UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

July 29, 2022

MEMORANDUM

SUBJECT: Guidance for Ozone and Fine Particulate Matter Permit Modeling

FROM: Richard Wayland, Division Director
Air Quality Assessment Division

Wayland, Richard

Digitally signed by Wayland, Richard
Date: 2022.07.29 12:46:07 -04'00'

Scott Mathias, Division Director
Air Quality Policy Division

SCOTT MATHIAS

Digitally signed by SCOTT MATHIAS
Date: 2022.07.29 11:31:23 -04'00'

TO: Regional Air Division Directors, Regions 1 – 10

The Environmental Protection Agency (EPA) is pleased to release the attached "Guidance for Ozone and Fine Particulate Matter Permit Modeling" (final guidance) in a final form to the state, local, and tribal air agencies, as well as the public. The final guidance reflects the EPA's recommendations for how a stationary source seeking a Prevention of Significant Deterioration (PSD) permit may demonstrate that it will not cause or contribute to a violation of the National Ambient Air Quality Standards (NAAQS) for ozone (O_3) and fine particulate matter ($PM_{2.5}$) and PSD increments for $PM_{2.5}$, as required under Section 165(a)(3) of the Clean Air Act and 40 CFR sections 51.166(k) and 52.21(k).

The final guidance does not substitute for provisions or regulations of the Clean Air Act, nor is it a regulation itself. As the term "guidance" suggests, it provides recommendations on how to implement the modeling requirements of a PSD compliance demonstration. Thus, it does not impose binding, enforceable requirements on any party, nor does it assure that the EPA will approve all instances of its application, as the guidance may not apply to a particular situation based upon the circumstances. Final decisions by the EPA regarding a particular PSD compliance demonstration will only be made based on the statute and applicable regulations and will only be made following a final submission by air agencies and after notice and opportunity for public review and comment.

BACKGROUND

On December 20, 2016, the Administrator signed a final rule[1] that revised the *Guideline on Air Quality Models.*[2] The final rule was published in the Federal Register on January 17, 2017, and the effective date of this action was deferred to May 22, 2017. The 2017 *Guideline* provides EPA-recommended models and other techniques, as well as guidance on their use, for predicting ambient concentrations of air pollutants. For this final revision to the 2017 *Guideline*, the EPA determined that advances in chemical transport modeling science indicate that 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 source on secondary formation of O_3 and $PM_{2.5}$.

As discussed in the preamble of the 2017 revisions to the EPA's *Guideline on Air Quality Models*:

> "…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 $PM_{2.5}$."

This recommended two-tiered demonstration approach was promulgated as part of the 2017 *Guideline* revisions.

DRAFT AND REVISED DRAFT GUIDANCE

On February 10, 2020, the EPA provided an initial "DRAFT Guidance for Ozone and Fine Particulate Matter Permit Modeling"[3] (draft guidance) to the state, local, and tribal air agencies, as well as the public, for consideration, review, and comment. Upon consideration of the comments received, and consistent with Executive Order 13990, the EPA decided to revise one important aspect of that draft guidance and, as a result, provided a "Revised Draft Guidance for

---

[1] https://www.epa.gov/scram/2017-appendix-w-final-rule.

[2] *Guideline on Air Quality Models*. 40 CFR Part 51, Appendix W (82 FR 5182, Jan. 17, 2017). https://www.epa.gov/sites/production/files/2020-09/documents/appw_17.pdf. Also known as the "2017 *Guideline*."

[3] "DRAFT Guidance for Ozone and Fine Particulate Matter Permit Modeling." February 10, 2020. Publication No. EPA 457-P-20-002. Office of Air Quality Planning and Standards, Research Triangle Park, NC. https://www.epa.gov/scram/draft-guidance-ozone-and-fine-particulate-matter-permit-modeling.

Ozone and Fine Particulate Matter Permit Modeling"[4] (revised draft guidance) on September 20, 2021 for additional consideration, review and comment. The revision reflected a change in EPA policy with respect to determining which regulated New Source Review (NSR) pollutants should be included in PSD compliance demonstration for O_3 and $PM_{2.5}$.

In the February 10, 2020 draft guidance, EPA's recommended compliance demonstration approach was that sources only include those precursors (or the direct component, in the case of $PM_{2.5}$) that would be emitted in a significant amount for purposes of determining whether a source will cause or contribute to a NAAQS or PSD increment violation. The September 20, 2021 revised guidance communicated EPA's current policy that, in order to make the required demonstration that the allowable emissions increases from a source or modification would not cause or contribute to a NAAQS or PSD increment violation, sources should provide a full accounting of the combined impacts of their allowable precursor (and direct component, in the case of $PM_{2.5}$) emissions on ambient concentrations of the relevant NAAQS (*i.e.*, O_3 or $PM_{2.5}$) if any precursor(s) (or the direct component, in the case of $PM_{2.5}$) would be emitted in a significant amount. In other words, for O_3, if either NO_X or VOC precursor emissions would be emitted in a significant amount, then both precursors should be included in the assessment of O_3 impacts. Analogously, for $PM_{2.5}$, if a source would emit a significant amount of one or more of: NO_X, SO_2, or direct $PM_{2.5}$ emissions, then the source should include NO_X and SO_2 precursor and direct $PM_{2.5}$ emissions in the assessment of $PM_{2.5}$ impacts.

As described in the revised draft guidance, this holistic approach to the PSD compliance demonstrations for O_3 and $PM_{2.5}$ is supported both scientifically and legally. This is because it ensures that the source provides a full accounting of its projected air quality impacts for the relevant NAAQS pollutant, including all precursor (and direct component, in the case of $PM_{2.5}$) emissions. Therefore, it better aligns with the requirements in the PSD regulations that the owner or operator of a proposed new major stationary source or major modification demonstrate that it will not cause or contribute to a NAAQS or PSD increment violation.

FINAL GUIDANCE

Based on the feedback received to both the draft and revised draft guidance documents and subsequent revisions, the EPA is now able to finalize and provide the attached "Guidance for Ozone and Fine Particulate Matter Permit Modeling" in a final form to the state, local, and tribal air agencies, as well as the public. We are maintaining the holistic compliance demonstration approach and all other recommendations from the revised draft guidance. We have made a few clarifications and associated updates to the final guidance based on the external comments, but the overall nature of the final guidance remains unchanged from the revised draft guidance.

---

[4] "Revised Draft Guidance for Ozone and Fine Particulate Matter Permit Modeling." September 20, 2021. Publication No. EPA 454-P-21-001. Office of Air Quality Planning and Standards, Research Triangle Park, NC. https://www.epa.gov/scram/revised-draft-guidance-ozone-and-fine-particulate-matter-permit-modeling.

This final guidance is now the full replacement to the previous "Guidance for $PM_{2.5}$ Permit Modeling"[5] reflecting the 2017 revisions to the *Guideline* and incorporation of appropriate sections for addressing O_3 along with, or in additional to, $PM_{2.5}$. The final guidance also replaces the February 10, 2020 draft and September 20, 2021 revised guidance documents and the recommendations contained within.

As additional experience is gained with O_3 and $PM_{2.5}$ PSD compliance demonstrations, the EPA may update this and related guidance and provide further specificity on procedures for assessing the impacts of a single source on O_3 and secondary $PM_{2.5}$ concentrations. The EPA still highly recommends consultation with the appropriate permitting authority and EPA Regional Office for any permit applicants developing O_3 and $PM_{2.5}$ PSD compliance demonstrations. Such consultation can resolve potential issues early in the permitting process and alleviate unnecessary work with developing an acceptable compliance demonstration.

WEBINAR AND CONTACT INFORMATION

The EPA will conduct a release webinar providing an overview of the final guidance allowing for an open exchange on Thursday, August 11th at 3pm EDT. Additional information on how to connect to the webinar is posted on the EPA's SCRAM website, https://www.epa.gov/scram, under the Announcements section and will be shared with the regulatory air quality modeling community through typical email distributions.

For convenience, the final guidance document is available electronically on the EPA's SCRAM website at:
https://www.epa.gov/scram/guidance-ozone-and-fine-particulate-matter-permit-modeling.

If there are any questions regarding the final guidance, please contact George Bridgers of EPA's Air Quality Modeling Group at (919) 541-5563 or *bridgers.george@epa.gov*.

cc: Air Program Managers, EPA Regions 1 – 10
Peter Tsirigotis, OAQPS
Mike Koerber, OAQPS
Rochelle Boyd, OAQPS, AQPD
Brian Doster, OGC
Jim Creech, OGC
Mark Kataoka, OGC
Tyler Fox, OAQPS, AQAD

Attachment

---

[5] "Guidance for PM2.5 Modeling." May 20, 2014. Publication No. EPA-454/B-14-001. Office of Air Quality Planning and Standards, Research Triangle Park, NC. https://www.epa.gov/sites/production/files/2020-09/documents/guidance_for_pm25_permit_modeling.pdf.

United States Environmental Protection Agency

Guidance for Ozone and Fine Particulate Matter Permit Modeling

EPA-454/R-22-005
July 2022

Guidance for Ozone and Fine Particulate Matter Permit Modeling

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, NC

This Page Intentionally Left Blank

TABLE OF CONTENTS

I. Introduction

The U.S. Environmental Protection Agency (EPA) is providing this “Guidance for Ozone and Fine Particulate Matter Permit Modeling” to fulfill a need for additional guidance on demonstrating compliance with the ozone (O_3) and fine particulate matter ($PM_{2.5}$) National Ambient Air Quality Standards (NAAQS) and the Prevention of Significant Deterioration (PSD) increments for $PM_{2.5}$ in the context of PSD permit applications. Because of the complex chemistry of secondary formation of O_3 and $PM_{2.5}$, the EPA’s judgment in the past was that it was not technically sound to specify with “reasonable particularity” air quality models that must be used to assess the impacts of a single source on O_3 and secondary $PM_{2.5}$ concentrations. Instead, the EPA employed a case-by-case process for determining analytical techniques that should be used for these secondary pollutants. Under the former process, the EPA recommended that the “[c]hoice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with their Regional Office to determine the most suitable approach on a case-by-case basis” (2005 *Guideline on Air Quality Models,* U.S. EPA, 2005; hereafter referred to as 2005 *Guideline*; sections 5.2.1.c and 5.2.2.1.c). As such, under the 2005 *Guideline*, the appropriate methods for assessing O_3 and secondary $PM_{2.5}$ impacts were determined as part of the normal consultation process with the appropriate permitting authority.

On January 4, 2012, the EPA granted a petition submitted on behalf of the Sierra Club on July 28, 2010 (U.S. EPA, 2012), which requested that the EPA initiate rulemaking regarding the establishment of air quality models for O_3 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 2005 *Guideline* were warranted and, as appropriate, incorporate new analytical techniques or models for O_3 and secondarily formed $PM_{2.5}$. As discussed in the preamble of the 2017 revisions to the EPA's *Guideline on Air Quality Models* (U.S. EPA, 2017a; hereafter referred to as 2017 *Guideline*), "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 $PM_{2.5}$." This recommended two-tiered demonstration approach was promulgated as part of the 2017 *Guideline* revisions.

As presented in section 5.2 of the 2017 *Guideline*, the first tier involves use of technically credible relationships between precursor emissions and a source's impacts. Such information may be published in peer-reviewed literature; developed from modeling that was previously conducted for an area by a source, a governmental agency, or some other entity that is deemed sufficient; or generated by a peer-reviewed reduced form model. To assist permitting authorities, the EPA released the "Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program" (U.S. EPA, 2019; hereafter referred to as MERPs Guidance) that provides a framework to develop MERPs for consideration and use as a Tier 1 demonstration tool, as described in the preamble of the 2017 *Guideline*.

The second tier, also presented in section 5.2 of the 2017 *Guideline*, 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. The EPA provided guidance to permitting authorities on procedures for applying CTMs in the "Guidance on the Use of Models for Assessing the Impacts of Emissions from Single Sources on the Secondarily Formed Pollutants: Ozone and $PM_{2.5}$" (U.S. EPA, 2016; hereafter Single-source Modeling Guidance). The Single-source Modeling Guidance is intended to inform that second tier approach by providing appropriate technical methods to assess O_3 and secondary $PM_{2.5}$ impacts associated with the precursor emissions from the new or modifying source. The appropriate tier for a given application should be selected in consultation with the appropriate permitting authority and be consistent with EPA guidance.

This guidance provides an update to the previous "Guidance for $PM_{2.5}$ Permit Modeling" (U.S. EPA, 2014) to reflect the 2017 revisions to the *Guideline* and incorporate appropriate sections for O_3. As experience is gained with these types of PSD compliance demonstrations, the EPA expects to update this and related guidance and provide further specificity on procedures for assessing the impacts of a single source on O_3 and secondary $PM_{2.5}$ concentrations.

This guidance document is organized in three primary areas:

1. Guidance Overview – Section II provides a general overview of the steps that a permit applicant should take under the PSD program for demonstrating compliance with the O_3 NAAQS and/or the $PM_{2.5}$ NAAQS and PSD increments.

2. PSD Compliance Demonstrations for the O_3 and $PM_{2.5}$ NAAQS – Sections III and IV provide a detailed framework for conducting a source impact analysis and a cumulative impact analysis, respectively, to appropriately address O_3 and $PM_{2.5}$ impacts from the proposed source[1] in determining whether it may cause or contribute to a NAAQS violation.
3. PSD Compliance Demonstrations for $PM_{2.5}$ Increments – Section V provides a detailed discussion of the assessment of primary and secondary $PM_{2.5}$ impacts of a new or modifying source with respect to the $PM_{2.5}$ increments.

This document recommends procedures for permit applicants and permitting authorities to follow to show that they have satisfied some of the criteria for obtaining or issuing a permit under applicable PSD regulations. This document is not a rule or regulation, and the guidance it contains may not apply to a particular situation based upon the individual facts and circumstances. This guidance does not change or substitute for any law, regulation, or any other legally binding requirement, may refer to regulatory provisions without repeating them in their entirety, and is not legally enforceable. The use of non-mandatory language such as "guidance," "recommend," "may," "should," and "can," is intended to describe EPA policies and recommendations. Mandatory terminology such as "must" and "required" are intended to describe requirements under the terms of the CAA and EPA regulations, but this document does not establish or alter any legally binding requirements in and of itself.

This guidance does not create any rights or obligations enforceable by any party or impose binding, enforceable requirements on any PSD permit applicant, PSD permitting

---

[1] The term "proposed source" as used in this guidance document should be read to mean the proposed source or modification for which the compliance demonstration is being conducted.

authority, the EPA, or any other person. Since each permitting action will be considered on a case-by-case basis, this document does not limit or restrict any particular justifiable approach that permit applicants and permitting authorities may take to conduct the required compliance demonstrations. Each individual decision to issue a PSD permit must be supported by a record sufficient to demonstrate that the proposed construction and operation of a stationary source will not cause or contribute to a violation of the applicable NAAQS and PSD increments. While this document illustrates a particular approach that the EPA considers appropriate and acceptable as a general matter, permit applicants and permitting authorities should examine all relevant information regarding air quality in the area that may be affected by a proposed new or modifying source and evaluate whether alternative or additional analysis may be necessary in a given case to demonstrate that the regulatory criteria for a PSD air quality analysis are satisfied. This document does not represent a conclusion or judgment by the EPA that the technical approaches recommended in this document will be sufficient to make a successful compliance demonstration in every permit application or circumstance.

Permitting authorities retain the discretion to address particular issues discussed in this document in a different manner than the EPA recommends so long as the approach is adequately justified, supported by the permitting record and relevant technical literature, and consistent with the applicable requirements in the CAA and implementing regulations, including the terms of an approved State Implementation Plan (SIP) or Tribal Implementation Plan (TIP). Furthermore, this guidance is not a final agency action and does not determine applicable legal requirements or the approvability of any particular permit application.

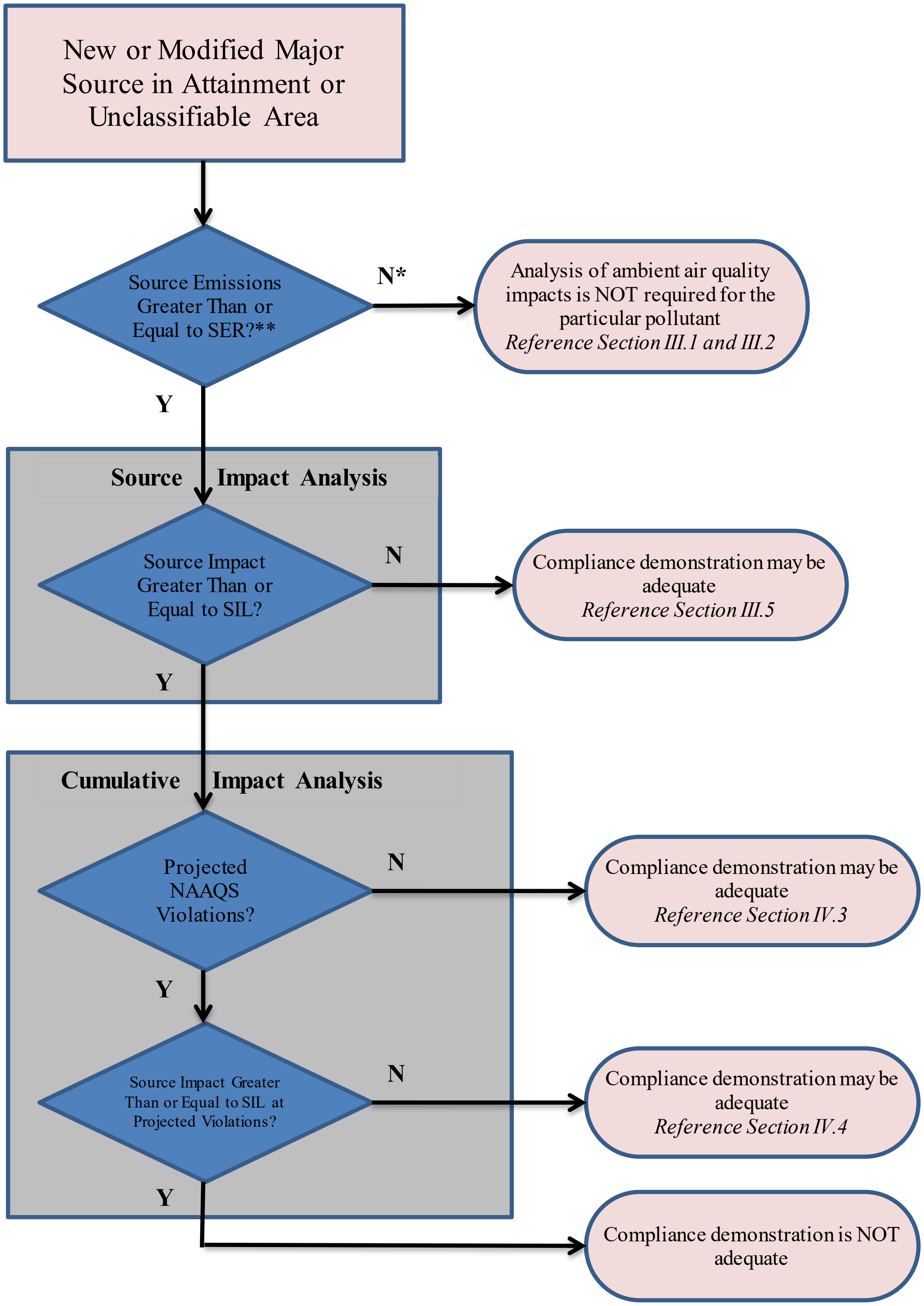
The EPA Regional Offices may seek clarification from the EPA's Office of Air Quality Planning and Standards (OAQPS) on issues and areas of concern in a modeling protocol or PSD compliance demonstration. Through these interactions and subsequent resolutions of specific issues, clarifications of preferred modeling procedures can become additional EPA guidance. This can happen in several ways: 1) the preferred procedures are published as regulations or guidelines; 2) the preferred procedures are formally transmitted as guidance to the Air Division Directors in the EPA Regional Offices; 3) the preferred procedures are formally transmitted as guidance to the EPA Regional Office modeling contacts; or 4) the preferred procedures are relied upon in decisions by the EPA's Model Clearinghouse that establish national precedent that the approach is technically sound. The Model Clearinghouse is the EPA focal point for the review of the technical adequacy of pollutant modeling to satisfy regulatory criteria and other NAAQS compliance demonstration techniques. Model Clearinghouse memoranda involving interpretation of modeling guidance for specific applications, as well as other clarification memoranda addressing modeling more generally, are available at the Support Center for Regulatory Atmospheric Modeling (SCRAM) website at: https://www.epa.gov/scram/air-quality-model-clearinghouse.

