the National Technical Information Service (NTIS), *http://www.ntis.gov,* and, when available, are referenced with the appropriate NTIS accession number.

A.1 AERMOD (AMS/EPA Regulatory Model)

References

U.S. Environmental Protection Agency, 2016. AERMOD Model Formulation. Publication No. EPA–454/B–16–014. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Cimorelli, A., *et al.,* 2005. AERMOD: A Dispersion Model for Industrial Source Applications. Part I: General Model Formulation and Boundary Layer Characterization. *Journal of Applied Meteorology,* 44(5): 682–693.

Perry, S. *et al.,* 2005. AERMOD: A Dispersion Model for Industrial Source Applications. Part II: Model Performance against 17 Field Study Databases. *Journal of Applied Meteorology,* 44(5): 694–708.

U.S. Environmental Protection Agency, 2016. User's Guide for the AMS/EPA Regulatory Model (AERMOD). Publication No. EPA–454/B–16–011. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. Environmental Protection Agency, 2016. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). Publication No. EPA–454/B–16–010. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. Environmental Protection Agency, 2016. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). Publication No. EPA–454/B–16–012. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Schulman, L. L., D.G. Strimaitis and J.S. Scire, 2000. Development and evaluation of the PRIME plume rise and building downwash model. *Journal of the Air and Waste Management Association,* 50: 378–390.

Schulman, L. L., and Joseph S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P–7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 81–164642).

Availability

The model codes and associated documentation are available on EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

AERMOD is a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple point, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. AERMOD accounts for building wake effects (*i.e.,* plume downwash) based on the PRIME building downwash algorithms. The model employs hourly sequential preprocessed meteorological data to estimate concentrations for averaging times from 1-hour to 1-year (also multiple years). AERMOD can be used to estimate the concentrations of nonreactive pollutants from highway traffic. AERMOD also handles unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary buoyant line sources are important. AERMOD is designed to operate in concert with two pre-processor codes: AERMET processes meteorological data for input to AERMOD, and AERMAP processes terrain elevation data and generates receptor and hill height information for input to AERMOD.

a. Regulatory Use

(1) AERMOD is appropriate for the following applications:

- Point, volume, and area sources;
- Buoyant, elevated line sources (*e.g.,* aluminum reduction plants);
- Mobile sources;
- Surface, near-surface, and elevated releases;
- Rural or urban areas;
- Simple and complex terrain;
- Transport distances over which steady-state assumptions are appropriate, up to 50km;
- 1-hour to annual averaging times; and
- Continuous toxic air emissions.

(2) For regulatory applications of AERMOD, the regulatory default option should be set, *i.e.,* the parameter DFAULT should be employed in the MODELOPT record in the COntrol Pathway. The DFAULT option requires the use of meteorological data processed with the regulatory options in AERMET, the use of terrain elevation data processed through the AERMAP terrain processor, stack-tip downwash, sequential date checking, and does not permit the use of the model in the SCREEN mode. In the regulatory default mode, pollutant half-life or decay options are not employed, except in the case of an urban source of sulfur dioxide where a 4-hour half-life is applied. Terrain elevation data from the U.S. Geological Survey (USGS) 7.5-Minute Digital Elevation Model (DEM), or equivalent (approx. 30-meter resolution), (processed through AERMAP) should be used in all applications. Starting in 2011, data from the National Elevation Dataset (NED, *https://nationalmap.gov/elevation.html*) can also be used in AERMOD, which includes a range of resolutions, from 1-m to 2 arc seconds and such high resolution would always be preferred. In some cases, exceptions from the terrain data requirement may be made in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. Input Requirements

(1) Source data: Required inputs include source type, location, emission rate, stack height, stack inside diameter, stack gas exit velocity, stack gas exit temperature, area and volume source dimensions, and source base elevation. For point sources subject to the influence of building downwash, direction-specific building dimensions (processed through the BPIPPRM building processor) should be input. Variable emission rates are optional. Buoyant line sources require coordinates of the end points of the line, release height, emission rate, average line source width, average building width, average spacing between buildings, and average line source buoyancy parameter. For mobile sources, traffic volume; emission factor, source height, and mixing zone width are needed to determine appropriate model inputs.