II. Guidance Overview

This guidance is appropriate for proposed new or modifying sources locating in, or located in, an area classified as attainment or unclassifiable for O_3 and/or $PM_{2.5}$. It is intended to provide recommendations on how to conduct compliance demonstrations for the O_3 NAAQS and the $PM_{2.5}$ NAAQS and PSD increments under the PSD program following the progressive steps shown in Figure II-1 (for O_3 and $PM_{2.5}$ NAAQS) and Figure II-2 (for $PM_{2.5}$ increments). Since each permitting action is considered on a case-by-case basis, this guidance does not limit or restrict any particular justifiable approach that permit applicants and permitting authorities may take to conduct the required compliance demonstrations. Prospective permit applicants should recognize the importance of the consultation process with the appropriate permitting authority. This process will help identify the most appropriate analytical techniques to be used for conducting a compliance demonstration for the O_3 NAAQS and the $PM_{2.5}$ NAAQS and PSD increments.

The EPA has historically supported the use of screening tools to facilitate the implementation of the PSD program and streamline the permitting process in circumstances where proposed construction is projected to have an insignificant impact on air quality. These screening tools include significant emissions rates (SERs) and significant impact levels (SILs). The use of these screening tools at each progressive step, as demonstrated in Figure II-1 and Figure II-2, is described in more detail throughout Section II.

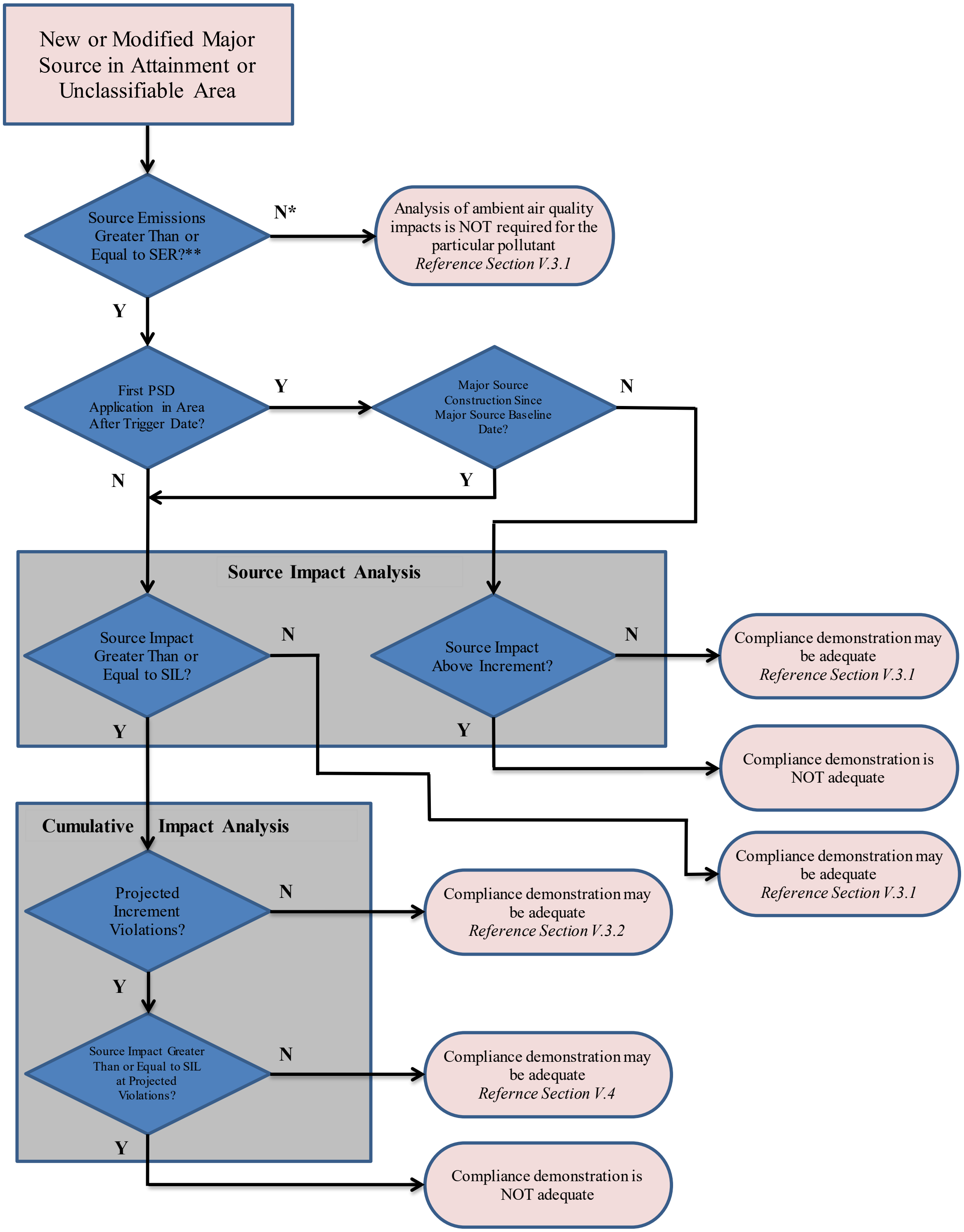
Figure II-1. Overview of O_3 and $PM_{2.5}$ NAAQS Compliance Demonstration for New or Modifying Sources under PSD Programs



* State, local, and tribal permit authorities may have specific regulations that require alternative or additional analyses and processes for assuring NAAQS and PSD Increments compliance.

** Any emissions rate or any net emissions increase associated with a major stationary source or major modification, which would construct within 10 kilometers of a Class I area, and have an impact on such area equal to or greater than 1 $\mu g/m^3$ (24-hour average), is considered significant and should proceed with an appropriate air quality assessment. *See* 40 CFR 52.21(b)(23)(iii).

Figure II-2. Overview of $PM_{2.5}$ PSD Increments Compliance Demonstration for New or Modifying Sources under PSD Programs



* State, local, and tribal permit authorities may have specific regulations that require alternative or additional analyses and processes for assuring NAAQS and PSD Increments compliance.

** Any emissions rate or any net emissions increase associated with a major stationary source or major modification, which would construct within 10 kilometers of a Class I area, and have an impact on such area equal to or greater than 1 $\mu g/m^3$ (24-hour average), is considered significant and should proceed with an appropriate air quality assessment. *See* 40 CFR 52.21(b)(23)(iii).

II.1 Significant Emissions Rates for O_3 and $PM_{2.5}$

O_3 and $PM_{2.5}$ are “regulated NSR pollutant[s]” as that term is defined in the PSD regulations.[2] Pursuant to that definition, ambient concentrations of O_3 are generally addressed through the regulation of its two precursors, nitrogen oxides (NO_X) and volatile organic compounds (VOC), while ambient concentrations of $PM_{2.5}$ are generally addressed through the regulation of direct $PM_{2.5}$ and its precursors, NO_X and sulfur dioxide (SO_2).[3] “Significant” is defined in the EPA regulations at 40 CFR 52.21(b)(23) in reference to a source’s potential to emit (or in the case of a modification, the emissions increase[4] and net emissions increase) of a regulated NSR pollutant. That definition specifies the pollutant and the corresponding emissions rate that, if equaled or exceeded, would qualify as “significant.” For ozone, the significant emissions rate is defined as 40 tpy of VOC or NO_X, and for $PM_{2.5}$, the significant emission rate is defined as 10 tpy of direct $PM_{2.5}$ emissions, 40 tpy of SO_2 emissions, or 40 tpy of NO_X emissions.[5]

---

[2] 40 CFR 52.21(b)(50). The regulations at 40 CFR 52.21 apply to the federal PSD program. This guidance document generally cites those regulations for simplicity, but the guidance reflected here may also be considered when applying EPA-approved state regulations modeled on 40 CFR 51.166, which contains the PSD program requirements for an approvable SIP that parallel the requirements of 40 CFR 52.21. This guidance may also cite the regulations at 40 CFR 51.166 when specifically discussing requirements for state PSD programs.

[3] *See* 73 FR 28321, 28333 (May 16, 2008). The EPA’s PSD regulations do not establish a presumption that VOC be treated as a precursor to $PM_{2.5}$ in the PSD program. However, a state, or the EPA, may demonstrate that VOC emissions in a specific area are a significant contributor to that area’s ambient $PM_{2.5}$ concentrations and, thus, should be treated as a regulated NSR pollutant subject to the PSD permitting requirements. 40 CFR 51.166(b)(49)(i)(b)(4); 40 CFR 52.21(b)(50)(i)(b)(4).

[4] While section 52.21(b)(23) explicitly defines “significant” for purposes of a net emissions increase or potential to emit, section 52.21(b)(40) defines “significant emissions increase” by reference to the definition of “significant” found in paragraph (b)(23).

[5] A significance rate for VOC as a $PM_{2.5}$ precursor is not defined in the PSD regulations. However, the preamble to EPA’s final rule on implementing the PSD permitting requirements for $PM_{2.5}$ and its precursors indicated that any state making a demonstration that VOC is a significant contributor to an area’s ambient $PM_{2.5}$ concentrations under 40 CFR 51.166(b)(49)(i)(b)(4) “would be required to adopt the 40-tpy significant emissions rate [for VOC as a $PM_{2.5}$ precursor] unless it demonstrates that a more stringent significant emissions rate (lower rate) is more appropriate.” 73 FR at 28333.

II.2 Pollutant Applicability for O_3 and $PM_{2.5}$ PSD Air Quality Assessments

The EPA's PSD regulations apply specific permitting requirements to regulated New Source Review (NSR) pollutants that would be emitted in a significant amount by a proposed new or modified major stationary source.[6] For a new major stationary source, PSD permitting requirements apply to any regulated NSR pollutant for which the source would have the potential to emit a significant amount. For a modification at an existing major stationary source, PSD permitting requirements apply to any regulated NSR pollutant for which the modification would result in a significant emissions increase *and* a significant net emissions increase (*i.e.*, a "major modification") of that pollutant.[7] Regulated NSR pollutants include pollutants for which a NAAQS has been promulgated, such as O_3 and $PM_{2.5}$, including any pollutant identified in the regulations as a constituent or precursor of a pollutant subject to a NAAQS, *i.e.*, NO_X and VOC in the case of O_3, and $PM_{2.5}$ direct emissions, SO_2, and NO_X in the case of $PM_{2.5}$.[8] As described in Section II.1, SERs for direct $PM_{2.5}$ emissions and each precursor of O_3 and $PM_{2.5}$ are defined in the regulations.[9]

The CAA and the EPA's implementing regulations require a PSD permit applicant to demonstrate that emissions from the proposed source or modification will not cause or contribute

---

[6] *See* 40 CFR 52.21(a)(2) for applicability procedures for new or modified major stationary sources. State, local, and tribal permit authorities may also have specific regulations that require alternative or additional analyses and processes for assuring NAAQS and PSD Increments compliance.

[7] Elsewhere in this document, simplified language may be used referring to a pollutant emitted in a significant amount or a source that would emit a significant amount of a pollutant. Where such language is used, it should be read to apply equally to the potential to emit of a new major stationary source and the emissions increase and net emissions increase from a modification at an existing major stationary source.

[8] *See* 40 CFR 52.21(b)(50).

[9] *See* 40 CFR 52.21(b)(23)(i). Individual O_3 precursors (*i.e.*, NO_X and VOC) are not summed when determining a significant emissions increase for O_3. Likewise, emissions of individual $PM_{2.5}$ precursors (*i.e.*, SO_2 and NO_X) are not summed when determining a significant emissions increase for $PM_{2.5}$; nor are emissions of a $PM_{2.5}$ precursor summed with direct $PM_{2.5}$ emissions when determining a significant emissions increase for $PM_{2.5}$. See 57 FR 55620, 55624 (Nov. 25, 1992); 80 FR 65292, 65441 (Oct. 26, 2015); *see also* 73 FR 28321, 28331 (May 16, 2008).

to a violation of any NAAQS or PSD increment and to provide an analysis of the impact of those emissions on ambient air quality based on monitoring data and air quality modeling.[10] The provisions at 40 CFR 52.21(k)(1) and (m)(1) describe the preconstruction air quality analysis requirements of the PSD program. Paragraph (k)(1) implements section 165(a)(3) of the CAA and provides that the owner or operator "shall demonstrate that allowable emission increases from the proposed source or modification. . . would not cause or contribute to air pollution in violation of [any NAAQS or PSD increment]." Paragraph (m)(1) implements section 165(e) of the CAA and provides that any PSD permit application shall contain an analysis of ambient air quality for each NAAQS pollutant that the source or modification would emit or increase in a significant amount and for each non-NAAQS pollutant as the Administrator determines necessary. Paragraph (m)(1)(iii) further provides that, for each NAAQS pollutant, the analysis shall contain continuous air quality monitoring data for determining whether emissions of that pollutant would cause or contribute to a violation of any NAAQS or PSD increment. For O_3 or $PM_{2.5}$, that analysis should examine the impact of the proposed source or modification on ambient concentrations of the NAAQS pollutant, as opposed to the impact of each individual precursor or direct component in isolation.

To make the required NAAQS or PSD increment compliance demonstration or air quality assessment, sources should provide a full accounting of the combined impacts of their allowable precursor (and direct component in the case of $PM_{2.5}$) emissions on ambient concentrations of the relevant NAAQS (*i.e.*, O_3 or $PM_{2.5}$) if any precursor(s) (or the direct component in the case of $PM_{2.5}$) would be emitted in a significant amount. In other words, for O_3, if either NOx or VOC precursor emissions would be emitted in a significant amount, then both precursors should be

---

[10] *See* CAA § 165(a)(3), CAA § 165(e), 40 CFR 52.21(k) and 40 CFR 52.21(m).

included in the assessment of O_3 impacts. Analogously, for $PM_{2.5}$, if a source would emit a significant amount of one or more of: NOx, SO_2, or direct $PM_{2.5}$ emissions, then the source should include NOx and SO_2 precursor and direct $PM_{2.5}$ emissions in the assessment of $PM_{2.5}$ impacts.[11] This approach is supported both scientifically, because it ensures that the source provides a full accounting of its projected air quality impacts for the relevant NAAQS, including all precursor (and direct component, in the case of $PM_{2.5}$) emissions, and legally, because it is needed to meet the requirements in the PSD regulations that the owner or operator of a proposed new major stationary source or major modification demonstrate that it will not cause or contribute to a NAAQS or PSD increment violation. The definition of "major modification" provides that any significant emissions increase or net emissions increase at a major stationary source that is significant for VOC *<u>or</u>* NO_X shall be considered significant for ozone.[12] This regulatory definition clearly states that if the emissions increase from a proposed modification at a major stationary source is significant for either VOC or NOx, then it shall be treated as significant not solely for the specific precursor that would exceed the SER but also for ozone in general. For purposes of the air quality assessment, this means that emissions of both ozone precursors should be evaluated to determine the proposed source or modification's impact on ambient ozone levels. Also, as discussed in Section II.1, the SER for ozone is defined as 40 tpy

---

[11] *See* Tables III-1 and III-2 for EPA recommended approaches for assessing ozone and $PM_{2.5}$ impacts by assessment case. This holistic approach is necessary for PSD air quality assessments for O_3 and $PM_{2.5}$ but not other substantive PSD permitting requirements, such as BACT, that apply directly to source emissions, and are not based on the source's projected impact on ambient air quality. The EPA regulations and longstanding EPA policy make clear that BACT limitations apply to directly emitted NAAQS pollutants or precursor pollutants (or both in the case of $PM_{2.5}$) that would be emitted from the proposed source (or increased by a modification) in a significant amount. *See* 40 CFR 52.21(j)(2), (3) and *In re Footprint Power Salem Harbor Development, LP*, PSD Appeal No. 14-02 (EAB 2014).

[12] *See* 40 CFR 52.21(b)(2)(ii). Similarly, the definition of "major stationary source" provides that a major source that is major for VOC <u>*or*</u> NO_X shall be considered major for ozone. *See* 40 CFR 52.21(b)(1)(ii).

of VOC *or* NO_X.[13] Thus, it is EPA's position that both scientific considerations and the regulatory language support a full accounting of the air quality impact of a pollutant and its precursors that would be emitted by a proposed source or modification, *i.e.*, all precursors, and the direct component in the case of $PM_{2.5}$, if any one of those would be emitted or would increase in a significant amount.

The EPA believes that adopting a narrower approach that would limit the air quality assessment to only the individual direct or precursor components with emissions equal to or greater than the corresponding SER, and excluding direct or precursor components with emissions less than the corresponding SER, would provide an incomplete and potentially deficient demonstration that the projected emissions from the proposed source or modification would not cause or contribute to a NAAQS or PSD increment violation. A reviewing authority considering only the impacts associated with a subset of direct and precursor emissions that would be emitted by the proposed source or modification may come to an incompletely supported determination that the required source impact demonstration had been made, whereas a more complete assessment that includes the impacts of all direct and precursor emissions may show that the proposed source or modification would cause or contribute to a NAAQS or PSD increment violation. Such a limited air quality assessment would be incomplete and therefore technically and legally flawed. A full accounting of the air quality impact of direct and precursor emissions, as applicable, is necessary to make the required demonstration that the allowable

---

[13] The SER definition for $PM_{2.5}$ is less clear because each pollutant-specific value is separated by a semicolon without using a connector such as "or;" however, the EPA reads the $PM_{2.5}$ SER definition consistently with the clearly stated ozone SER definition, meaning that for both ozone and $PM_{2.5}$, if the emissions of any precursor (or the direct emissions component in the case of $PM_{2.5}$) equals or exceeds the respective SER, all precursor emissions (and direct emissions in the case of $PM_{2.5}$) are treated as significant with respect to assessing air quality impacts for the corresponding NAAQS pollutant.

emissions increases would not cause or contribute to a violation of the NAAQS or PSD increments.

II.3 Significant Impact Levels for O_3 and $PM_{2.5}$

The EPA has issued guidance recommending that permitting authorities consider the use of appropriate pollutant-specific concentration levels known as "significant impact levels" as a compliance demonstration tool for O_3 and $PM_{2.5}$ air quality assessments on a case-by-case basis in PSD permitting actions (U.S. EPA, 2018a). The "SILs Guidance" identified recommended SIL values for the O_3 and $PM_{2.5}$ NAAQS and the $PM_{2.5}$ PSD increments and included a policy document, as well as supporting technical and legal analyses, that the EPA and other permitting authorities may use in case-by-case PSD permitting actions. As explained in the guidance, if a permitting authority chooses to use a recommended SIL value to support a PSD permitting decision, it should justify the SIL value and its use in the administrative record for the permitting action and may choose to rely upon the EPA's SILs Guidance, including the supporting technical and legal documents, in doing so.

The EPA's recommended SIL values from the SILs Guidance for the O_3 and $PM_{2.5}$ NAAQS are presented in Table II-1 and for the $PM_{2.5}$ PSD increments in Table II-2. It is important to note that the $PM_{2.5}$ NAAQS has two averaging periods: 24-hour and annual. There are no PSD increments established for O_3 and, thus, no O_3 increment SIL values. For a full discussion of the basis and purpose of the recommended O_3 and $PM_{2.5}$ SIL values, see the SILs Guidance and supporting documents (U.S. EPA, 2018a).

Table II-1. EPA Recommended SIL Values for O_3 and $PM_{2.5}$ NAAQS

Criteria Pollutant (NAAQS Level)	NAAQS SIL Concentration
Ozone 8-hour (70 ppb)	1.0 ppb
$PM_{2.5}$ 24-hour (35 µg/m^3)	1.2 µg/m^3*
$PM_{2.5}$ Annual (12 µg/m^3 or 15 µg/m^3)**	0.2 µg/m^3***

* The table accounts for the significant level for the 24-hour $PM_{2.5}$ NAAQS in 40 CFR 51.165(b)(2).
** Primary and secondary annual PM2.5 NAAQS, respectively.
*** The EPA recommends 0.2 µg/m3 as the SIL value. This value is lower than the value of 0.3 µg/m3 listed in 40 CFR 51.165(b)(2). Reference the SILs Gudiance for more information.

Table II-2. EPA Recommended SIL Values for $PM_{2.5}$ PSD Increments

Criteria Pollutant	PSD Increment SIL Concentration		
	Class I	Class II	Class III
$PM_{2.5}$ 24-hour	0.27 µg/m^3	1.2 µg/m^3	1.2 µg/m^3
$PM_{2.5}$ Annual	0.05 µg/m^3	0.2 µg/m^3	0.2 µg/m^3

As explained in the SILs Guidance, SILs are designed to have a role throughout the PSD air quality compliance demonstration. A permitting authority that chooses to use SILs should initially compare the modeled concentrations resulting from the proposed source's emissions increase at the affected emissions units to the appropriate SIL. The EPA calls this initial comparison the "Source Impact Analysis." Where the proposed source's predicted impacts on air quality concentrations are found at this first stage to be greater than or equal to the appropriate SIL, the analysis should then proceed to a second stage, which involves a cumulative assessment of the air quality in the affected area. The "Cumulative Impact Analysis" considers the combined impact of the proposed source or modification and other relevant sources in determining whether there would be a violation of any NAAQS or PSD increment in the affected area and, if so, whether the proposed source or modification would cause or contribute to such violation based on the appropriate SIL.

II.4 Source Impact Analysis

As described in section 9.2.3 of the 2017 *Guideline*, the EPA's recommended procedure for conducting a PSD air quality assessment is a multi-stage approach. The first stage is a single-source impact analysis or a source impact analysis.[14] This involves assessing whether the allowable emissions increase(s) from the affected emissions units at the proposed new or modifying source could cause or contribute to a NAAQS or PSD increment violation. As discussed in section II.3, the EPA issued the SILs Guidance containing recommendations on how to compare the impact from the source or modification alone to the appropriate SIL.

The owner or operator of a new major stationary source should perform a source impact analysis to inform the demonstration required for each regulated NSR pollutant that the source would have the potential to emit in a significant amount. The owner or operator of an existing source proposing a major modification should perform the analysis to inform the demonstration requirement for each regulated NSR pollutant that would result in a significant emissions increase and a significant net emissions increase, as determined by the PSD applicability procedures (see Section II.2 of this document). For O_3 or $PM_{2.5}$, which can be formed from precursor emissions, a significant increase of direct (for $PM_{2.5}$) or any precursor (for O_3 or $PM_{2.5}$) emissions would mean that the source should perform the required demonstration for all precursors (for O_3 or $PM_{2.5}$) and the primary pollutant (for $PM_{2.5}$) emitted. For O_3 this should

---

[14] This is consistent with the EPA's overall approach for the use of screening techniques in air quality modeling. See 40 CFR part 51, Appendix W, sections 2.2 ("Levels of Sophistication of Air Quality Analyses and Models") and 4.2.1 ("Screening Models and Techniques"). In section 2.2.a, the *Guideline* observes that "[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."

include both NOx and VOC if either would be emitted in a significant amount. For $PM_{2.5}$, this should include direct emissions of $PM_{2.5}$, as well as emissions of both NOx and SO_2 if any one or more of the three pollutants would be emitted in a significant amount. This holistic approach ensures that all relevant impacts from a proposed new major stationary source or major modification (*i.e.*, the combined effect of the source's direct and precursor emissions of O_3 or $PM_{2.5}$) are accounted for in a demonstration that the proposed new or modified major source will not cause or contribute to a NAAQS or PSD increment violation.

It is important to note that in many cases, the emissions rate(s) used for the source impact analysis should not be the same as the rate calculated for applicability purposes converted into equivalent short-term model input rates. First, as part of the 2002 NSR Reform Rule, the EPA made clear that "baseline actual emissions" and the "actual-to-projected-actual applicability test" should not be used for PSD air quality analyses.[15] Instead, for major modifications, the definition of "actual emissions" at 40 CFR 52.21(b)(21) continues to apply and post-project emissions should be based on potential to emit or allowable emissions.[16] Second, the "allowable emission increases" that must be evaluated pursuant to 40 CFR 52.21(k) should correspond with the averaging time of the applicable standard.[17] For major modifications, this may also depend on the type of emissions unit (new or existing) and the effect the project has on the emissions unit (*e.g.*, increase in short-term potential to emit vs. increase in annual utilization).

In a source impact analysis, as illustrated in Figure II-1 and Figure II-2 and further explained in this guidance, a permitting authority should compare the modeled concentrations

---

[15] *See* 40 CFR 52.21(b)(21)(i) and 67 FR 80186 (December 31, 2002) at 80190-91, 80196.

[16] "In general, actual emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a consecutive 24-month period which precedes the particular date and which is representative of normal source operation." 40 CFR 52.21(b)(21)(ii).

[17] *See* Table 8-2 of the *Guideline*.

resulting from the proposed source's emissions increase to an appropriate O_3 or $PM_{2.5}$ SIL. If the proposed source's maximum modeled impacts are found to be below the level of the O_3 or $PM_{2.5}$ SIL at every modeled receptor, this finding of the source impact analysis may be sufficient to demonstrate that the source will not cause or contribute to a violation of the O_3 NAAQS, $PM_{2.5}$ NAAQS, or the $PM_{2.5}$ PSD increment, as necessary to receive a PSD permit. On the other hand, where the proposed source's predicted impacts on air quality concentrations are estimated to be greater than or equal to the level of an appropriate O_3 or $PM_{2.5}$ SIL at any modeled receptor, the demonstration should proceed to the second stage, conducting a cumulative impact analysis.

II.5 Cumulative Impact Analysis

This section provides an overview of cumulative impact analyses for O_3 and $PM_{2.5}$ NAAQS, as well as $PM_{2.5}$ PSD increments compliance. The cumulative impact analysis is illustrated in Figure II-1 and Figure II-2 and further explained in this guidance.

II.5.1 O_3 and $PM_{2.5}$ NAAQS Compliance

For either O_3 or $PM_{2.5}$, where the source impact analysis described in Section II.4 is insufficient to show that a proposed new or modifying PSD source will not cause or contribute to a violation of the respective NAAQS, a cumulative impact analysis is then necessary to make the required NAAQS demonstration, as described in section 9.2.3 of the 2017 *Guideline*. A cumulative impact analysis should account for the combined impacts of the following:

1. All direct and precursor emissions of a pollutant (*i.e.*, O_3 or $PM_{2.5}$) from the new or modifying source if the source would emit any direct or precursor emissions of the pollutant in a significant amount;[18]
2. Direct emissions from nearby sources (for primary $PM_{2.5}$ impacts only), as appropriate; and
3. Monitored background levels or concentrations that account for secondary impacts from regional background sources, secondary impacts from precursor emissions from nearby sources, and, in the case of primary $PM_{2.5}$, $PM_{2.5}$ impacts from direct emissions from background sources, and nearby sources not explicitly modeled.[19]

Once the direct and precursor emissions impacts are taken into account, the estimated cumulative impact should then be compared to the NAAQS to determine if there is a modeled violation. If not, then the NAAQS compliance demonstration should be sufficient to show that the proposed source or modification will not cause or contribute to a violation. If there are predicted NAAQS violations, then the impacts of the direct and precursor emissions increases from the new or modifying source at those locations can be compared to the appropriate SIL to determine whether that increase will cause or contribute to the modeled violation of the NAAQS. Several aspects of the cumulative impact analysis for O_3 and $PM_{2.5}$ will be comparable to

---

[18] For a new major stationary source, this includes all direct and precursor pollutants if the source has the potential to emit any direct or precursor pollutant in an amount greater than or equal to the SER and for a modification to an existing major stationary source, it includes all direct and precursor pollutants, if the modification would result in a significant emissions increase and a significant net emissions increase of any direct or precursor pollutant.

[19] The emissions impact of any nearby source that has received a permit but is not yet operational should be included in the air quality assessment. In such cases, consultation with the appropriate permitting authority on the appropriate assessment approach is recommended. Consideration should also be given to the potential for some double-counting of the impacts from modeled emissions that may be also included in the background monitored concentrations.

analyses conducted for other criteria pollutants, while other aspects will differ due to the issues identified earlier.

II.5.2 PM$_{2.5}$ PSD Increments Compliance

For PM$_{2.5}$, where the source impact analysis described in Section II.4 is insufficient to show that a source will not cause or contribute to a violation of any PM$_{2.5}$ PSD increment, a cumulative impact analysis is necessary to make the PSD increment demonstration, as described in section 9.2.3 of the 2017 *Guideline*. A cumulative impact analysis for an increment differs from the NAAQS cumulative impact analysis in that the increment assessment only accounts for the combined impact of the new or modifying source's emissions increase and certain previous emissions changes from sources (including the modifying source) that affect the PSD increment under the EPA's PSD regulations. A more complete description of the types of emissions that affect increment consumption and other aspects of the PSD increment system is contained in Section V.1 of this guidance document. The cumulative impacts are then compared to the appropriate PM$_{2.5}$ PSD increments to determine whether the new or modifying source emissions will cause or contribute to a violation of any PM$_{2.5}$ PSD increment. The cumulative analysis for PM$_{2.5}$ PSD increments is described in greater detail in Section V.3.2.

For PM$_{2.5}$ PSD increments, since the requirement for calculating the amount of increment consumed was established relatively recently in comparison to the increments for other pollutants, a new or modified source being evaluated for PM$_{2.5}$ PSD increments compliance may still find that it is the first source, or one of only a few sources, with increment-consuming emissions in a particular attainment or unclassifiable area. As shown in Figure II-2, for such situations, a permitting authority may have sufficient reason (based on the approach for conducting source impact analysis described below) to conclude that the impacts of the new or modified source may be compared directly to the allowable increments, without the need for a cumulative modeling analysis. This would be the case where it can be shown that any other increment-consuming sources in the same baseline area, if any, do not have much or any overlapping impact with the proposed new or modified source.[20]

Another important consideration for $PM_{2.5}$ PSD increments is the differences in the EPA recommended SIL values for Class I and Class II / III areas, as presented in Table II-2. Given substantially lower recommended SIL values for Class I areas, there is a greater likelihood that a proposed new or modifying source would have a predicted impact that equals or exceeds an EPA recommended SIL for $PM_{2.5}$ PSD increments in a Class I area, even at distances beyond the nominal 50 km near-field application distance. Section 4.2 of the 2017 *Guideline* provides screening and compliance assessment approaches for near-field (50 km or less) and long-range transport (beyond 50 km) situations. The MERPs Guidance (*i.e.*, Tier 1 Assessment Approach) and the Single-source Modeling Guidance (*i.e.*, Tier 2 Assessment Approach) should be referenced for assessing secondary $PM_{2.5}$ impacts. There is also distance-weighted empirical relationship information (*i.e.*, precursor contributions to secondary impacts by distance from source) provided within the MERPs Guidance that may be particularly useful for assessing secondary $PM_{2.5}$ impacts in long-range transport situations. Consultation with the appropriate permitting authority and the appropriate EPA Regional Office is highly recommended for any permit applicants demonstrating long-range Class I area increment compliance per the requirements of section 4.2.c.ii of the 2017 *Guideline*.

---

[20] The term "increment-consuming source," as used in this guidance, is intended to refer to any type of source whose emissions changes (increases or decreases) affects the amount of increment consumed or expanded.

III. PSD Compliance Demonstrations for the O_3 and $PM_{2.5}$ NAAQS: Source Impact Analysis

This section provides details regarding the EPA's recommended approaches for conducting the source impact analysis as part of a PSD compliance demonstration for the O_3 and/or $PM_{2.5}$ NAAQS.

III.1 O_3 NAAQS

This section provides details regarding the EPA's recommended approaches for conducting the source impact analysis for the O_3 NAAQS associated with each of the two assessment cases presented in Table III-1. In each of the assessment cases, the analysis should begin by evaluating whether the impacts of either O_3 precursor (VOC or NO_X) would be emitted in a significant amount, *i.e.*, equal to or greater than the respective SER (40 tpy).

Table III-1. EPA Recommended Approaches for Assessing O_3 Impacts by Assessment Case

Assessment Case	**Description of Assessment Case**		**Secondary Impacts Approach***
Case 1: No Air Quality Analysis	NO_X emissions and VOC emissions < 40 tpy SER		N/A
Case 2*: Secondary Air Quality Impacts	NO_X emissions or VOC emissions ≥ 40 tpy SER		Include both precursors of O_3, see Section II.2. • **Tier 1 Approach** (*e.g.*, MERPs) • **Tier 2 Approach** (*e.g.*, Chemical Transport Modeling)

* In unique situations (*e.g.*, in parts of Alaska where photochemistry is not possible for portions of the year), it may be acceptable for the applicant to rely upon a qualitative approach to assess the secondary impacts. Any qualitative assessments should be justified on a case-by-case basis in consultation with the appropriate permitting authority and the appropriate EPA Regional Office.

For Case 1, a modeled O_3 NAAQS compliance demonstration is not required since neither O_3 precursor (NO_X or VOC) is proposed to be emitted in an amount equal to or greater than the applicable SER. For Case 2, where either NO_X or VOC precursor emissions are greater than the applicable SER, the permit applicant would need to conduct a compliance demonstration for secondary impacts for both O_3 precursors based on the two-tiered demonstration approach in the EPA's 2017 *Guideline*. Permit applicants are encouraged to consult with the appropriate permitting authority and Regional Office to avoid any unnecessary steps or overly conservative assumptions regarding any O_3 demonstrations.

III.2 $PM_{2.5}$ NAAQS

This section provides details regarding the EPA's recommended approaches for conducting the source impact analysis for the $PM_{2.5}$ NAAQS associated with each of the two assessment cases presented in Table III-2. In each of the assessment cases, the analysis should begin by evaluating whether direct $PM_{2.5}$would be emitted in a significant amount, *i.e.*, equal to or greater than the SER (10 tpy), or whether either precursor (NO_X or SO_2) would be emitted in a significant amount, *i.e.*, equal to or greater than the respective SER (40 tpy).

Table III-2. EPA Recommended Approaches for Assessing Primary and Secondary $PM_{2.5}$ Impacts by Assessment Case

Assessment Case	**Description of Assessment Case**	**Primary Impacts Approach**	**Secondary Impacts Approach***
Case 1: No Air Quality Analysis	Direct $PM_{2.5}$ emissions < 10 tpy SER and NO_X emissions and SO_2 emissions < 40 tpy SER	N/A	N/A
Case 2*: Primary and Secondary Air Quality Impacts	Direct $PM_{2.5}$ emissions ≥ 10 tpy SER or NO_X emissions or SO_2 emissions ≥ 40 tpy SER	**Appendix W preferred or approved alternative dispersion model**	Include both precursors of $PM_{2.5}$, see Section II.2. • **Tier 1 Approach** (*e.g.*, MERPs) • **Tier 2 Approach** (*e.g.*, Chemical Transport Modeling)

* In unique situations (*e.g.*, in parts of Alaska where photochemistry is not possible for portions of the year), it may be acceptable for the applicant to rely upon a qualitative approach to assess the secondary impacts. Any qualitative assessments should be justified on a case-by-case basis in consultation with the appropriate EPA Regional Office or other applicable permitting authority.

A modeled $PM_{2.5}$ NAAQS compliance demonstration is not required for Case 1 since neither direct $PM_{2.5}$, nor any $PM_{2.5}$ precursor (NO_X or SO_2), is proposed to be emitted in an amount equal to or greater than the applicable SER. Case 1 is the only assessment case that does not require conducting a source impact analysis.

For Case 2, where direct $PM_{2.5}$ emissions or NO_X or SO_2 precursor emissions are greater than or equal to the applicable SER, the primary $PM_{2.5}$ impacts from direct $PM_{2.5}$ emissions can be estimated based on application of AERMOD or another appropriate preferred model listed in Appendix A of the 2017 *Guideline*, or an alternative model subject to the provisions of section 3.2 of the 2017 *Guideline*. However, AERMOD and other preferred models currently listed in Appendix A of the 2017 *Guideline* do not account for secondary formation of $PM_{2.5}$ associated with the source's precursor emissions. The assessment of NO_X and SO_2 precursor emission impacts on secondary $PM_{2.5}$ formation should be conducted based on the two-tiered demonstration approach in EPA's 2017 *Guideline*. Permit applicants are encouraged to consult with the appropriate permitting authority and Regional Office to avoid any unnecessary steps or overly conservative assumptions regarding any secondary $PM_{2.5}$ formation demonstrations.

III.3 Assessing Primary $PM_{2.5}$ Impacts

The assessment of primary $PM_{2.5}$ impacts from the proposed new or modifying source is generally the same for the $PM_{2.5}$ NAAQS and PSD increments. Section 4.2.3.5 of the 2017 *Guideline* identifies the AERMOD modeling system as the preferred model for addressing direct $PM_{2.5}$ emissions unless another preferred model listed in the *Guideline* is more appropriate, such as the Offshore and Coastal Dispersion Model (OCD), or the use of an alternative model is justified consistent with section 3.2 of the 2017 *Guideline*.

The AERMOD modeling system includes the following regulatory components:

- AERMOD: the dispersion model (U.S. EPA, 2022a);
- AERMAP: the terrain processor for AERMOD (U.S. EPA, 2018b); and
- AERMET: the meteorological data processor for AERMOD (U.S. EPA, 2022b).

Other components that may be used, depending on the application, are:

- BPIPPRIME: the building input processor (U.S. EPA, 2004);
- AERSURFACE: the surface characteristics processor for AERMET (U.S. EPA, 2020);
- AERSCREEN: a screening version of AERMOD (U.S. EPA, 2021; U.S. EPA, 2011a); and
- AERMINUTE: a pre-processor to calculate hourly average winds from Automated Surface Observing System (ASOS) 2-minute observations (U.S. EPA, 2015).

Before applying AERMOD, the applicant should become familiar with the user's guides associated with the modeling components listed above and the most recent version of the AERMOD Implementation Guide (U.S. EPA, 2022c). In addition to these documents, detailed guidance on the use of the AERMOD modeling system for estimating primary $PM_{2.5}$ impacts is provided in Appendix B. Because AERMOD is limited to modeling direct $PM_{2.5}$ emissions, additional or alternative approaches are needed to provide an assessment of secondary $PM_{2.5}$ impacts from the proposed new or modifying source, as discussed in more detail in the following sections.

III.4 Assessing O_3 and Secondary $PM_{2.5}$ Impacts

This section provides more detail on the EPA's recommended approaches for assessing the impacts of precursor emissions on O_3 and/or secondary $PM_{2.5}$ formation.

III.4.1 Conceptual Model

Each NAAQS compliance demonstration is unique and may require multiple factors to be considered and assumptions to be thoroughly justified as a part of the technical assessment. A well-developed modeling protocol that includes a detailed conceptual description of the current air pollutant concentrations in the area (see Appendix A for examples of elements of a conceptual description) and of the nature of the emissions sources within proximity of the new or modifying emissions source is essential for determining the necessary components of an acceptable assessment of the impact from O_3 and/or secondary $PM_{2.5}$ formation.[21] The

---

[21] For more detailed information on the development of such conceptual descriptions for an area, please refer to the following:

development of this conceptual description and understanding does not need to be an onerous task and can build upon previous conceptual descriptions generated for other projects in the same region With timely and appropriate consultation between the applicant and the appropriate permitting authority, along with the submittal and subsequent approval, if required, of the modeling protocol by the appropriate permitting authority, many potential problems and unintended oversights in the technical assessment can be resolved early in the process or avoided all together.