(2) Meteorological data: The AERMET meteorological preprocessor requires input of surface characteristics, including surface roughness (zo), Bowen ratio, and albedo, as well as, hourly observations of wind speed between 7zo and 100 m (reference wind speed measurement from which a vertical profile can be developed), wind direction, cloud cover, and temperature between zo and 100 m (reference temperature measurement from which a vertical profile can be developed). Meteorological data can be in the

form of observed data or prognostic modeled data as discussed in paragraph 8.4.1(d). Surface characteristics may be varied by wind sector and by season or month. When using observed meteorological data, a morning sounding (in National Weather Service format) from a representative upper air station is required. Latitude, longitude, and time zone of the surface, site-specific (if applicable) and upper air meteorological stations are required. The wind speed starting threshold is also required in AERMET for applications involving site-specific data. When using prognostic data, modeled profiles of temperature and winds are input to AERMET. These can be hourly or a time that represents a morning sounding. Additionally, measured profiles of wind, temperature, vertical and lateral turbulence may be required in certain applications (*e.g.,* in complex terrain) to adequately represent the meteorology affecting plume transport and dispersion. Optionally, measurements of solar and/or net radiation may be input to AERMET. Two files are produced by the AERMET meteorological preprocessor for input to the AERMOD dispersion model. When using observed data, the surface file contains observed and calculated surface variables, one record per hour. For applications with multi-level site-specific meteorological data, the profile contains the observations made at each level of the meteorological tower (or remote sensor). When using prognostic data, the surface file contains surface variables calculated by the prognostic model and AERMET. The profile file contains the observations made at each level of a meteorological tower (or remote sensor), the one-level observations taken from other representative data (*e.g.,* National Weather Service surface observations), one record per level per hour, or in the case of prognostic data, the prognostic modeled values of temperature and winds at user-specified levels.

(i) Data used as input to AERMET should possess an adequate degree of representativeness to ensure that the wind, temperature and turbulence profiles derived by AERMOD are both laterally and vertically representative of the source impact area. The adequacy of input data should be judged independently for each variable. The values for surface roughness, Bowen ratio, and albedo should reflect the surface characteristics in the vicinity of the meteorological tower or representative grid cell when using prognostic data, and should be adequately representative of the modeling domain. Finally, the primary atmospheric input variables, including wind speed and direction, ambient temperature, cloud cover, and a morning upper air sounding, should also be adequately representative of the source area when using observed data.

(ii) For applications involving the use of site-specific meteorological data that includes turbulences parameters (*i.e.,* sigma-theta and/or sigma-w), the application of the ADJ_U* option in AERMET would require approval as an alternative model application under section 3.2.

(iii) For recommendations regarding the length of meteorological record needed to perform a regulatory analysis with AERMOD, *see* section 8.4.2.

(3) Receptor data: Receptor coordinates, elevations, height above ground, and hill height scales are produced by the AERMAP terrain preprocessor for input to AERMOD. Discrete receptors and/or multiple receptor grids, Cartesian and/or polar, may be employed in AERMOD. AERMAP requires input of DEM or NED terrain data produced by the USGS, or other equivalent data. AERMAP can be used optionally to estimate source elevations.

c. Output

Printed output options include input information, high concentration summary tables by receptor for user-specified averaging periods, maximum concentration summary tables, and concurrent values summarized by receptor for each day processed. Optional output files can be generated for: A listing of occurrences of exceedances of user-specified threshold value; a listing of concurrent (raw) results at each receptor for each hour modeled, suitable for post-processing; a listing of design values that can be imported into graphics software for plotting contours; a listing of results suitable for NAAQS analyses including NAAQS exceedances and culpability analyses; an unformatted listing of raw results above a threshold value with a special structure for use with the TOXX model component of TOXST; a listing of concentrations by rank (*e.g.,* for use in quantile-quantile plots); and a listing of concentrations, including arc-maximum normalized concentrations, suitable for model evaluation studies.

d. Type of Model

AERMOD is a steady-state plume model, using Gaussian distributions in the vertical and horizontal for stable conditions, and in the horizontal for convective conditions. The vertical concentration distribution for convective conditions results from an assumed bi-Gaussian probability density function of the vertical velocity.

e. Pollutant Types

AERMOD is applicable to primary pollutants and continuous releases of toxic and hazardous waste pollutants. Chemical transformation is treated by simple exponential decay.