In the development of an appropriate conceptual description to support an assessment, it is important to fully characterize the current O_3 and/or $PM_{2.5}$ concentrations in the region where the new or modifying source is to be located and not just the most current design values, which historically has been used as background concentrations in a cumulative modeling demonstration. For O_3, this characterization should take into consideration episodic high O_3 concentrations and any trends in the area. For $PM_{2.5}$, this characterization should take into consideration the seasonality and speciated composition of the current $PM_{2.5}$ concentrations and any long-term trends that may be occurring. It may also be important to describe the typical background concentrations of certain chemical species that participate in the photochemical reactions that form O_3 and secondary $PM_{2.5}$. It is possible that there are mitigating factors for

---

Chapter 10 of "Particulate Matter Assessment for Policy Makers: A NARSTO Assessment." P. McMurry, M. Shepherd, and J. Vickery, eds. Cambridge University Press, Cambridge, England (NARSTO, 2004).

Section 11, "How Do I Get Started? 'A Conceptual Description'" of "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze." U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (U.S. EPA, 2007a).

In addition, relevant regional examples include: "Conceptual Model of $PM_{2.5}$ Episodes in the Midwest," January 2009, Lake Michigan Air Directors Consortium; and "Conceptual Model of Particulate Matter Pollution in the California San Joaquin Valley," Document Number CP045-1-98, September 8, 1998.

secondary $PM_{2.5}$ formation given limitations of other chemical species important in the photochemical reactions, *e.g.*, minimal ammonia (NH_3) in the ambient environment that could limit any precursor pollutant from readily reacting to form secondary $PM_{2.5}$. This understanding of the atmospheric environment will provide important insights on the potential for secondary formation and highlight aspects that will need to be accounted for in the source impact and/or cumulative impact assessment.

A good conceptual description will also characterize the meteorological conditions that are representative of the region and are associated with periods and/or seasons of higher and lower ambient O_3 and/or 24-hour $PM_{2.5}$ concentrations. For example, identification of meteorological phenomena that typically occur during periods of high daily 8-hour O_3 or 24-hour $PM_{2.5}$ concentrations, such as low-level temperature inversions, stagnant high pressure systems, low-level jets, etc., can be extremely important in understanding the importance, or lack thereof, of photochemistry and secondary $PM_{2.5}$ formation for the higher ambient O_3 and $PM_{2.5}$ concentrations. The analysis and understanding of meteorological conditions will also inform the assessment of high O_3 episodes and seasonal 24-hour $PM_{2.5}$ concentrations in the region.

III.4.2 Tier 1 Assessment Approach

As discussed in the section 5.2 of the 2017 *Guideline*, the EPA has determined that advances in chemical transport modeling science make it reasonable to provide more specific, generally-applicable guidance that identifies particular models or analytical techniques that may be appropriate for use under specific circumstances for assessing the impacts of an individual proposed source on O_3 and secondary $PM_{2.5}$ concentrations. There is not a preferred model or technique for estimating O_3 or secondary $PM_{2.5}$ for specific source impacts. Instead, for assessing secondary pollutant impacts from individual proposed sources, the degree of complexity required to appropriately assess potential single-source impacts varies depending on the nature of the source, its proposed emissions, and the background environment. In order to provide the user community flexibility in estimating single-source secondary pollutant impacts, which allows for different approaches to credibly address these different areas, the 2017 *Guideline* recommends a two-tiered demonstration approach for addressing single-source impacts on ambient concentrations of O_3 and secondary $PM_{2.5}$.

To inform a Tier 1 assessment,[22] the existing air quality model-based information that is used should be appropriate in terms of representing the type of source, its precursor emissions, its geographic location, and a current composition of regional emissions, in addition to those elements of the conceptual description discussed above. The air quality modeling information may be available from past or current SIP attainment demonstration modeling, published modeling studies, or peer-reviewed literature with estimates of model responsiveness to precursor emissions in contexts that are relevant to the new or modifying source. The estimates of model responsiveness, such as impact on O_3 concentrations per ton of NO_X or impact on $PM_{2.5}$ concentrations per ton of SO_2 emissions, could then be used in conjunction with the precursor emissions estimates for the proposed new or modifying source to provide a quantitative estimate of the impact of such precursor emissions on the formation of O_3 and/or secondary $PM_{2.5}$ concentrations. The estimates of responsiveness should be technically credible

---

[22] A Tier 1 assessment involves the use of technically credible relationships between precursor emissions and a source's secondary impacts, *e.g.*, as demonstrated in modeling for a source impact analysis, 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 for evaluating a proposed source's impacts, or generated by a peer-reviewed reduced form model. In such cases, the EPA expects that existing air quality model-based information regarding the potential for NO_X and VOC precursor emissions to form O_3 and for SO_2 and NO_X precursor emissions to form secondary $PM_{2.5}$ concentrations may be used to establish an appropriate estimate of O_3 and/or secondary $PM_{2.5}$ impacts from the proposed new or modifying source.

in representing such impacts and it may be advisable for the estimate to reflect an upper bound of potential impacts.

To assist in the development of appropriate Tier 1 demonstration tools, the EPA developed the MERPs Guidance to provide a framework for permitting authorities to develop area-specific MERPs. The MERPs Guidance illustrates how permitting authorities may appropriately develop MERPs for specific areas and use them as a Tier 1 compliance demonstration tool for O_3 and secondary $PM_{2.5}$ under the PSD permitting program. The MERPs Guidance also addresses the appropriate use of MERPs to reflect the combined ambient impacts across O_3 or $PM_{2.5}$ precursors and, in the case of $PM_{2.5}$, the combined primary and secondary ambient impacts. Such an approach includes flexibility with respect to the use of Tier 1 demonstration tools to generate information relevant for specific regions or areas and representative of secondary formation in a particular region or area.

Specifically, the MERPs Guidance provides information about how to use CTMs to estimate single-source impacts on O_3 and secondary $PM_{2.5}$ and how such model simulation results for specific areas can be used to develop empirical relationships between a source's O_3 and $PM_{2.5}$ precursor emissions and its secondary impacts that may be appropriate for use as a Tier 1 demonstration tool. It also provides results from EPA photochemical modeling of a set of more than 100 hypothetical sources across geographic areas and source types that may be used in developing MERPs as discussed in the guidance. 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.

As discussed in the MERPs Guidance, the EPA's Single-source Modeling Guidance provides information to stakeholders about how to appropriately address the variety of chemical and physical characteristics regarding a project scenario and key receptor areas in conducting photochemical modeling to inform development of MERPs. The development of MERPs for O_3 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 PSD permit demonstrations.

As an example, a Tier 1 assessment of secondary O_3 and $PM_{2.5}$ impacts was developed by a permit applicant, the Tennessee Valley Authority (TVA), for a major modification at their Gleason facility in Tennessee in 2018. The TVA and the Tennessee Department of Environment and Conservation (TDEC) worked closely with EPA Region 4 to ensure that the ambient impacts analysis was technically sound and consistent with applicable PSD regulations and EPA guidance. The PSD air quality modeling analysis was submitted to TDEC in late 2018 using an approach that was consistent with the MERPs Guidance to relate facility emissions to potential downwind impacts of secondary O_3 and $PM_{2.5}$. A more detailed discussion of the TVA's technical assessment is provided in Appendix C.

The National Association of Clean Air Agencies (NACAA) Workgroup final report (NACAA, 2011) provides details on potential approaches to quantify the secondary $PM_{2.5}$ impacts from a proposed new or modifying source that may be appropriate to inform a Tier 1 assessment of $PM_{2.5}$ impacts (see Appendices C and D of NACAA, 2011). One suggested method in the final report is to convert emissions of precursors into equivalent amounts of direct $PM_{2.5}$ emissions using "pollutant offset ratios" and then use a dispersion model to assess the impacts of the combination of direct $PM_{2.5}$ emissions and the equivalent direct $PM_{2.5}$ emissions.

The "pollutant offset ratios" referenced in the NACAA Workgroup report were from the EPA's 2008 "Implementation of the New Source Review (NSR) Program for Particulate Matter Less Than 2.5 Micrometers ($PM_{2.5}$)" final rule notice (73 Fed. Reg. 28321, May 16, 2008) concerning the development and adoption of interpollutant trading (offset) provisions for $PM_{2.5}$ under state nonattainment area NSR programs for $PM_{2.5}$. The EPA's July 23, 2007, technical analysis titled "Details on Technical Assessment to Develop Interpollutant Trading Ratios for $PM_{2.5}$ Offsets" describes the method used to develop the original "preferred" precursor offset ratios (U.S. EPA, 2007b).[23]

The EPA does not support using the specific results from the EPA's 2007 technical assessment in the context of PSD compliance demonstrations without additional technical demonstration specific to the source(s) and area(s) for which the ratios would be applied. As described in the EPA's July 21, 2011 memorandum changing its policy on use of the "preferred" interpollutant offset trading ratios included in the preamble to the 2008 final rule, the EPA acknowledged that existing models and techniques are adequate to "conduct local demonstrations leading to the development of area-specific ratios for $PM_{2.5}$ nonattainment areas" and provided a general framework for efforts that may be relevant in developing appropriate "pollutant offset ratios" for use in hybrid qualitative/quantitative assessment of secondary $PM_{2.5}$ impacts (U.S. EPA, 2011b). A similar general framework is embodied in the MERPs Guidance in which the EPA addresses how to conduct modeling to inform the development of a MERP for

---

[23] In the preamble to the 2008 final rule, the EPA included preferred or presumptive offset ratios, applicable to specific $PM_{2.5}$ precursors that the EPA said at that time state/local air agencies could adopt in conjunction with the new interpollutant offset provisions for $PM_{2.5}$, and for which the state could rely on the EPA's technical work to demonstrate the adequacy of the ratios for use in any $PM_{2.5}$ nonattainment area. In a July 21, 2011 memorandum, EPA changed its policy and stated that it no longer supported the ratios provided in the preamble to the 2008 final rule as presumptively approvable ratios for adoption in SIPs containing nonattainment NSR programs for $PM_{2.5}$. Memorandum from Gina McCarthy, Assistant Administrator, to Regional Air Division Directors, "Revised Policy to Address Reconsideration of Interpollutant Trading Provisions for Fine Particles ($PM_{2.5}$)" (U.S. EPA, 2011b).

a particular area.

The EPA also notes that the NACAA Workgroup "considered, but rejected, other methods for assessing secondary $PM_{2.5}$ impacts, including use of a simple emissions divided by distance (Q/D) metric and use of AERMOD with 100 percent conversion of SO_2 and NO_X concentrations to $(NH_4)_2SO_4$ and $(NH_4)NO_3$." The EPA has reviewed the detailed discussion provided in Appendix E of the NACAA Workgroup final report and agrees with these technical conclusions.

III.4.3 Tier 2 Assessment Approach

As discussed in the 2017 *Guideline*, a Tier 2 assessment involves application of more sophisticated, case-specific CTMs in consultation with the appropriate permitting authority and conducted consistent with the recommendations in the most current version of the Single-source Modeling Guidance. Where it is necessary to estimate O_3 and/or secondary $PM_{2.5}$ impacts with case-specific air quality modeling, a candidate model should be selected for estimating single-source impacts on O_3 and/or secondarily formed $PM_{2.5}$ that meets the general criteria for an "alternative model" where there is no preferred model as outlined in section 3.2.2.e of the 2017 *Guideline*. The general criteria include:

i. The model has received a scientific peer review;

ii. The model can be demonstrated to be applicable to the problem on a theoretical basis;

iii. The databases that are necessary to perform the analysis are available and adequate;

iv. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and

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

Section 3.2.2 further provides that the appropriate EPA Regional Office, in consultation with the EPA Model Clearinghouse, is authorized to approve a particular model and approach as an alternative model application.

Both Lagrangian puff models and photochemical grid models may be appropriate for this purpose where those models satisfy alternative model criteria in section 3.2.2 of the 2017 *Guideline*. That said, the EPA believes photochemical grid models are generally most appropriate for addressing O_3 and secondary $PM_{2.5}$ impacts because they provide a spatially and temporally dynamic realistic chemical and physical environment for plume growth and chemical transformation. Publicly available and documented Eulerian photochemical grid models such as the Comprehensive Air Quality Model with Extensions (CAMx) (Ramboll Environ, 2018) and the Community Multiscale Air Quality (CMAQ) (Byun and Schere, 2006) 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 O_3 and $PM_{2.5}$ (Chen et al., 2014; Civerolo et al., 2010; Russell, 2008; Tesche et al., 2006). In addition, these models have been used extensively to support O_3 and $PM_{2.5}$ SIPs and to explore relationships between inputs and air quality impacts in the United States and elsewhere (Cai et al., 2011; Civerolo et al., 2010; Hogrefe et al., 2011).

On August 4, 2017, the EPA released a memorandum (U.S. EPA, 2017b) providing information specific to how the CAMx and the CMAQ model systems were relevant for each of these elements. This memorandum provides an alternative model demonstration for the CAMx and CMAQ photochemical transports models establishing their fit for purpose in PSD compliance demonstrations for O_3 and $PM_{2.5}$ and in NAAQS attainment demonstrations for O_3, $PM_{2.5}$ and Regional Haze. The memorandum also provides support for their general applicability for use in PSD compliance demonstrations; however, it does not replace the need for such demonstrations to provide model protocols describing model application choices or the evaluation of model inputs and baseline predictions against measurements relevant for their specific use by permit applicants and state, local, and tribal air agencies.

For those situations where a refined Tier 2 demonstration is necessary, the EPA has also provided the Single-source Modeling Guidance that provides recommended, credible procedures to estimate single-source secondary impacts from sources for permit related assessments. Extensive peer-reviewed literature demonstrates and documents that photochemical grid models have been applied for assessing single-source impacts and that the models adequately represent secondary pollutant impacts from a specific facility, in comparison to near-source downwind in-plume measurements. The literature shows that these models can clearly differentiate impacts of a specific facility from those of other sources (Baker and Kelly, 2014; Zhou et al., 2012). Other peer-reviewed research has clearly shown that photochemical grid models are able to simulate impacts from single sources on secondarily-formed pollutants (Baker et al., 2015; Bergin et al., 2008; Kelly et al., 2015). 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 (ENVIRON 2012a; ENVIRON 2012b; Yarwood et al., 2011). 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 will lead to continual improvements in science and associated predictive capabilities of these models.

For the purposes of conducting a Tier 2 assessment, the application of a CTM will involve case-specific factors that should be part of the consultation process with the appropriate permitting authority and reflected in the agreed-upon modeling protocol. Consistent with the Single-source Modeling Guidance and section 9.2.1 of the 2017 *Guideline*, the EPA recommends that the modeling protocols for this purpose should include the following elements:

1. Overview of Modeling/Analysis Project
    - Participating organizations
    - Schedule for completion of the project
    - Description of the conceptual model for the project source/receptor area
    - Identify how modeling and other analyses will be archived and documented
    - Identify specific deliverables to the appropriate permitting authority
2. Model and Modeling Inputs
    - Rationale for the selection of air quality, meteorological, and emissions models
    - Modeling domain
    - Horizontal and vertical resolution
    - Specification of initial and boundary conditions
    - Episode selection and rationale for episode selection
    - Rationale for and description of meteorological model setup
    - Basis for and development of emissions inputs
    - Methods used to quality assure emissions, meteorological, and other model inputs
3. Model Performance Evaluation

- Describe ambient database(s)
- Describe evaluation procedures and performance metrics

As stated previously, the EPA expects that the EPA Regional Offices, with assistance from the OAQPS, may assist reviewing authorities, as necessary, to structure appropriate technical demonstrations leading to the development of appropriate CTM applications for the purposes of estimating potential O_3 and/or secondary $PM_{2.5}$ impacts.

III.5 Comparison to the SIL

This section provides recommendations for source impact analyses where a permit applicant compares the proposed source's ambient O_3 or $PM_{2.5}$ impacts to an appropriate SIL as part of the required demonstration that a proposed source or modification will not cause or contribute to a violation of the O_3 or $PM_{2.5}$ NAAQS. These recommendations are also generally applicable for demonstrations that a proposed source or modification will not cause or contribute to a violation of the $PM_{2.5}$ PSD increments, see Section V.4. The EPA's recommended SIL values for O_3 and $PM_{2.5}$ NAAQS and $PM_{2.5}$ PSD increments are listed in Table II-1 and Table II-2. (U.S. EPA, 2018a).

III.5.1 SIL Comparison for O_3

For Assessment Case 2, an analysis of secondary O_3 impacts should be conducted where the proposed source's precursor emissions of NO_X or VOC are equal to or greater than the respective SERs. The EPA recommends that the assessment of the combined precursor emissions impacts on O_3 formation be conducted based on the two-tiered demonstration approach specific to O_3 in section 5.3 of the 2017 *Guideline*. Under the Tier 1 approach, for source impact analyses, the highest of the multi-season (or episode) averages of the maximum modeled daily 8-hour O_3 concentrations predicted each season (or episode) at each grid cell or location should be compared to the appropriate O_3 SIL, since this metric represents the maximum potential daily 8-hour O_3 impact from the proposed source or modification. A source impact analysis applied consistently with the MERPs Guidance is also an acceptable Tier 1 approach. Under the Tier 2 approach, where a CTM is directly applied to estimate the source impacts, the comparison should be done at each receptor, *i.e.*, each modeled grid cell. If the source impact is less than the SIL, then the source impact analysis is generally sufficient to support a finding that the source will not cause or contribute to a NAAQS violation. However, if the source impact is equal to or greater than the SIL, then the analysis is insufficient to show that a source will not cause or contribute to a violation of the NAAQS and a cumulative impact assessment is necessary.

III.5.2 SIL Comparison for $PM_{2.5}$

For Assessment Case 2, analyses of both primary and secondary $PM_{2.5}$ impacts are necessary because the proposed source's direct $PM_{2.5}$ emissions or emissions of at least one $PM_{2.5}$ precursor are equal to or greater than the respective SERs. In this case, the combined primary and secondary $PM_{2.5}$ impacts from the proposed source or modification should be included in the comparison to the appropriate $PM_{2.5}$ SIL in the source impact analysis.

The assessment of the primary $PM_{2.5}$ concentrations due to direct emissions should be conducted using the EPA preferred AERMOD dispersion model (or other acceptable preferred or approved alternative model). The dispersion modeling methods here are similar to the methods used for other primary pollutants, including the use of maximum allowable emissions, following Table 8-2 of the 2017 *Guideline*. However, due to the form of the $PM_{2.5}$ NAAQS, the EPA recommends that one of the following be included in the combined $PM_{2.5}$ SIL comparison for the source impact analysis, depending on the meteorological data used in the analysis:

- The highest of the 5-year averages of the maximum modeled annual 24-hour $PM_{2.5}$ concentrations (for the 24-hour $PM_{2.5}$ NAAQS) or highest of the 5-year averages of the annual average $PM_{2.5}$ concentrations (for the annual $PM_{2.5}$ NAAQS) predicted each year at each receptor, based on 5 years of representative National Weather Service (NWS) data;
- The highest modeled 24-hour $PM_{2.5}$ concentration (for the 24-hour $PM_{2.5}$ NAAQS) or the highest modeled average $PM_{2.5}$ concentration (for the annual $PM_{2.5}$ NAAQS) predicted at each receptor based on 1 year of site-specific meteorological data; or the highest of the multi-year averages of the maximum modeled annual 24-hour $PM_{2.5}$ concentration (for the 24-hour $PM_{2.5}$ NAAQS) or the highest of the multi-year averages of the maximum modeled annual average $PM_{2.5}$ concentrations (for the annual $PM_{2.5}$ NAAQS) predicted each year at each receptor, based on 2 or more years, up to 5 complete years, of available site-specific meteorological data; or
- The highest of the 3-year averages of the maximum modeled annual 24-hour $PM_{2.5}$ concentrations (for the 24-hour $PM_{2.5}$ NAAQS) or highest of the 3-year averages of the annual average $PM_{2.5}$ concentrations (for the annual $PM_{2.5}$ NAAQS) predicted each year at each receptor, based on 3 years of prognostic meteorological data.

These metrics represent the maximum potential 24-hour or annual $PM_{2.5}$ impacts from the proposed source or modification at any receptor, given the form of the NAAQS, and therefore provide an appropriate part of the basis for determining whether a cumulative modeling analysis would be needed.

For the assessment of the precursor emission impacts on $PM_{2.5}$ formation, the EPA recommends that this part of the assessment be conducted based on the two-tiered demonstration approach specific to $PM_{2.5}$ in section 5.4 of the 2017 *Guideline*. The MERPs Guidance is available to assist with the secondary $PM_{2.5}$ impact aspects of a Tier 1 approach; whereas a Tier 2 approach would directly apply a CTM to estimate the source secondary $PM_{2.5}$ impacts. The resulting combined primary and secondary $PM_{2.5}$ impact included in the comparison to the appropriate $PM_{2.5}$ SIL will depend on the type of assessment conducted for the secondary $PM_{2.5}$ impacts from the source.

In the SIL comparison for Case 2, the primary and secondary $PM_{2.5}$ impacts may be combined in various ways that may entail greater or lesser degrees of conservatism. For example, combining the peak estimated primary $PM_{2.5}$ impact with the peak estimated secondary $PM_{2.5}$ impact, unpaired in time and space, would tend to be a conservative estimate of combined impacts since, as noted above, peak impacts associated with a source's direct $PM_{2.5}$ and precursor emissions are not likely well-correlated in time or space. The conservatism associated with combining peak estimated primary and secondary impacts for comparison to a SIL makes this an appropriate initial approach to combining estimated primary and secondary $PM_{2.5}$ impacts.

Other approaches for combining primary and secondary $PM_{2.5}$ impacts for comparison to a SIL will vary based on the degree of temporal and spatial pairing of estimated primary and secondary $PM_{2.5}$ impacts. Full temporal and spatial pairing may not be feasible in many cases, given that the dispersion modeling and chemical transport modeling may be based on different data periods. Furthermore, full temporal and spatial pairing of primary and secondary $PM_{2.5}$ impacts may not be appropriate in many cases because photochemical grid modeling represents gridded concentration estimates whereas dispersion modeling produces estimates at discrete receptor locations and because of the limitations of both the dispersion model and the photochemical grid model to accurately predict impacts on a paired in time and space basis. As a result, consideration of some degree of temporal pairing of primary and secondary $PM_{2.5}$ impacts is most appropriate on a seasonal or monthly basis with considerations of spatial pairing that reflects the general lack of correlation between primary and secondary impacts, *i.e.*, primary impacts being higher near the source while secondary impacts being higher at some distance away from the source.

The permitting authority and the permit applicant should thoroughly discuss the details regarding combining modeled primary and secondary $PM_{2.5}$ impacts for Case 2 situations and should reach agreement during the initial review of the modeling protocol. The permitting authority should ensure that any approach for combining estimated primary and secondary $PM_{2.5}$ impacts for comparison to a SIL for Case 2 conforms to the recommendations described above regarding the form of the modeled estimate. Accordingly, the approach should be based on the highest of the multi-year averages of the maximum modeled 24-hour or annual $PM_{2.5}$ concentrations predicted each year at each receptor, which represents the maximum potential impact from the proposed source or modification.

Ultimately, if the combined primary and secondary $PM_{2.5}$ impacts are less than the SIL, then the analysis is generally sufficient to support a finding that the source will not cause or contribute to a NAAQS violation. However, if the combined primary and secondary $PM_{2.5}$ impacts are equal to or greater than the SIL, then the analysis is insufficient to show that a source will not cause or contribute to a violation of the NAAQS and a cumulative impact assessment is necessary to make the NAAQS compliance demonstration.

IV. PSD Compliance Demonstrations for the O_3 and $PM_{2.5}$ NAAQS: Cumulative Impact Analysis

Where the source impact analysis described in Section III is insufficient to show that a source will not cause or contribute to a violation of the O_3 or $PM_{2.5}$ NAAQS, a cumulative impact assessment is necessary to make the NAAQS compliance demonstration. A cumulative assessment accounts for the combined impacts of the proposed new or modifying source's emissions, emissions from other nearby sources, and representative background levels of O_3 or $PM_{2.5}$ within the modeling domain. The cumulative impacts are then compared to the O_3 or $PM_{2.5}$ NAAQS to determine whether there is a modeled NAAQS violation. If not, then the NAAQS compliance demonstration is sufficient. If there are modeled violations, then the source impact at the location of these predicted violations is compared to the appropriate SIL to determine if the proposed new or modifying source emissions will cause or contribute to a violation of the NAAQS. This section provides details on conducting an appropriate cumulative impact assessment for the O_3 and $PM_{2.5}$ NAAQS.

O_3

The cumulative impact assessment should include the following components of O_3 impacts, as appropriate, for comparison to the NAAQS:

- Proposed new or modifying source
    - Impacts on O_3 from each precursor (NO_X and VOC)
- Nearby sources
    - Impacts on O_3 from precursors (NO_X and VOC) are typically accounted

    for through representative monitored background[24]

- Monitored background concentrations of O_3 that accounts for O_3 impacts from regional transport and from nearby sources, and O_3 impacts from background sources not included in the modeled inventory, *e.g.*, minor and mobile sources.

$PM_{2.5}$

The cumulative impact assessment should include the following components of $PM_{2.5}$ impacts, as appropriate, for comparison to the NAAQS:

- Proposed new or modifying source
    - Primary impacts on $PM_{2.5}$, *i.e.*, from direct $PM_{2.5}$ emissions
    - Secondary impacts on $PM_{2.5}$ from each precursor (NO_X and SO_2)
- Nearby sources
    - Primary impacts on $PM_{2.5}$[25]
    - Impacts on $PM_{2.5}$ from precursors (NO_X and SO_2) are typically accounted for through representative monitored background
- Monitored background concentrations of $PM_{2.5}$ that accounts for secondary $PM_{2.5}$ impacts from regional transport and from nearby sources, and primary $PM_{2.5}$ impacts from background sources not included in the modeled inventory, *e.g.*, minor sources.

---

[24] The emissions impact of any nearby source that has received a permit but is not yet operational should be included in the air quality assessment. In such cases, consultation with the appropriate permitting authority on the appropriate assessment approach is recommended.

[25] The emissions impact of any nearby source that has received a permit but is not yet operational should be included in the air quality assessment. In such cases, consultation with the appropriate permitting authority on the appropriate assessment approach is recommended

As with the source impact analysis, the primary impacts of direct $PM_{2.5}$ emissions from the proposed new or modifying source and nearby sources in a cumulative impact analysis should be estimated based on the AERMOD dispersion model (or other acceptable preferred or approved alternative model). In addition, EPA recommends that the estimate of secondary $PM_{2.5}$ impacts from the proposed new or modifying source be conducted based on the two-tiered demonstration approach described in section 5.2 of the 2017 *Guideline*. As noted above, secondary impacts on $PM_{2.5}$ from regional transport, precursor emissions from nearby sources, and primary $PM_{2.5}$ impacts from background sources not included in the modeled inventory should be accounted for through representative monitored background concentrations.

IV.1 Modeling Inventory

Section 8 of the 2017 *Guideline* provides the current required and recommended approaches for characterizing source emissions and developing the O_3 and/or $PM_{2.5}$ modeling inventory for purposes of NAAQS compliance modeling in PSD air quality assessments. Section 8.2 and Table 8-2 of the 2017 *Guideline* address the appropriate emissions limit, operating level, and operating factor to be modeled, which is the maximum allowable emissions rate for the proposed new or modifying source in most cases and an allowable emissions rate adjusted for actual operations for any nearby sources. For applications that require the assessment of secondarily formed O_3 or $PM_{2.5}$ through a case-specific CTM, information regarding the development of the appropriate modeling inventory can be found in the Single-source Modeling Guidance.

Section 8.3.3 of the 2017 *Guideline* emphasizes the importance of professional judgment in the identification of nearby and other sources “that are not adequately represented by ambient monitoring data" that should be included in the modeled emission inventory and identifies "a significant concentration gradient in the vicinity of the [proposed] source" as a primary criterion for this selection. Additionally, the 2017 *Guideline* suggests that "the number of nearby sources to be explicitly modeled in the air quality analysis is expected to be few except in unusual situations" and that "[i]n most cases, the few nearby sources will be located within the first 10 to 20 km from the [proposed] source." The EPA also provided modeling guidance in March 2011 (U.S. EPA, 2011c) that includes a detailed discussion of the significant concentration gradient criterion. However, several application-specific factors should be considered when determining the appropriate inventory of nearby sources to include in the cumulative modeling analysis, including the potential influence of terrain characteristics on concentration gradients and the availability and adequacy of ambient monitoring data to account for impacts from nearby sources as well as other background sources.

Consistent with the 2017 revisions to the *Guideline*, the EPA cautions against the application of very prescriptive procedures for identifying which nearby sources should be included in the modeled emission inventory for NAAQS compliance demonstrations, such as the procedures described in Chapter C, Section IV.C.1 of the draft "New Source Review Workshop Manual" (U.S. EPA, 1990). Our main concern is that following such procedures in a literal and uncritical manner may, in many cases, increase the likelihood of double-counting modeled and monitored concentrations, resulting in cumulative impact assessments that are overly conservative and would unnecessarily complicate the permitting process. The identification of which sources to include in the modeled emissions inventory should be addressed in the modeling protocol and, as necessary, discussed in advance with the permitting authority.

Since modeling of direct $PM_{2.5}$ emissions has been limited and infrequent, the availability of an adequate direct $PM_{2.5}$ emission inventory for nearby sources may not exist in all cases. Recommendations for developing $PM_{2.5}$ emission inventories for use in PSD applications will be addressed separately, but existing SIP inventories for $PM_{2.5}$ or statewide PSD inventories of sources for refined modeling are expected to provide a useful starting point for this effort.

IV.2 Monitored Background

Section 8.3 of the 2017 *Guideline* provides recommendations for determination of monitored background concentrations to include in cumulative impact assessments for NAAQS compliance, which should account for impacts from existing sources that are not explicitly included in the modeled inventory and natural sources. From newly-acquired, pre-construction monitoring data and/or existing representative air quality data gathered for purposes of a permitting analysis, permit applicants should assess and document what the background monitoring data represent to the extent possible, including any information that may be available from the state or other agency responsible for siting and maintaining the monitor.[26]

Determining the monitored background concentrations of O_3 and/or $PM_{2.5}$ to include in the cumulative impact assessment may entail different considerations from those for other criteria pollutants lacking secondary formation. Given that the monitored background determination can be a complex process with many uncertainties based on unique situations, permit applicants are encouraged to consult with the appropriate permitting authority.

---

[26] Please note that in the case of an existing source seeking a permit for a modification, there is potential overlap across secondary impacts from monitored background and from precursor emissions from the existing source. In such cases, recommendations for excluding monitored values when the source in question is impacting the monitor in section 8.3.2.c of the 2017 *Guideline* may need to be modified to avoid overcompensating when the monitored concentrations are also intended to account for the existing source's impacts on secondary $PM_{2.5}$. Additionally, permit applicants should consult with the appropriate permitting authority.

An important aspect of the monitored background concentrations for O_3 or $PM_{2.5}$ is that the ambient monitoring data should in most cases account for the impact of secondary formation of either pollutant from precursor emissions of existing sources impacting the modeling domain. Due to the nature of O_3 and secondary $PM_{2.5}$, monitored background concentrations of O_3 and $PM_{2.5}$ are more likely to be homogeneous across the modeling domain in most cases compared to most other pollutants. Additionally, for $PM_{2.5}$, ambient monitoring data should account for the component of the background levels of primary $PM_{2.5}$ from direct $PM_{2.5}$ emissions of nearby sources that are not included in the modeled inventory. As with other criteria pollutants, consideration should also be given to the potential for some double-counting of the impacts from modeled emissions that may be also included in the background monitored concentrations. This should generally be of less importance than the representativeness of the monitor for secondary formation of O_3 and $PM_{2.5}$, unless the monitor is located relatively close to nearby sources of primary $PM_{2.5}$ that could be impacting the monitor.

Depending on the nature of local $PM_{2.5}$ levels within the modeling domain, it may be appropriate to account for seasonal variations in monitored background $PM_{2.5}$ levels, which may not be correlated with seasonal patterns of the modeled primary $PM_{2.5}$ levels. For example, maximum modeled primary $PM_{2.5}$ impacts associated with low-level emission sources are likely to occur during winter months due to longer periods of stable atmospheric conditions, whereas maximum ambient levels of secondary $PM_{2.5}$ typically occur during spring and summer months due to high levels of sulfates (particularly in the eastern United States). The use of temporally-varying monitored background concentrations in a cumulative impact analysis is discussed in more detail in Section IV.3.

IV.3 Comparison to the NAAQS

As indicated in Figure II-1, the first step of a cumulative impact analysis consists of a comparison of the combined modeled and monitored concentrations, as discussed above, with the applicable NAAQS to determine if there are any predicted violations of the O_3 and/or $PM_{2.5}$ NAAQS.

O_3

Ozone differs from other criteria pollutants because it is secondarily formed by NOx and VOC precursor emissions and there are not direct O_3 emissions to be considered in the NAAQS compliance demonstration. The O_3 design value that is representative for the area, rather than the overall maximum monitored background concentration, should generally be used as the monitored component of the cumulative analysis. The O_3 design value is based on the 3-year average of the annual fourth-highest daily maximum 8-hour average O_3 concentrations (80 FR 65292).

The EPA recommends that the modeled O_3 impacts be added to the monitor-based design value for comparison to the NAAQS, as appropriate. The monitoring data should be representative in that it accounts for O_3 formation associated with existing sources both within and outside of the modeling domain. The EPA recommends that modeled O_3 impacts be based on a Tier 1 or 2 assessment that accounts for the source’s precursor emissions of NOx and VOC. The modeled O_3 impacts should be based on the average of the predicted annual fourth-highest daily maximum 8-hour averaged O_3 concentrations. For episodic cases, consultation with the appropriate permitting authority is recommended to determine the most appropriate rank of the daily maximum 8-hour average O_3 concentration to use based on the length of the episode. The resulting cumulative O_3 concentrations should then be compared to the O_3 NAAQS (0.070 ppm).

$PM_{2.5}$

Combining the modeled and monitored concentrations of $PM_{2.5}$ for comparison to the 24-hour or annual $PM_{2.5}$ NAAQS entails considerations that differ from those for other criteria pollutants due to the issues identified at the end of Section IV.2. The discussion below addresses comparisons to the NAAQS in the context of dispersion modeling of direct $PM_{2.5}$ emissions and a Tier 1 or 2 assessment of secondary $PM_{2.5}$ impacts accounting for the proposed source's $PM_{2.5}$ precursor emissions.

Given the importance of secondary formation of $PM_{2.5}$ and the potentially high background levels relative to the $PM_{2.5}$ NAAQS, greater emphasis should generally be placed on the monitored background concentrations relative to the modeled inventory for $PM_{2.5}$ than for other pollutants. This is true for both $PM_{2.5}$ NAAQS and PSD increments assessments. Also, given the probabilistic form of the $PM_{2.5}$ NAAQS, careful consideration should be given to how the monitored and modeled concentrations are combined to estimate the cumulative impact levels.

The $PM_{2.5}$ design value that is representative for the area, rather than the overall maximum monitored background concentration, should generally be used as the monitored component of the cumulative analysis. The $PM_{2.5}$ design value for the annual averaging period is based on the 3-year average of the annual average $PM_{2.5}$ concentrations, while the $PM_{2.5}$ design value for the 24-hour averaging period is based on the 3-year average of the annual 98th percentile 24-hour average $PM_{2.5}$ concentrations (78 FR 3086). Details regarding the determination of the annual 98th percentile monitored 24-hour value based on the number of days sampled during the year are provided in the data interpretation procedures for the $PM_{2.5}$ NAAQS in Appendix N to 40 CFR part 50.

It should be noted here that, although the monitored design values for the $PM_{2.5}$ standards are defined in terms of 3-year averages, this definition does not preempt or alter the 2017 *Guideline's* requirement for use of 5 years of representative NWS meteorological data, at least 1 year of site-specific data, or at least 3 years of prognostic meteorological data for purposes of modeling direct emissions of $PM_{2.5}$.[27] The 5-year average based on use of representative NWS meteorological data, the average across one or more (up to 5) complete years of available site-specific data, or the average across 3 years of prognostic meteorological data serves as an unbiased estimate of the 3-year average for purposes of modeling demonstrations of compliance with the NAAQS. Modeling of "rolling 3-year averages," using years 1 through 3, years 2 through 4, and years 3 through 5, as recommended in the EPA's SIP Modeling Guidance, is not required.

The EPA recommends that the modeled design concentrations of primary $PM_{2.5}$ and the Tier 1 or 2 assessed secondary $PM_{2.5}$ impacts should be added to the monitor-based design value for comparison to the NAAQS, as appropriate. The primary $PM_{2.5}$ modeled design concentration should be based on:

- The 5-year average of the modeled annual 98th percentile 24-hour $PM_{2.5}$ concentrations (for the 24-hour $PM_{2.5}$ NAAQS) or 5-year average of the modeled annual average $PM_{2.5}$ concentration (for the annual $PM_{2.5}$ NAAQS) predicted each year at each receptor, based on 5 years of representative NWS data;

---

[27] See 40 CFR part 51, Appendix W, section 8.4.2.e.

- The modeled 98th percentile 24-hour $PM_{2.5}$ concentrations (for the 24-hour $PM_{2.5}$ NAAQS) or modeled average $PM_{2.5}$ concentration (for the annual $PM_{2.5}$ NAAQS) predicted at each receptor based on 1 year of site-specific meteorological data, or the multi-year average of the modeled annual 98th percentile 24-hour $PM_{2.5}$ concentrations (for the 24-hour $PM_{2.5}$ NAAQS) or modeled annual average $PM_{2.5}$ concentration (for the annual $PM_{2.5}$ NAAQS) predicted each year at each receptor, based on 2 or more years, up to 5 complete years, of available site-specific meteorological data; or
- The 3-year average of the modeled annual 98th percentile 24-hour $PM_{2.5}$ concentrations (for the 24-hour $PM_{2.5}$ NAAQS) or 3-year average of the modeled annual average $PM_{2.5}$ concentration (for the annual $PM_{2.5}$ NAAQS) predicted each year at each receptor, based on 3 years of prognostic meteorological data.

The EPA recommends that secondary $PM_{2.5}$ modeled impacts be based on either a Tier 1 or 2 assessment accounting for the source's $PM_{2.5}$ precursor emissions of NOx and SO_2. The resulting cumulative $PM_{2.5}$ concentrations should then be compared to the 24-hour $PM_{2.5}$ NAAQS (35 $\mu g/m^3$) and/or the annual $PM_{2.5}$ NAAQS (12 $\mu g/m^3$).

Specifically, the cumulative impact for comparison to the NAAQS should be based on the combined modeled design concentration for primary $PM_{2.5}$ impacts based on AERMOD (or other acceptable preferred or approved alternative model) estimates of the proposed source's and other nearby sources' direct $PM_{2.5}$ emissions, the modeled secondary $PM_{2.5}$ impacts (based on a Tier 1 or 2 assessment accounting for the proposed source's $PM_{2.5}$ precursor emissions), and the monitored design value. The monitor should be representative, in that it accounts for secondary $PM_{2.5}$ formation associated with existing sources both within and outside of the modeling domain, in addition to the background levels of primary $PM_{2.5}$ associated with nearby and background sources that are not included in the modeled inventory.