f. Source-Receptor Relationships

AERMOD applies user-specified locations for sources and receptors. Actual separation between each source-receptor pair is used. Source and receptor elevations are user input or are determined by AERMAP using USGS DEM or NED terrain data. Receptors may be located at user-specified heights above ground level.

g. Plume Behavior

(1) In the convective boundary layer (CBL), the transport and dispersion of a plume is characterized as the superposition of three modeled plumes: (1) The direct plume (from the stack); (2) the indirect plume; and (3) the penetrated plume, where the indirect plume accounts for the lofting of a buoyant plume near the top of the boundary layer, and the penetrated plume accounts for the portion of a plume that, due to its buoyancy, penetrates above the mixed layer, but can disperse downward and re-enter the mixed layer. In the CBL, plume rise is superposed on the displacements by random convective velocities (Weil *et al.,* 1997).

(2) In the stable boundary layer, plume rise is estimated using an iterative approach to account for height-dependent lapse rates, similar to that in the CTDMPLUS model (*see* A.2 in this appendix).

(3) Stack-tip downwash and buoyancy induced dispersion effects are modeled. Building wake effects are simulated for stacks subject to building downwash using the methods contained in the PRIME downwash algorithms (Schulman, *et al.,* 2000). For plume rise affected by the presence of a building, the PRIME downwash algorithm uses a numerical solution of the mass, energy and momentum conservation laws (Zhang and Ghoniem, 1993). Streamline deflection and the position of the stack relative to the building affect plume trajectory and dispersion. Enhanced dispersion is based on the approach of Weil (1996). Plume mass captured by the cavity is well-mixed within the cavity. The captured plume mass is re-emitted to the far wake as a volume source.

(4) For elevated terrain, AERMOD incorporates the concept of the critical dividing streamline height, in which flow below this height remains horizontal, and flow above this height tends to rise up and over terrain (Snyder *et al.,* 1985). Plume concentration estimates are the weighted sum of these two limiting plume states. However, consistent with the steady-state assumption of uniform horizontal wind direction over the modeling domain, straight-line plume trajectories are assumed, with adjustment in the plume/receptor geometry used to account for the terrain effects.

h. Horizontal Winds

Vertical profiles of wind are calculated for each hour based on measurements and surface-layer similarity (scaling) relationships. At a given height above ground, for a given hour, winds are assumed constant over the modeling domain. The effect of the vertical variation in horizontal wind speed on dispersion is accounted for through simple averaging over the plume depth.

i. Vertical Wind Speed

In convective conditions, the effects of random vertical updraft and downdraft velocities are simulated with a bi-Gaussian probability density function. In both convective and stable conditions, the mean vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Gaussian horizontal dispersion coefficients are estimated as continuous functions of the parameterized (or measured) ambient lateral turbulence and also account for buoyancy-induced and building wake-induced turbulence. Vertical profiles of lateral turbulence are developed from measurements and similarity (scaling) relationships. Effective turbulence values are determined from the portion of the vertical profile of lateral turbulence between the plume height and the receptor height. The effective lateral turbulence is then used to estimate horizontal dispersion.

k. Vertical Dispersion

In the stable boundary layer, Gaussian vertical dispersion coefficients are estimated as continuous functions of parameterized vertical turbulence. In the convective boundary layer, vertical dispersion is characterized by a bi-Gaussian probability density function and is also estimated as a continuous function of parameterized vertical turbulence. Vertical turbulence profiles are developed from measurements and similarity (scaling) relationships. These turbulence profiles account for both convective and mechanical turbulence. Effective turbulence values are determined from the portion of the vertical profile of vertical turbulence between the plume height and the receptor height. The effective vertical turbulence is then used to estimate vertical dispersion.

l. Chemical Transformation

Chemical transformations are generally not treated by AERMOD. However, AERMOD does contain an option to treat chemical transformation using simple exponential decay, although this option is typically not used in regulatory applications except for sources of sulfur dioxide in urban areas. Either a decay coefficient or a half-life is input by the user. Note also that the Plume Volume Molar Ratio Method and the Ozone Limiting Method (section 4.2.3.4) for NO_2 analyses are available.

m. Physical Removal

AERMOD can be used to treat dry and wet deposition for both gases and particles.

n. Evaluation Studies

American Petroleum Institute, 1998. Evaluation of State of the Science of Air Quality Dispersion Model, Scientific Evaluation, prepared by Woodward-Clyde Consultants, Lexington, Massachusetts, for American Petroleum Institute, Washington, DC 20005–4070.