The recommendations provided above constitute a First Level analysis for $PM_{2.5}$ NAAQS compliance demonstrations. For applications where impacts from direct $PM_{2.5}$ emissions are not temporally correlated with background $PM_{2.5}$ levels, combining the modeled and monitored levels as described above may be overly conservative in some situations. For example, there are areas of the country where background $PM_{2.5}$ levels are substantially higher on average during the summer months as compared to the winter months; however, the predicted impacts from the new or modified source may be substantially greater in the winter rather than in the summer. In such cases, a Second Level modeling analysis may be advisable to account for these temporal relationships. Such an analysis would involve combining the monitored and modeled $PM_{2.5}$ concentrations on a seasonal (or quarterly) basis, as appropriate. The use of a seasonally-varying monitored background component is likely to be a more important factor for the 24-hour $PM_{2.5}$ NAAQS analysis than for the annual $PM_{2.5}$ NAAQS. Careful evaluation of when model projections of $PM_{2.5}$ impacts and background $PM_{2.5}$ levels peak throughout the year is recommended before embarking on a Second Level modeling analysis. This is because the First Level approach may already adequately capture the temporal correlation. As a part of this process to determine the appropriate level of analysis, the permit applicant should consult with the appropriate permitting authority and then reflect the appropriate approach in their modeling protocol.

The AERMOD model provides several options for specifying the monitored background concentration for inclusion in the cumulative impact assessment. The options that are most relevant to $PM_{2.5}$ analyses include:

- For First Level 24-hour or annual $PM_{2.5}$ NAAQS analyses, an option to specify a single annual background concentration that is applied to each hour of the year, and
- For Second Level 24-hour $PM_{2.5}$ NAAQS analyses, an option to specify four seasonal background values that are combined with modeled concentrations on a seasonal basis.

The AERMOD model also allows the user to track the effect of background concentrations on the cumulative modeled design concentration.

For Second Level 24-hour $PM_{2.5}$ NAAQS modeling analyses, EPA recommends that the distribution of monitored data equal to and less than the annual 98th percentile be appropriately divided into seasons (or quarters) for each of the three years that are used to develop the monitored design value. This will result in data for each year of the multi-year data, which contains one season (or quarter) with the 98th percentile value and three seasons (quarters) with maximum values which are less than or equal to the 98th percentile value. The maximum concentration from each of the seasonal (or quarterly) subsets should then be averaged across these three years of monitoring data. The resulting average of seasonal (or quarterly) maximums should then be included as the four seasonal background values within the AERMOD model. Therefore, the monitored concentrations greater than the 98th percentile in each of the three years would not be included in the seasonal (or quarterly) subsets. These excluded monitored concentrations are the same values that are excluded when determining the monitored design value. An example of the calculations for a Second Level 24-hour $PM_{2.5}$ NAAQS modeling analysis is provided in Appendix D.

For a monitor with a daily (1-in-1 day monitor) sampling frequency and 100% data completeness, the highest seven monitored concentrations for each year should be excluded from the seasonal (or quarterly) subdivided datasets. Similarly, for a monitor with every third day (1-in-3 day monitor) sampling frequency and 100% data completeness, the highest two monitored concentrations for each year should be excluded from the seasonal (or quarterly) subdivided datasets. The monitored concentrations excluded from the subdivided datasets could primarily come from one or two seasons (or quarters) each year or could be evenly distributed across all four seasons (or quarters) each year. Additionally, the monitored concentrations not included in the subdivided datasets could shift seasonally (or quarterly) from one year to the next. Given the reason for considering a Second Level 24-hour analysis (*i.e.*, lack of temporal correlation between modeled and monitored concentrations), it is likely that the monitored data greater than the 98th percentile would be concentrated in one or two seasons as opposed to evenly distributed throughout the year. As mentioned earlier, see Appendix N of 40 CFR part 50 in determining the appropriate 98th percentile rank of the monitored data based on the monitor sampling frequency and valid number of days sampled during each year.

The EPA does not recommend a "paired sums" approach on an hour-by-hour basis because of the spatial and temporal variability throughout a typical modeling domain on an hourly basis and the complexities and limitations of hourly observations from the current $PM_{2.5}$ ambient monitoring network. The implicit assumption underlying this “paired sums’ approach is that the background monitored levels for each hour are spatially uniform and that the monitored concentrations are fully representative of background levels at each receptor for each hour. Such an assumption does not account for the many factors that contribute to the temporal and spatial variability of ambient $PM_{2.5}$ concentrations across a typical modeling domain on an hourly basis.[28] Furthermore, the pairing of daily monitored background and 24-hour average modeled concentrations is not recommended except in rare cases of relatively isolated sources where the available 1-in-1 day monitor can be shown to be representative of the ambient concentration levels in the areas of maximum impact from the proposed new or modifying source. In most cases, the seasonal (or quarterly) pairing of monitored and modeled concentrations previously described in the Second Level approach should sufficiently address situations in which the impacts from direct $PM_{2.5}$ emissions are not temporally correlated with background $PM_{2.5}$ levels. Any monitor-model pairing approach aside from the First or Second Level methods should be justified on a case-by-case basis in consultation with the appropriate permitting authority and the appropriate EPA Regional Office.

IV.4 Determining Whether Proposed Source Causes or Contributes to Modeled Violations

If the cumulative impact assessment following these recommendations results in predicted violations of the O_3 and/or $PM_{2.5}$ NAAQS, then the permit applicant will need to demonstrate that the proposed source's emissions do not cause or contribute to the modeled NAAQS violations. In the SILs Guidance, the EPA explained that the permitting authority may further evaluate whether the proposed source or modification will cause or contribute to

---

[28] The complexity of the $PM_{2.5}$ ambient monitoring network presents special challenges with a "paired sum" approach that are not present with other NAAQS pollutants. The Federal Reference Method (FRM) $PM_{2.5}$ monitoring network is based on 24-hour samples that are taken on average every third day at the 1-in-3 day monitors. The frequency of daily or 1-in-1 day $PM_{2.5}$ monitors is steadily increasing but is relatively limited to the largest cities and metropolitan regions of the U.S. Various methods to "data fill" the 1-in-3 day monitoring database to create a pseudo-daily dataset have been explored in a few situations, but none of these data filling methods have been demonstrated to create a representative daily $PM_{2.5}$ dataset that the EPA would consider acceptable for inclusion in a $PM_{2.5}$ NAAQS compliance demonstration. The use of continuous $PM_{2.5}$ monitors, which are more limited in number compared to the FRM monitors and may require careful quality assurance of individual hourly measurements, may be an option but should be discussed in advance with the appropriate permitting authority.

predicted violations by comparing the proposed source's modeled impacts, paired in time and space with the predicted violations, to an appropriate SIL. The proposed source or modification may be considered to not cause or contribute to predicted violations of the O_3 or $PM_{2.5}$ NAAQS where the modeled impacts of the proposed source or modification at those particular times and locations are less than the appropriate O_3 or $PM_{2.5}$ NAAQS SIL. As explained in the SILs Guidance, a permitting authority that chooses to use an O_3 or $PM_{2.5}$ SIL value to support a PSD permitting decision should justify the value and its use in the administrative record for the permitting action.

A demonstration that a proposed source or modification does not cause or contribute to a predicted violation should be based on a comparison of the modeled concentrations (primary and secondary impacts) at the receptor location(s) showing the violation(s) of the O_3 or $PM_{2.5}$ NAAQS to the appropriate O_3 or $PM_{2.5}$ NAAQS SIL. Considering the form of each NAAQS, the following approaches are recommended:

- For a predicted violation of the O_3 NAAQS, the average of the predicted annual (or episodic) fourth-highest daily maximum 8-hour averaged O_3 concentrations at the affected receptor(s) should be compared to an appropriate O_3 NAAQS SIL, *e.g.*, SIL values recommended by EPA in the SILs Guidance (Table II-1).
- For a predicted violation of the annual $PM_{2.5}$ NAAQS, the average of the predicted annual concentrations at the affected receptor(s) should be compared to an appropriate $PM_{2.5}$ annual NAAQS SIL, *e.g.*, SIL values recommended by EPA in the SILs Guidance (Table II.1).
- For a predicted violation of the 24-hour $PM_{2.5}$ NAAQS, the average of the predicted annual 98th percentile 24-hour average concentrations at the affected

receptor(s) should be compared to an appropriate $PM_{2.5}$ 24-hour NAAQS SIL, *e.g.*, SIL values recommended by EPA in the SILs Guidance (Table II-1).

V. PSD Compliance Demonstration for the $PM_{2.5}$ Increments

As summarized in Section II of this guidance, CAA section 165(a)(3) requires that proposed new and modified major stationary sources seeking a PSD permit demonstrate that their proposed emissions increases will not cause or contribute to a violation of any NAAQS or PSD increment. Consistent with the flow diagram presented in Figure II-2, this section describes the EPA's recommendations for completing the required compliance demonstration for the PSD increments for $PM_{2.5}$.

V.1 Overview of the PSD Increment System

This section provides an overview of the PSD increment system by defining basic terms, such as increment, baseline concentration, baseline area, trigger date, minor source baseline date, and major source baseline date. This section also introduces and discusses the concepts of increment consumption and expansion.

V.1.1 PSD Increments and Baseline Concentration

The term "increment" generally refers to what the CAA calls the "maximum allowable increase over baseline concentrations" with respect to a criteria pollutant. CAA section 169(4) defines "baseline concentration," generally, as "the ambient concentration levels which exist at the time of the first application for a [PSD] permit for an area subject to this part…."[29] Accordingly, an increment analysis is generally concerned with the emissions increases affecting air quality in a particular PSD area after the date that the first complete PSD application is

---

[29] EPA's regulations at 40 CFR 52.21(b)(14)(ii) provide that the application that determines the baseline concentration is to be a complete PSD application. Hence, the term "complete application" will be used throughout this section with regard to the minor source baseline date and increment consumption.

submitted to the permitting authority.[30] When comparing the ambient impact of such total emissions increases against the increment value for a particular pollutant, a cumulative increase in the ambient concentration of that pollutant that is greater than the increment generally is considered "significant deterioration." When the cumulative impact analysis identifies significant deterioration in this way, the permitting authority should determine whether the emissions increase from the proposed new or modifying source will cause or contribute to the predicted violation of the PSD increment.

Based on the statutory definition of baseline concentration, as described above, it is conceptually possible to measure whether there will be significant deterioration in at least two separate ways. The first way involves comparing a direct modeled projection of the change in air quality caused by all increment-consuming and expanding emissions to the increment in the area of concern (known as the baseline area, discussed below in Section V.1.2). The second approach is to make a determination of whether the current monitored ambient air quality concentration in the applicable baseline area, supplemented by the modeled impact of the proposed source, will exceed an allowable ambient air quality ceiling. This latter approach requires comparing such monitored concentration(s) to the sum of the increment and the baseline concentration for the baseline area.

Historically, because of the lack of monitoring data to adequately represent the baseline concentration combined with various other limitations associated with the use of ambient air

---

[30] The EPA also considers emissions decreases occurring after the date of the first PSD application to affect increment consumption to the extent that such decreases cause an improvement of air quality in the area of concern. Thus, the concept of increment "expansion" is also discussed in this section.

quality monitoring data for measuring increment consumption,[31] the EPA has recommended that the required increment analysis be based exclusively on the first approach, which models the increment-related emissions increases or decreases to determine the resulting ambient air quality change and compares this value with the increments for a particular pollutant.

V.1.2 PSD Baseline Area and Key Baseline Dates

In order to evaluate in a PSD permit review whether a PSD increment would be violated by proposed construction of a stationary source, it is necessary to identify (1) the affected geographic area in which the increment will be tracked and (2) the key baseline dates after which emissions changes affect increment in that area. The relevant geographic area for determining the amount of increment consumed is known as the baseline area. The baseline area is established primarily on the basis of the location of the first major source to submit a complete PSD application after an established "trigger date" (see discussion of key dates below) and may be comprised of one or more areas that are designated as "attainment" or "unclassifiable" pursuant to CAA section 107(d) for a particular pollutant within a state. In accordance with the regulatory definition of baseline area at 40 CFR 52.21(b)(15), the area is an "intrastate area" and does not include any area in another state.[32] At a minimum, the baseline area is the attainment or unclassifiable area in which the first PSD applicant after the trigger date proposes to locate, but additional attainment or unclassifiable areas could be included in a particular baseline area when

---

[31] The EPA described certain limitations associated with the use of ambient air quality monitoring data for measuring increment consumption in the preamble to its proposed PSD regulations in 1979. For example, the CAA provides that certain emissions changes should not be considered increment consuming. These limitations generally continue to apply to the extent that certain emissions changes detected by an ambient monitor are not considered to consume increment. See 44 Fed. Reg. 51924, 51944 (September 5, 1979).

[32] While baseline dates are established on an intrastate basis, once a baseline area is established, emissions changes from other states may contribute to the amount of increment consumed.

the proposed source's modeled impact in any such additional areas exceeds certain concentrations specified in the regulatory definition of baseline area (*i.e.*, concentrations found in 40 CFR 52.21(b)(15)(i)). For $PM_{2.5}$ this concentration is 0.3 $\mu g/m^3$ on an annual average basis. Once a baseline area has been established, subsequent PSD applications for sources located in that area, or sources that could have a significant impact in that area, should rely on the baseline date associated with that baseline area to determine whether the applicant's proposed emissions increase, along with other increment-consuming emissions, would cause or contribute to an increment violation. (See discussion on cumulative increment analysis in Section V.3.2 of this guidance.)

Within any baseline area, the following three key dates are relevant when conducting the required increment analysis: (1) trigger date; (2) minor source baseline date; and (3) major source baseline date. The trigger date is a date fixed by regulation for each pollutant at 40 CFR 52.21(b)(14)(ii). The "minor source baseline date" in a newly established baseline area is the earliest date after the applicable trigger date on which a proposed new or modified major source submits a complete PSD application.[33] The minor source baseline date for a baseline area or adjacent baseline area may also be triggered based on the single source impacts greater than or equal to specified values for NO_2, SO_2, PM_{10}, or $PM_{2.5}$.[34] The minor source baseline date is the date on which tracking of increment consumption must begin. Depending upon the number of

---

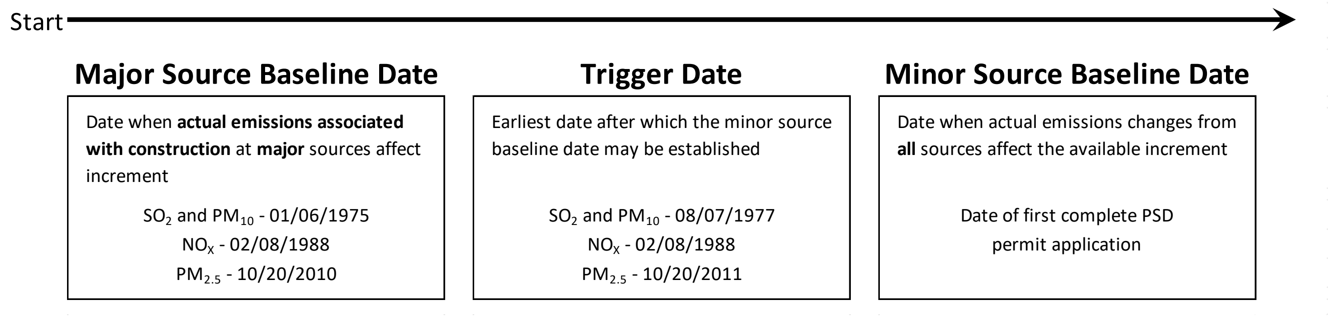
[33] The minor source baseline date is established for each pollutant for which increments have been established if, in the case of a major stationary source, the pollutant would be emitted in significant amounts, or, in the case of a major modification, there would be a significant emissions increase of the pollutant. *See* 40 CFR 52.21(b)(14)(iii). In the PSD program, the pollutant $PM_{2.5}$ includes $PM_{2.5}$ direct emissions and the regulated $PM_{2.5}$ precursors, SO_2 and NO_X. Consequently, the minor source baseline date for $PM_{2.5}$ is established by the first complete PSD application after the trigger date that would have significant direct $PM_{2.5}$ emissions or significant emissions of SO_2 or NO_X as $PM_{2.5}$ precursors.

[34] *See* 40 CFR 52.21(b)(15)(i).

separate attainment and unclassifiable areas that exist for a particular pollutant in a state and the timing of major source construction within the state, there may be a number of minor source baseline dates that apply to different baseline areas established in that state. Beginning with the PSD source whose complete application has established the minor source baseline date in a particular area, any increase or decrease in actual emissions of the pollutant of concern occurring after the minor source baseline date at any source (minor or major) that will affect air quality in the baseline area will affect the amount of PSD increment consumed in that baseline area for that pollutant (in the case of an emissions decrease, see discussion on increment expansion in Section V.1.3 of this guidance, below).

Finally, the "major source baseline date" is a date fixed by regulation for each pollutant at 52.21(b)(14)(i) and *precedes* the trigger date. As further explained below, changes in emissions resulting from construction at major stationary sources only that occur after the major source baseline date, but before the minor source baseline date, will also affect increment. The relationship of these three key dates with each other is further illustrated in Figure V-1.

Figure V-1. Determining Baseline Date(s) and When Increment Consumption Starts



Start

Major Source Baseline Date

Date when **actual emissions associated with construction** at **major** sources affect increment

SO_2 and PM_{10} - 01/06/1975
NO_X - 02/08/1988
$PM_{2.5}$ - 10/20/2010

Trigger Date

Earliest date after which the minor source baseline date may be established

SO_2 and PM_{10} - 08/07/1977
NO_X - 02/08/1988
$PM_{2.5}$ - 10/20/2011

Minor Source Baseline Date

Date when actual emissions changes from **all** sources affect the available increment

Date of first complete PSD permit application

Emissions changes occurring before the minor source baseline date generally do not affect increment in an area (*i.e.*, are not increment-consuming) but are considered to affect the baseline concentration, which, as explained above, represents the ambient pollutant concentration levels that exist at the time of the minor source baseline date, or the date of the first complete application for a PSD permit in an area after the trigger date. However, as noted above, the CAA provides an exception for certain emissions changes that occur specifically at major stationary sources as a result of construction[35] that commences after the major source baseline date. Specifically, for projects at major stationary sources on which construction commenced on a date prior to the major source baseline date, the changes in emissions from such projects affect the baseline concentration (not the amount of increment consumed) even if the emissions change may not actually occur until after the major or minor source baseline dates. Alternatively, for projects at major stationary sources on which construction commences after the major source baseline date, the project emissions affect increment, even if the new or modified source actually begins operation before the minor source baseline date.

V.1.3 PSD Increment Expansion

The "increment consumption" analysis allows permit applicants and permitting authorities to take into account emissions reductions that occur in the baseline area of concern. Such emissions reductions are generally said to result in the *expansion* of increment in the area; however, not all emissions reductions truly result in an expansion of the increment. Some emissions reductions, instead, result in a *freeing up* of increment that had previously been consumed.

In the case of true "increment expansion," emissions in the area are allowed to increase

---

[35] CAA section 169(2)(C) indicates that the term "construction," when used in connection with any source or facility, includes modifications defined in CAA section 111(a)(4). "Modification" is defined at section 111(a)(4) to mean "any physical change in, or change in the method of operation of a stationary source which increases the amount of any air pollutant emitted by such source or which results in the emission of any air pollutant not previously emitted."

by the amount allowed by the original increment plus the amount of actual air quality improvement (relative to the baseline concentration) achieved by the reduction of emissions because of its relationship to the established baseline dates for the area.[36] In such cases, it is appropriate to model the actual emissions decrease as a negative amount to effectively lower the baseline concentration to simulate the expansion of the increment.

On the other hand, in cases where a source's emissions contribute to the amount of increment consumed, a reduction in such increment-consuming emissions at some later date results in some amount of the consumed increment being freed up. That is, the resulting air quality improvement is now available for a source to increase its emissions within the limits of the original increment level. A subsequent reduction in increment-consuming emissions should not be modeled as a negative value to determine the amount of increment that has been freed up; instead, such emissions reductions are simply no longer counted in the increment consumption analysis.

V.2 PSD $PM_{2.5}$ Increments

In 2010, the EPA established the $PM_{2.5}$ increments at the levels shown in Table V-1 through the final rule entitled "Prevention of Significant Deterioration (PSD) for Particulate Matter Less Than 2.5 Micrometers ($PM_{2.5}$) – Increments, Significant Impact Levels (SILs) and

---

[36] The concept of increment expansion is derived from CAA section 163(a), which provides that a PSD applicant must assure "that maximum allowable increases *over baseline concentrations* … shall not be exceeded." [Emphasis added.] The target for determining significant deterioration thus becomes the ambient concentration resulting from the sum of the increment and the baseline concentration. When a decrease in emissions that contributed to the baseline concentration occurs, an emissions increase that simply "restores" the air quality to the baseline concentration in a particular baseline area can be allowed, regardless of the amount of increment otherwise being consumed.

Significant Monitoring Concentration (SMC)."[37] This 2010 rule established October 20, 2011, as the trigger date and October 20, 2010, as the major source baseline date for $PM_{2.5}$ increments. The EPA developed the increment system for $PM_{2.5}$ generally following the same concepts that were previously applied for development of the increments for PM_{10}, SO_2, and nitrogen dioxide (NO_2). As explained above, the framework reflects the statutory concepts set forth in the statutory definition of baseline concentration that was explained in Section V.1 of this guidance.

Table V-1. $PM_{2.5}$ Increments

	Class I	Class II	Class III
Increments, $\mu g/m^3$			
Annual arithmetic mean……………………………………………………	1	4	8
24-hour maximum……………………………………………………	2	9	18

Source: Prevention of Significant Deterioration (PSD) for Particulate Matter Less Than 2.5 Micrometers (PM2.5) - Increments, Significant Impact Levels (SILs) and Significant Monitoring Concentration (SMC) final rule (75 FR 64864)

The obvious difference between an increment analysis and the NAAQS analysis for $PM_{2.5}$ is that the increment analysis is concerned with the degree of change in air quality caused by a new or modified PSD source rather than the impact of that source on overall air quality (as defined by the applicable NAAQS) in the area of concern (baseline area). With this in mind, it should be noted here that an increment analysis is relevant only to the extent that NAAQS compliance has been ensured. That is, an adequate air quality analysis demonstrating compliance with the statutory requirements must ensure that the proposed PSD source's emissions will not cause or contribute to either the NAAQS or PSD increments.[38]

Another key difference involves the modeling inventory from which the necessary

---

[37] See 75 FR 64864 (Oct. 20, 2010).

[38] CAA section 163(b)(4) provides that the maximum allowable concentration of any air pollutant allowed in an area shall not exceed the concentration allowed by the primary or secondary NAAQS.

emissions data is derived. That is, only sources that have $PM_{2.5}$ emissions (direct and precursor) that affect the amount of increment consumed in the area of concern should be included in the modeling inventory for the increment analysis. Moreover, from such sources, only those specific emissions changes that affect increment should be included in the actual modeling analysis.

The cumulative impact analysis for $PM_{2.5}$ increments is also different and based on the actual emission changes occurring at existing sources in the baseline area after the pertinent baseline dates (*i.e.*, major and minor source baseline dates), whereas NAAQS analyses are generally based on the cumulative impact associated with the maximum allowable emissions from the new or modifying source and other nearby sources (with specific provisions for operating levels of nearby sources). Furthermore, ambient monitoring data, while useful for establishing background concentration for the NAAQS analysis, may not be particularly useful for the typical increment analysis. The limitations associated with using monitoring data for an increment analysis are discussed in greater detail in Sections V.1 and V.3 of this guidance.

It is also important to note that the $PM_{2.5}$ NAAQS and increments for the 24-hour averaging period are defined in different forms and therefore must be analyzed differently.[39] The 24-hour $PM_{2.5}$ NAAQS is defined based on the 3-year average of the annual 98th percentile of the 24-hour average concentrations, while the 24-hour $PM_{2.5}$ increments are based on the second highest maximum 24-hour concentration.

V.3 PSD Compliance Demonstration for the $PM_{2.5}$ Increments

The initial steps for the $PM_{2.5}$ increment analysis, which include the determination of the allowable emissions increases to model in the source impact analysis and a comparison of the

---

[39] The annual NAAQS and increments for $PM_{2.5}$ are both measured as annual arithmetic mean values.

modeled impacts against the appropriate $PM_{2.5}$ SILs, may rely, in part, upon the results derived from the $PM_{2.5}$ NAAQS analysis described in Sections III and IV of this guidance. Moreover, the technical approach involving the options and alternatives agreed upon for estimating secondary $PM_{2.5}$ impacts and combining primary and secondary $PM_{2.5}$ impacts for the NAAQS analysis may also be relevant for completing the $PM_{2.5}$ increment analysis to determine whether the allowable emissions increase(s) from the proposed source or modification will cause or contribute to any increment violation.

V.3.1 $PM_{2.5}$ Increments: Source Impact Analysis

The EPA's recommendations on how to complete the required compliance demonstration for the $PM_{2.5}$ PSD increments are based upon the same assessment cases detailed in Section II.4 for $PM_{2.5}$ NAAQS. As shown in Table V-2, a modeled compliance demonstration is not required for Case 1 since neither direct $PM_{2.5}$ emissions nor $PM_{2.5}$ precursor (NO_X or SO_2) emissions are equal to or greater than the respective SERs. Case 1 is the only assessment case that does not require a modeled compliance demonstration for $PM_{2.5}$, whereas Case 2 requires a source impact analysis that should be conducted following the detailed recommendations provided in previous sections for a NAAQS analysis.

Table V-2. EPA Recommended Approaches for Assessing Primary and Secondary $PM_{2.5}$ Impacts by Assessment Case

Assessment Case	Description of Assessment Case		Primary Impacts Approach	Secondary Impacts Approach*
Case 1: No Air Quality Analysis	Direct $PM_{2.5}$ emissions < 10 tpy SER and NO_X emissions and SO_2 emissions < 40 tpy SER		N/A	N/A
Case 2: Primary and Secondary Air Quality Impacts	Direct $PM_{2.5}$ emissions ≥ 10 tpy SER or NO_X emissions or SO_2 emissions ≥ 40 tpy SER		**Appendix W preferred or approved alternative dispersion model**	Include both precursor of $PM_{2.5}$, see Section II.2. • **Tier 1 Approach** (*e.g.*, MERPs) • **Tier 2 Approach** (*e.g.*, Chemical Transport Modeling)

* In unique situations (*e.g.*, in parts of Alaska where photochemistry is not possible for portions of the year), it may be acceptable for the applicant to rely upon a qualitative approach to assess the secondary impacts. Any qualitative assessments should be justified on a case-by-case basis in consultation with the appropriate EPA Regional Office or other applicable permitting authority.

A modeling analysis based solely on the PSD applicant's proposed emissions increase (*i.e.*, source impact analysis) that does not predict an ambient impact equal to or greater than the appropriate $PM_{2.5}$ SIL at any location generally will satisfy the requirement for a demonstration that the source will not cause or contribute to a violation of the $PM_{2.5}$ increments.

In light of the relatively recent establishment of the fixed dates (*i.e.*, major source baseline date and trigger date) associated with the $PM_{2.5}$ increments (compared to comparable fixed dates for other PSD increments), and the possibility that the minor source baseline date for a particular area has not yet been set, a proposed new or modified source being evaluated for compliance with the $PM_{2.5}$ increments in a particular area may be the first source in the area with increment-consuming emissions. As indicated in Figure II-2, under this situation, a permitting authority may have a sufficient basis to conclude that the $PM_{2.5}$ impacts of the new or modified PSD source, although greater than the appropriate $PM_{2.5}$ SILs, may be compared directly to the allowable $PM_{2.5}$ increments without the need for a cumulative analysis (described in Section V.3.2 of this guidance below). Reliance on this first-in source impact analysis likely would be appropriate to assess the amount of increment consumed when the proposed new or modified source represents the first complete PSD application since the trigger date, thus establishing the baseline concentration in the area, and there has been no other major source construction since the major source baseline date.

V.3.2 $PM_{2.5}$ Increments: Cumulative Analysis

Where the source impact analysis described above is insufficient to show that a proposed PSD source will not cause or contribute to a violation of the $PM_{2.5}$ PSD increments, a cumulative impact assessment is necessary to complete the required increment analysis. A cumulative assessment of increment consumption accounts for the combined impacts of the following:

1. Direct and precursor *allowable* emissions from the proposed new or modifying source;
2. Direct and precursor *actual* emissions changes that have occurred at existing sources (including the existing source at which a major modification is being proposed, where applicable) since the minor source baseline date for the proposed source's baseline area;
3. Direct and precursor *actual* emissions from any major stationary source on which construction commenced after October 20, 2010 (major source baseline date for $PM_{2.5}$); and
4. Direct and precursor *allowable* emissions of permitted sources that are not yet fully

operative.[40]

Unlike the guidance provided for the cumulative NAAQS analysis for $PM_{2.5}$ in Section IV, it is not typically practical to utilize ambient monitoring data to represent any portion of the impacts that affect the $PM_{2.5}$ increments. Therefore, it is usually necessary to model the applicable emissions from any existing source that will be considered to consume a portion of the $PM_{2.5}$ increments in the baseline area(s) of concern. As part of the determination of which existing sources should be included in the cumulative analysis, it will be necessary to identify the total area in which a significant impact from the new or modified PSD source will occur. A new or modified source with an extensive impact area may affect more than one existing baseline area. Once the affected area has been defined, and the associated minor source baseline dates have been taken into account, the potential sources can be selected from which increment-consuming emissions must be quantified. Existing sources whose actual emissions have not changed substantially since the applicable baseline date may not need to be included for purposes of increment consumption since, as previously explained, increment is consumed by increases in actual emissions that occur from existing sources after the baseline date. It is highly recommended that the PSD applicant work closely with the permitting authority to determine the existing sources (including newly permitted sources) of direct $PM_{2.5}$ and precursor emissions that should be included in the modeling inventory for the increment analysis. Also, if there is reason to believe that an existing source's actual emissions have decreased since the applicable baseline date, the PSD applicant may want to check with the permitting authority to ascertain whether the authority allows for increment expansion to be considered.

---

[40] Regarding the use of allowable emissions, see 40 CFR 52.21(b)(21)(iv).

Once the modeling inventory for the increment analysis has been developed and approved, and the increment-consuming emissions have been determined, the modeled cumulative impacts resulting from the increases and decreases in emissions are then compared to the $PM_{2.5}$ increments to determine whether any increment violations will result. This section provides recommendations on conducting an appropriate cumulative impact assessment for $PM_{2.5}$ increments.

V.3.2.1 Assessing Primary $PM_{2.5}$ Impacts

As explained in Section III.3 of this guidance, the assessment of primary $PM_{2.5}$ impacts from the proposed new or modifying PSD source is essentially the same for the $PM_{2.5}$ NAAQS and increments. In both cases, the permit applicant must account for the impacts from the proposed new or modifying source's *allowable* emissions increase of direct $PM_{2.5}$.

To assess the impact of direct $PM_{2.5}$ emissions from existing increment-consuming sources, *actual* emissions increases that have occurred since the applicable minor source baseline date should generally be modeled. Alternatively, existing source impacts from direct $PM_{2.5}$ emissions may be conservatively modeled using an existing source's *allowable* emissions where the PSD applicant determines that such emissions are more readily available and especially when such allowable emissions are not expected to contribute substantially to the amount of increment consumed. In the event that an applicant chooses to conduct the cumulative analysis using *allowable* emissions and identifies potential problems concerning increment consumption, the PSD applicant may then rely on more refined data that better represent a particular source's *actual* emissions.

The $PM_{2.5}$ increments analysis should follow the traditional approach involving modeling only direct $PM_{2.5}$ emissions changes that affect the increment and should be based on application of AERMOD (or other acceptable preferred or approved alternative model), using actual emission changes associated with any increment-consuming or increment-expanding sources. The AERMOD model allows for inclusion of these emissions (represented as negative emissions for the sources expanding increment)[41] in the same model run that includes the allowable increase in emissions from the proposed source and will, therefore, output the net cumulative concentrations at each receptor established for the modeling domain.[42]

V.3.2.2 Assessing Secondary $PM_{2.5}$ Impacts

To assess the secondary impacts from changes in $PM_{2.5}$ precursor emissions from the new or modified source, as well as from other increment-consuming sources, the EPA recommends the analysis for each applicable precursor of $PM_{2.5}$ be conducted collectively based on the two-tiered demonstration approach outlined in EPA's 2017 *Guideline*.

In recent years, several rules promulgated by the EPA have resulted in control requirements that have significantly reduced NO_X and SO_2 precursor emissions affecting ambient $PM_{2.5}$ concentrations in many areas.[43] This is particularly true in the eastern U.S. As a result, in some cases, the secondary $PM_{2.5}$ impacts may be addressed by a demonstration that provides ambient monitoring data that generally confirms a downward trend in precursor emissions occurring after the applicable $PM_{2.5}$ minor source baseline date (or the major source baseline

---

[41] See discussion about increment expansion in Section V.1.3 of this guidance.

[42] The "maximum" cumulative impacts will be output as zero if the cumulative impacts computed in the model are less than zero).

[43] Such rules include the following: the Clean Air Interstate Rule (CAIR) Final Rule, 70 FR 25162 (May 12, 2005); CSAPR Final Rule, 76 FR 48208 (August 8, 2011); CSAPR Update for the 2008 Ozone NAAQS (CSAPR Update) Final Rule, 81 FR 74504 (October 26, 2016); and the Mercury and Air Toxics Standards Rule (MATS), 77 FR 9304 (February 16, 2012).

date). If it can be confirmed that such emissions reductions have occurred in a particular baseline area, it may be possible to complete the $PM_{2.5}$ increments modeling analysis simply by focusing on potential increment consumption associated with direct $PM_{2.5}$ emissions. For areas where $PM_{2.5}$ precursor emission increases from other increment-consuming sources have occurred since the major or minor source baseline dates, and are, thus, likely to have added to $PM_{2.5}$ concentration increases within the baseline area (and, thus, consume $PM_{2.5}$ increment), the Tier 1 and Tier 2 assessment approaches based on CTMs (using the emissions input data applicable to increment analyses) discussed in Section III of this guidance may be appropriate for estimating the portion of $PM_{2.5}$ increment consumed due to secondary $PM_{2.5}$ impacts associated with those increases in precursor emissions.

V.4. Determining Whether a Proposed Source Will Cause or Contribute to an Increment Violation

When a proposed PSD source predicts, through a cumulative impact analysis, that a modeled violation of any $PM_{2.5}$ increment will occur within the baseline area of concern, a closer examination of the proposed source's individual impact(s) at the violating receptor(s) and the time(s) of modeled violation become important considerations. The EPA's longstanding policy is to consider a proposed PSD source to cause or contribute to an increment violation if its impact (primary and secondary) is significant (equal to or greater than the appropriate $PM_{2.5}$ SIL) at the location and time of the modeled violation.[44] Accordingly, if a source can demonstrate to the

---

[44] *See*, *e.g.*, 43 FR 26380 at 26401, June 19, 1978; EPA memo titled "Interpretation of 'Significant Contribution,'" December 16, 1980; EPA memo titled "Air Quality Analysis for Prevention of Significant Deterioration," July 5, 1988; and more recently, EPA memo titled "Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program," April 17, 2018, Attachment at page 18 ("If the modeled impact is below the recommended SIL value *at the violating receptor during the violation*, the EPA believes this will be sufficient in most cases for a permitting authority …to conclude that the source does not cause or contribute to…the predicted violation.")(Emphasis added).

satisfaction of the permitting authority that significant impacts attributable to the source do *not* occur at the location and time of any modeled violation,[45] the proposed source or modification generally may be considered to not cause or contribute to an increment violation. In cases where a proposed PSD source models impacts that equal or exceed the appropriate $PM_{2.5}$ SIL *and* would cause a new violation of any $PM_{2.5}$ increment, it is the EPA's longstanding policy to allow the PSD applicant to obtain sufficient offsets, in the form of emissions reductions internally or from another existing source, to avoid causing the predicted violation at each affected receptor where (and when) a violation is modeled. In an area where a proposed PSD source would cause or contribute to an existing increment violation(s), the PSD source must not be approved for construction unless such existing violation(s) is entirely corrected at each affected receptor prior to the operation of the proposed source.[46]

---

[45] The difficulties associated with combining primary and secondary impacts spatially and temporally were described in Sections III and IV of this guidance. In the case of a $PM_{2.5}$ increment analysis, as with the $PM_{2.5}$ NAAQS analysis, the applicant and permitting authority will need to agree upon an approach that best satisfies the required compliance demonstration.

[46] *See*, *e.g.*, 43 FR 26380 at 26401, June 19, 1978; 45 FR 52676 at 52678, August 7, 1980; and EPA memo titled "Air Quality Analysis for Prevention of Significant Deterioration," July 5, 1988. ("…for any increment violation (new or existing) for which the proposed source has a significant impact, the permit should not be approved unless the increment violation is corrected prior to operation of the proposed source.) Note that this policy for the PSD increments differs from the policy for sources that contribute to an existing NAAQS violation, for which the proposed sources needs only compensate for its own adverse impact on the NAAQS violation in accordance with 40 CFR 51.165(b)(3).

This Page Intentionally Left Blank

VI. References

Baker, K.R., Kelly, J.T., 2014. Single source impacts estimated with photochemical model source sensitivity and apportionment approaches. *Atmospheric Environment* 96, 266-274.

Baker, K.R., Kotchenruther, R.A., Hudman, R.C., 2015. Estimating Ozone and Secondary PM2.5 Impacts from Hypothetical Single Source Emissions in the Central and Eastern United States. *Atmospheric Pollution Research* 7, 122-133.

Bergin, M., Russell, A., Odman, T., Cohan, D., and Chameldes, W., 2008. Single Source Impact Analysis Using Three-Dimensional Air Quality Models. *Journal of the Air & Waste Management Association*. 2008; 58, 1351–1359.

Byun and Schere, 2006: Review of the governing equations, computational algorithms, and other components of the models-3 Community Multiscale Air Quality (CMAQ) modeling system. D. Byun and K. Schere. *Applied Mechanics Reviews*. 2006; 59, 51-77.

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.

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.

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.

ENVIRON, 2012a. Comparison of Single-Source Air Quality Assessment Techniques for Ozone, PM2.5, other Criteria Pollutants and AQRVs, EPA Contract No: EP-D-07-102. September 2012. 06-20443M6.

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.

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.

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.

NACAA, 2011: $PM_{2.5}$ Modeling Implementation for Projects Subject to National Ambient Air Quality Demonstration Requirements Pursuant to New Source Review. Report from NACAA $PM_{2.5}$ Modeling Implementation Workgroup dated January 7, 2011. Washington, District of Columbia 20001. https://gaftp.epa.gov/Air/aqmg/SCRAM/conferences/2012_10th_Conference_On_Air_Quality_Modeling/Review_Material/01072011-NACAAPM2.5ModelingWorkgroupReport-FINAL.pdf.

NARSTO, 2004. Particulate Matter Assessment for Policy Makers: A NARSTO Assessment. P. McMurry, M. Shepherd, and J. Vickery, eds. Cambridge University Press, Cambridge, England. ISBN 0 52 184287 5.

Ramboll Environ, 2018. User's Guide Comprehensive Air Quality Model with Extensions version 6. ENVIRON International Corporation, Novato, CA. http://www.camx.com.