Brode, R.W., 2002. Implementation and Evaluation of PRIME in AERMOD. Preprints of the 12th Joint Conference on Applications of Air Pollution Meteorology, May 20–24, 2002; American Meteorological Society, Boston, MA.

Brode, R.W., 2004. Implementation and Evaluation of Bulk Richardson Number Scheme in AERMOD. 13th Joint Conference on Applications of Air Pollution Meteorology, August 23–26, 2004; American Meteorological Society, Boston, MA.

U.S. Environmental Protection Agency, 2003. AERMOD: Latest Features and Evaluation Results. Publication No. EPA–454/R–03–003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Heist, D., et al, 2013. Estimating near-road pollutant dispersion: A model inter-comparison. *Transportation Research Part D: Transport and Environment,* 25: pp 93–105.

A.2 CTDMPLUS (Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations)

References

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.G. Strimaitis, R.J. Yamartino and E.M. Insley, 1989. User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). Volume 1: Model Descriptions and User Instructions. EPA Publication No. EPA–600/8–89–041. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89–181424).

Perry, S.G., 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part I: Technical Formulations. *Journal of Applied Meteorology,* 31(7): 633–645.

Availability

The model codes and associated documentation are available on the EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

CTDMPLUS is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain applications. The model contains, in its entirety, the technology of CTDM for stable and neutral conditions. However, CTDMPLUS can also simulate daytime, unstable conditions, and has a number of additional capabilities for improved user friendliness. Its use of meteorological data and terrain information is different from other EPA models; considerable detail for both types of input data is required and is supplied by preprocessors specifically designed for CTDMPLUS. CTDMPLUS requires the parameterization of individual hill shapes using the terrain preprocessor and the association of each model receptor with a particular hill.

a. Regulatory Use

CTDMPLUS is appropriate for the following applications:

- Elevated point sources;
- Terrain elevations above stack top;
- Rural or urban areas;
- Transport distances less than 50 kilometers; and
- 1-hour to annual averaging times when used with a post-processor program such as CHAVG.

b. Input Requirements

(1) Source data: For each source, user supplies source location, height, stack diameter, stack exit velocity, stack exit temperature, and emission rate; if variable emissions are appropriate, the user supplies hourly values for emission rate, stack exit velocity, and stack exit temperature.

(2) Meteorological data: For applications of CTDMPLUS, multiple level (typically three or more) measurements of wind speed and direction, temperature and turbulence (wind fluctuation statistics) are required to create the basic meteorological data file (''PROFILE''). Such measurements should be obtained up to the representative plume height(s) of interest (*i.e.,* the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening procedure (*e.g.,* CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately sited meteorological tower augmented by SODAR and/or RASS if the representative plume height(s) of interest is above the levels represented by the tower measurements. Meteorological preprocessors then create a SURFACE data file (hourly values of mixed layer heights, surface friction velocity, Monin-Obukhov length and surface roughness length) and a RAWINsonde data file (upper air measurements of pressure, temperature, wind direction, and wind speed).

(3) Receptor data: Receptor names (up to 400) and coordinates, and hill number (each receptor must have a hill number assigned).

(4) Terrain data: User inputs digitized contour information to the terrain preprocessor which creates the TERRAIN data file (for up to 25 hills).

c. Output

(1) When CTDMPLUS is run, it produces a concentration file, in either binary or text format (user's choice), and a list file containing a verification of model inputs, *i.e.,*

- Input meteorological data from ''SURFACE'' and ''PROFILE,''
- Stack data for each source,
- Terrain information,
- Receptor information, and
- Source-receptor location (line printer map).

(2) In addition, if the case-study option is selected, the listing includes:

- Meteorological variables at plume height,
- Geometrical relationships between the source and the hill, and
- Plume characteristics at each receptor, *i.e.,*
  - —Distance in along-flow and cross flow direction
  - —Effective plume-receptor height difference
  - —Effective σy & σz values, both flat terrain and hill induced (the difference shows the effect of the hill)
  - —Concentration components due to WRAP, LIFT and FLAT.

(3) If the user selects the TOPN option, a summary table of the top four concentrations at each receptor is given. If the ISOR option is selected, a source contribution table for every hour will be printed.

(4) A separate output file of predicted (1-hour only) concentrations (''CONC'') is written if the user chooses this option. Three forms of output are possible:

(i) A binary file of concentrations, one value for each receptor in the hourly sequence as run;

(ii) A text file of concentrations, one value for each receptor in the hourly sequence as run; or

(iii) A text file as described above, but with a listing of receptor information (names, positions, hill number) at the beginning of the file.

(5) Hourly information provided to these files besides the concentrations themselves includes the year, month, day, and hour information as well as the receptor number with the highest concentration.

d. Type of Model

CTDMPLUS is a refined steady-state, point source plume model for use in all stability conditions for complex terrain applications.

e. Pollutant Types

CTDMPLUS may be used to model non-reactive, primary pollutants.

f. Source-Receptor Relationship

Up to 40 point sources, 400 receptors and 25 hills may be used. Receptors and sources are allowed at any location. Hill slopes are assumed not to exceed 15°, so that the linearized equation of motion for Boussinesq flow are applicable. Receptors upwind of the impingement point, or those associated with any of the hills in the modeling domain, require separate treatment.

g. Plume Behavior

(1) As in CTDM, the basic plume rise algorithms are based on Briggs' (1975) recommendations.

(2) A central feature of CTDMPLUS for neutral/stable conditions is its use of a critical dividing-streamline height (H_c) to separate the flow in the vicinity of a hill into two separate layers. The plume component in the upper layer has sufficient kinetic energy to pass over the top of the hill while streamlines in the lower portion are constrained to flow in a horizontal plane around the hill. Two separate components of CTDMPLUS compute ground-level concentrations resulting from plume material in each of these flows.

(3) The model calculates on an hourly (or appropriate steady averaging period) basis how the plume trajectory (and, in stable/neutral conditions, the shape) is deformed by each hill. Hourly profiles of wind and temperature measurements are used by CTDMPLUS to compute plume rise, plume penetration (a formulation is included to handle penetration into elevated stable layers, based on Briggs (1984)), convective scaling parameters, the value of H_c, and the Froude number above H_c.

h. Horizontal Winds

CTDMPLUS does not simulate calm meteorological conditions. Both scalar and vector wind speed observations can be read by the model. If vector wind speed is unavailable, it is calculated from the scalar wind speed. The assignment of wind speed (either vector or scalar) at plume height is done by either:

- Interpolating between observations above and below the plume height, or
- Extrapolating (within the surface layer) from the nearest measurement height to the plume height.

i. Vertical Wind Speed

Vertical flow is treated for the plume component above the critical dividing streamline height (H_c); *see* ''Plume Behavior.''

j. Horizontal Dispersion

Horizontal dispersion for stable/neutral conditions is related to the turbulence velocity scale for lateral fluctuations, σv, for which a minimum value of 0.2 m/s is used. Convective scaling formulations are used to estimate horizontal dispersion for unstable conditions.

k. Vertical Dispersion

Direct estimates of vertical dispersion for stable/neutral conditions are based on observed vertical turbulence intensity, *e.g.,* σw (standard deviation of the vertical velocity fluctuation). In simulating unstable (convective) conditions, CTDMPLUS relies on a skewed, bi-Gaussian probability density function (pdf) description of the vertical velocities to estimate the vertical distribution of pollutant concentration.

l. Chemical Transformation

Chemical transformation is not treated by CTDMPLUS.

m. Physical Removal

Physical removal is not treated by CTDMPLUS (complete reflection at the ground/hill surface is assumed).

n. Evaluation Studies

Burns, D.J., L.H. Adams and S.G. Perry, 1990. Testing and Evaluation of the CTDMPLUS Dispersion Model: Daytime Convective Conditions. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J.O., S.G. Perry and D.J. Burns, 1990. An Analysis of CTDMPLUS Model Predictions with the Lovett Power Plant Data Base. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J.O., S.G. Perry and D.J. Burns, 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part II: Performance Characteristics. *Journal of Applied Meteorology,* 31(7): 646–660.

A.3 OCD (Offshore and Coastal Dispersion Model)

Reference

DiCristofaro, D.C. and S.R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model, Version 4. Volume I: User's Guide, and Volume II: Appendices. Sigma Research Corporation, Westford, MA. (NTIS Nos. PB 93–144384 and PB 93–144392).

Availability

The model codes and associated documentation are available on EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

(1) OCD is a straight-line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. These include water surface temperature, overwater air temperature, mixing height, and relative humidity.

(2) Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

a. Regulatory Use

OCD has been recommended for use by the Bureau of Ocean Energy Management for emissions located on the Outer Continental Shelf (50 FR 12248; 28 March 1985). OCD is applicable for overwater sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. Input Requirements

(1) Source data: Point, area or line source location, pollutant emission rate, building height, stack height, stack gas temperature, stack inside diameter, stack gas exit velocity, stack angle from vertical, elevation of stack base above water surface and gridded specification of the land/water surfaces. As an option, emission rate, stack gas exit velocity and temperature can be varied hourly.

(2) Meteorological data: 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.

(i) Over land: Surface weather data including hourly stability class, wind direction, wind speed, ambient temperature, and mixing height are required.

(ii) Over water: Hourly values for mixing height, relative humidity, air temperature, and water surface temperature are required; if wind speed/direction are missing, values over land will be used (if available); vertical wind direction shear, vertical temperature gradient, and turbulence intensities are optional.

(3) Receptor data: Location, height above local ground-level, ground-level elevation above the water surface.

c. Output

(1) All input options, specification of sources, receptors and land/water map including locations of sources and receptors.

(2) Summary tables of five highest concentrations at each receptor for each averaging period, and average concentration for entire run period at each receptor.

(3) Optional case study printout with hourly plume and receptor characteristics. Optional table of annual impact assessment from non-permanent activities.

(4) Concentration output files can be used by ANALYSIS postprocessor to produce the highest concentrations for each receptor, the cumulative frequency distributions for each receptor, the tabulation of all concentrations exceeding a given threshold, and the manipulation of hourly concentration files.

d. Type of Model

OCD is a Gaussian plume model constructed on the framework of the MPTER model.

e. Pollutant Types

OCD may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationship

(1) Up to 250 point sources, 5 area sources, or 1 line source and 180 receptors may be used.

(2) Receptors and sources are allowed at any location.

(3) The coastal configuration is determined by a grid of up to 3600 rectangles. Each element of the grid is designated as either land or water to identify the coastline.

g. Plume Behavior

(1) The basic plume rise algorithms are based on Briggs' recommendations.

(2) Momentum rise includes consideration of the stack angle from the vertical.

(3) The effect of drilling platforms, ships, or any overwater obstructions near the source are used to decrease plume rise using a revised platform downwash algorithm based on laboratory experiments.

(4) Partial plume penetration of elevated inversions is included using the suggestions of Briggs (1975) and Weil and Brower (1984).

(5) Continuous shoreline fumigation is parameterized using the Turner method where complete vertical mixing through the thermal internal boundary layer (TIBL) occurs as soon as the plume intercepts the TIBL.

h. Horizontal Winds

(1) Constant, uniform wind is assumed for each hour.

(2) Overwater wind speed can be estimated from overland wind speed using relationship of Hsu (1981).

(3) Wind speed profiles are estimated using similarity theory (Businger, 1973). Surface layer fluxes for these formulas are calculated from bulk aerodynamic methods.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Lateral turbulence intensity is recommended as a direct estimate of horizontal dispersion. If lateral turbulence intensity is not available, it is estimated from boundary layer theory. For wind speeds less than 8 m/s, lateral turbulence intensity is assumed inversely proportional to wind speed.

(2) Horizontal dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

(3) Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement and wind direction shear enhancement.

(4) At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either lateral turbulence intensity or Pasquill-Gifford curves. The change is implemented where the plume intercepts the rising internal boundary layer.

k. Vertical Dispersion

(1) Observed vertical turbulence intensity is not recommended as a direct estimate of vertical dispersion. Turbulence intensity should be estimated from boundary layer theory as default in the model. For very stable conditions, vertical dispersion is also a function of lapse rate.

(2) Vertical dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

(3) Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement.

(4) At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either vertical turbulence intensity or the Pasquill-Gifford coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

l. Chemical Transformation

Chemical transformations are treated using exponential decay. Different rates can be specified by month and by day or night.

m. Physical Removal

Physical removal is also treated using exponential decay.

n. Evaluation Studies

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