Russell, 2008: EPA Supersites Program-related emissions-based particulate matter modeling: Initial applications and advances. A. Russell. *Journal of the Air & Waste Management Association*. 2008; 58, 289-302.

Tesche, T., Morris, R., Tonnesen, G., McNally, D., Boylan, J., Brewer, P., 2006. CMAQ/CAMx annual 2002performance evaluation over the eastern US. *Atmospheric Environment* 40, 4906-4919.

U.S. EPA, 1990. New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting – DRAFT. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/default/files/2015-07/documents/1990wman.pdf.

U.S. EPA, 1992. Protocol for Determining the Best Performing Model. September 1992. EPA-454/R-92-025. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/model_eval_protocol.pdf.

U.S. EPA, 2004. User's Guide to the Building Profile Input Program. EPA-454/R-93-038. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/bpip/bpipdup.pdf.

U.S. EPA, 2005. *Guideline on Air Quality Models*. 40 CFR part 51 Appendix W (70 FR 68218, Nov. 9, 2005). https://www.epa.gov/sites/default/files/2020-09/documents/appw_05.pdf.

U.S. EPA, 2007a. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. April 2007. EPA-454/B-07-002. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/final-03-pm-rh-guidance.pdf.

U.S. EPA, 2007b. Details on Technical Assessment to Develop Interpollutant Trading Ratios for $PM_{2.5}$ Offsets. Technical Analysis dated July 23, 2007. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

U.S. EPA, 2010. Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS. Stephen Page Memorandum dated March 23, 2010. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 27711. https://www.epa.gov/sites/default/files/2015-07/documents/pm25memo.pdf.

U.S. EPA, 2011a. AERSCREEN Released as the EPA Recommended Screening Model. Tyler Fox Memorandum dated April 11, 2011. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/20110411_aerscreen_release_memo.pdf.

U.S. EPA, 2011b. Revised Policy to Address Reconsideration of Interpollutant Trading Provisions for Fine Particles ($PM_{2.5}$). Gina McCarthy Memorandum dated July 21, 2011. U.S. Environmental Protection Agency, Washington, District of Columbia 20460. https://www.epa.gov/sites/default/files/2020-10/documents/pm25trade.pdf.

U.S. EPA, 2011c. Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard. Tyler Fox Memorandum dated March 1, 2011. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/additional_clarifications_appendixw_hourly-no2-naaqs_final_03-01-2011.pdf.

U.S. EPA, 2012. Sierra Club Petition Grant. Gina McCarthy Administrative Action dated January 4, 2012. U.S. Environmental Protection Agency, Washington, District of Columbia 20460. https://gaftp.epa.gov/Air/aqmg/SCRAM/conferences/2012_10th_Conference_On_Air_Quality_Modeling/Review_Material/Sierra_Club_Petition_OAR-11-002-1093.pdf.

U.S. EPA, 2014. Guidance for PM2.5 Modeling. May 20, 2014. Publication No. EPA-454/B-14-001. Office of Air Quality Planning and Standards, Research Triangle Park, NC. https://www.epa.gov/sites/production/files/2020-09/documents/guidance_for_pm25_permit_modeling.pdf.

U.S. EPA, 2015. AERMINUTE User's Guide. U.S. Environmental Protection Agency, EPA-454/B-15-006. Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/aerminute/aerminute_userguide.pdf.

U.S. EPA, 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. https://www.epa.gov/sites/production/files/2020-09/documents/epa-454_r-16-005.pdf.

U.S. EPA, 2017a. *Guideline on Air Quality Models*. 40 CFR part 51 Appendix W (82 FR 5182, Jan. 17, 2017). https://www.epa.gov/sites/production/files/2020-09/documents/appw_17.pdf.

U.S. EPA, 2017b. Use of Photochemical Grid Models for Single-Source Ozone and secondary $PM_{2.5}$ impacts for Permit Program Related Assessments and for NAAQS Attainment Demonstrations for Ozone, PM2.5 and Regional Haze. Tyler Fox Memorandum dated August 4, 2017. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/20170804-photochemical_grid_model_clarification_memo.pdf.

U.S. EPA, 2018a. 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. https://www.epa.gov/nsr/significant-impact-levels-ozone-and-fine-particles.

U.S. EPA, 2018b. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-16-012. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aermap/aermap_userguide_v18081.pdf.

U.S. EPA, 2019. Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and PM2.5 under the PSD Permitting Program. Publication No. EPA 454/R-19-003. Office of Air Quality Planning and Standards, Research Triangle Park, NC. https://www.epa.gov/sites/production/files/2020-09/documents/epa-454_r-19-003.pdf.

U.S. EPA, 2020: AERSURFACE User's Guide. EPA-454/B-20-008. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aersurface/aersurface_ug_v20060.pdf.

U.S. EPA, 2021. AERSCREEN User's Guide. EPA-454/B-21-005. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/screening/aerscreen/aerscreen_userguide.pdf.

U.S. EPA, 2022a. User's Guide for the AMS/EPA Regulatory Model – AERMOD. EPA-454/B-22-007. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_userguide.pdf.

U.S. EPA, 2022b. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-22-006. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/aermet/aermet_userguide.pdf.

U.S. EPA, 2022c. AERMOD Implementation Guide. EPA-454/B-22-008. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_implementation_guide.pdf.

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.

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.

Appendix A: Draft Conceptual Description of O_3 and $PM_{2.5}$ Concentrations in the U.S.

This appendix provides a brief summary of the current O_3 and $PM_{2.5}$ monitoring networks. It also characterizes O_3 and PM air quality in terms of their precursor emissions and chemical composition, concentration levels, and spatial and temporal patterns across the nation based on the ambient data and analyses contained in the EPA's "Integrated Science Assessment for Ozone and Related Photochemical Oxidants,"[47] "The Particle Pollution Report,"[48] and "Particulate Matter Staff Paper."[49] Such information may be useful for permit applicants in preparing conceptual descriptions, as discussed in this guidance. Permit applicants also encouraged to reference the EPA's "Air Quality Trends" website at https://www.epa.gov/air-trends for the current O_3 and $PM_{2.5}$ trends and design values.

Conceptual Descriptions of O_3

1. O_3 Monitoring Networks

To monitor compliance with the NAAQS, state, local, and tribal environmental agencies operate O_3 monitoring sites at various locations, depending on the population of the area and typical peak O_3 concentrations. In 2015, there were over 1,300 O_3 monitors reporting O_3 concentration data to EPA. All monitors that currently report O_3 concentration data to the EPA use ultraviolet Federal Equivalent Methods (FEMs). Since the highest O_3 concentrations tend to be associated with particular seasons for various locations, EPA requires O_3 monitoring during specific monitoring seasons which vary by state. The O_3 monitoring seasons for each state are listed in Appendix D to 40 CFR part 58.

Figure A-1 shows the locations of all U.S. ambient O_3 monitoring sites reporting data to EPA during the 2013-2015 period. The gray dots represent State and Local Ambient Monitoring Stations (SLAMS) which are operated by state and local governments to meet regulatory requirements and provide air quality information to public health agencies. SLAMS monitors make up about 80 percent of the ambient O_3 monitoring network in the U.S. The minimum monitoring requirements to meet the SLAMS O_3 network design criteria are specified in Appendix D to 40 CFR part 58. The requirements are based on both population and ambient concentration levels for each Metropolitan Statistical Area (MSA). At least one site for each MSA must be designed to record the maximum concentration for that particular area. The blue dots highlight two important subsets of monitoring sites within the SLAMS network: the "National Core" (NCore) network, which consists of about 80 monitoring sites that collect multi-

---

[47] U.S. Environmental Protection Agency (2013). Integrated Science Assessment for Ozone and Related Photochemical Oxidants. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA/600/R-10/076 (2013 ISA), section 3.2.2 found at https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=247492.

[48] The Particle Pollution Report: Current Understanding of Air Quality and Emissions through 2003.

https://www.epa.gov/sites/production/files/2017-11/documents/pp_report_2003.pdf.

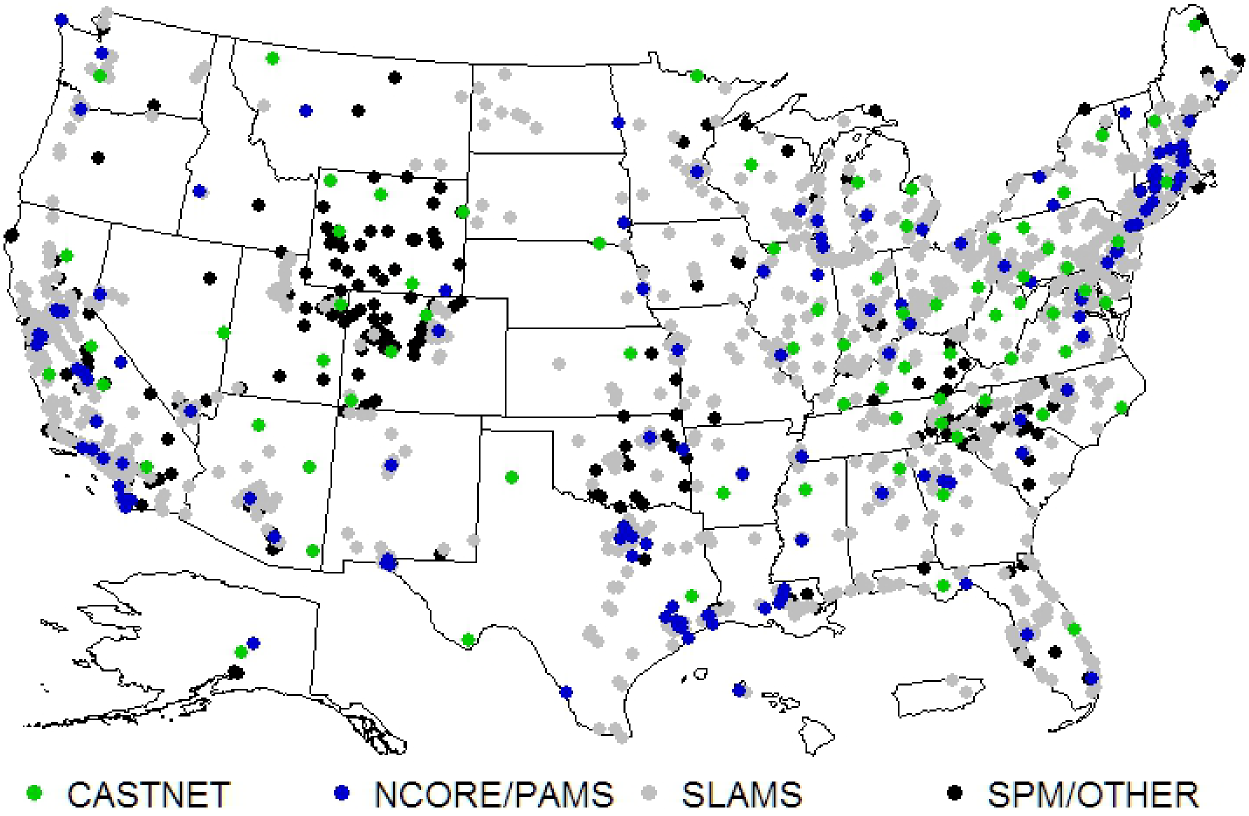
[49] Particulate Matter Staff Paper: Review completed in 2012. https://www.epa.gov/naaqs/particulate-matter-pm-air-quality-standards-documents-review-completed-2012.

pollutant measurements on a year-round basis, and the "Photochemical Assessment Monitoring Stations" (PAMS) network, which consists of about 75 monitoring sites that collect summertime measurements of various precursor gases involved O_3 formation.

The green dots in Figure A-1 represent O_3 monitoring sites in the Clean Air Status and Trends Network (CASTNet) which are mostly located in rural areas. There were about 80 CASTNet sites reporting data to EPA in 2015, with sites in the eastern U.S. generally being operated by the EPA, and sites in the western U.S. generally being operated by the National Park Service (NPS).

Finally, the black dots in Figure A-1 represent "Special Purpose" (SPM) monitoring sites, which generally collect data for research studies, public health reporting, or other non-regulatory purposes, and all other O_3 monitoring sites which includes monitors operated by tribes, industry, and other federal agencies such as the U.S. Forest Service (USFS).

Figure A-1. Locations of U.S. Ambient O_3 Monitoring Sites in 2013-2015



2. O_3 Precursor Emissions and Atmospheric Chemistry

O_3 is formed by photochemical reactions of precursor gases and is not directly emitted from specific sources. In the stratosphere, O_3 occurs naturally and provides protection against harmful solar ultraviolet radiation. In the troposphere, near ground level, O_3 forms through atmospheric reactions involving two main classes of precursor pollutants: volatile organic compounds (VOCs) and nitrogen oxides (NO_X). Carbon monoxide (CO) and methane (CH_4) are also important for O_3 formation over longer time periods.[50]

Emissions of O_3 precursor compounds can be divided into anthropogenic and natural source categories, with natural sources further divided into biogenic emissions (from vegetation, microbes, and animals) and abiotic emissions (from biomass burning, lightning, and geogenic sources). Anthropogenic sources, including mobile sources and power plants, account for the majority of NO_X and CO emissions. Anthropogenic sources are also important for VOC emissions, though in some locations and at certain times of the year (*e.g.*, southern states during summer), the majority of VOC emissions come from vegetation.[51] In practice, the distinction between natural and anthropogenic sources is often unclear, as human activities directly or indirectly affect emissions from what would have been considered natural sources during the preindustrial era. Thus, emissions from plants, animals, and wildfires could be considered either natural or anthropogenic, depending on whether emissions result from agricultural practices, forest management practices, lightning strikes, or other types of events.[52]

Rather than varying directly with emissions of its precursors, O_3 changes in a nonlinear fashion with the concentrations of its precursors. NO_X emissions lead to both the formation and destruction of O_3, depending on the local quantities of NO_X, VOC, radicals, and sunlight. In areas dominated by fresh emissions of NO_X, radicals are removed, which lowers the O_3 formation rate. In addition, the scavenging of O_3 by reaction with NO is called "titration" and is often found in downtown metropolitan areas, especially near busy streets and roads, as well as in power plant plumes. This short-lived titration results in localized areas in which O_3 concentrations are suppressed compared to surrounding areas, but which contain NO_2 that adds to subsequent O_3 formation further downwind. Consequently, O_3 response to reductions in NO_X emissions is complex and may include O_3 decreases at some times and locations and increases of O_3 at other times and locations. In areas with relatively low NO_X concentrations, such as those found in remote continental areas and rural and suburban areas downwind of urban centers, O_3 production typically varies directly with NO_X concentrations (*e.g.*, decreases with decreasing NO_X emissions). The NOx titration effect is most pronounced in urban core areas which have higher volume of mobile source NO_X emissions from vehicles than do the surrounding areas. It should be noted that such locations, which are heavily NO_X saturated (or radical limited), tend to have much lower observed O_3 concentrations than downwind areas. As a general rule, as NOx emissions reductions occur, one can expect lower O_3 values to increase while the higher O_3 values would be expected to decrease. NOx reductions are expected to result in a compressed O_3 distribution, relative to current conditions.

The formation of O_3 from precursor emissions is also affected by meteorological parameters such as the intensity of sunlight and atmospheric mixing. Major episodes of high ground-level O_3 concentrations in the eastern United States are associated with slow-moving high pressure systems. High pressure systems during the warmer seasons are associated with the

---

[50] 2013 ISA, section 3.2.2.

[51] 2013 ISA, section 3.2.1.

[52] 2013 ISA, sections 3.2 and 3.7.1.

sinking of air, resulting in warm, generally cloudless skies, with light winds. The sinking of air results in the development of stable conditions near the surface which inhibit or reduce the vertical mixing of O_3 precursors. The combination of inhibited vertical mixing and light winds minimizes the dispersal of pollutants, allowing their concentrations to build up. In addition, in some parts of the United States (*e.g.*, in Los Angeles), mountain barriers limit mixing and result in a higher frequency and duration of days with elevated O_3 concentrations. Photochemical activity involving precursors is enhanced during warmer seasons because of the greater availability of sunlight and higher temperatures.[53]

3. Spatial and Temporal Patterns in Ambient O_3 Concentrations

3.1. Diurnal and Seasonal Patterns

Since O_3 formation is a photochemical process, it is not surprising that concentration levels have strong diurnal and seasonal patterns. Concentration levels tend to be highest at times when sunlight reaches its highest intensity, namely during the afternoon hours of the late spring and summer months. However, there are other factors at work, such as the influence of biogenic VOC emissions and stratospheric intrusions during the spring months, long-range transport, and traffic patterns which often cause peak NO_X emissions to occur during the morning and evening rush hours.

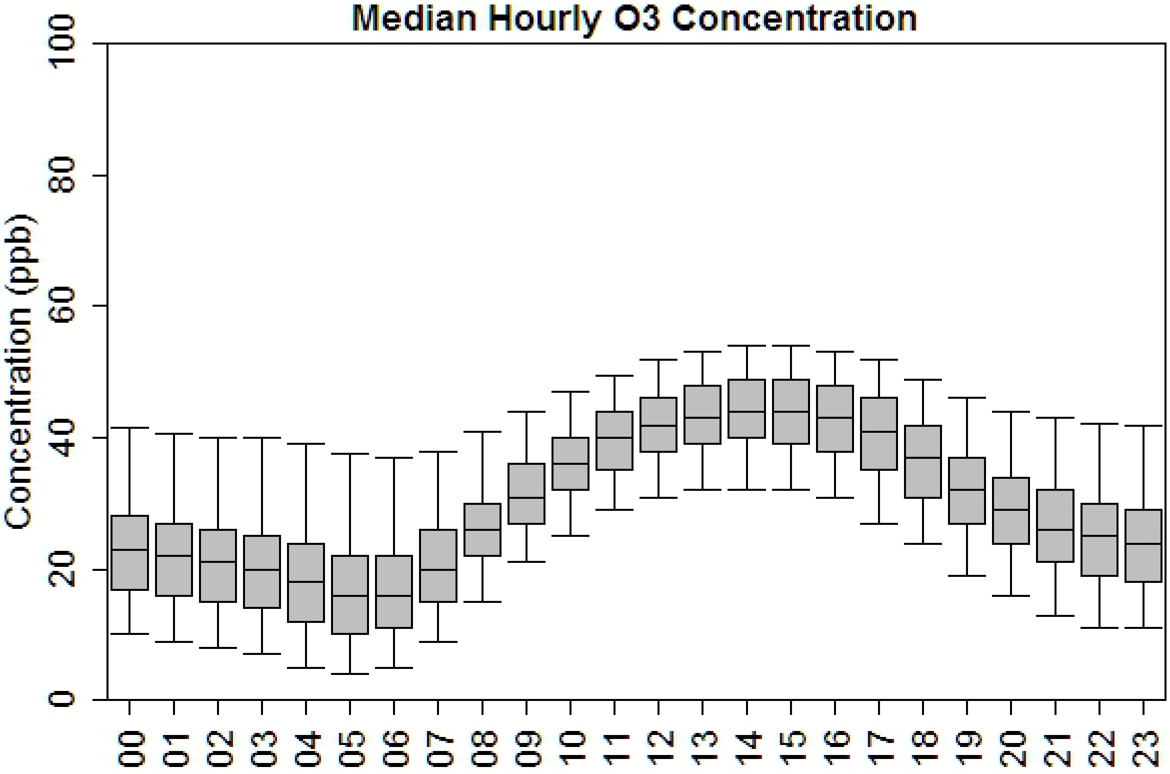
Figure A-2 shows the diurnal pattern in the hourly O_3 concentrations based on ambient monitoring data from 2000 to 2015. For each monitoring site, the median (top panel) and 95th percentile (bottom panel) values for each hour of the day were calculated, and each boxplot shows the range of those values for that particular hour across all monitoring sites. The whiskers of each boxplot extend to the 5th and 95th percentiles, the box represents the inter-quartile range, and the centerline represents the median value. The median and 95th percentile values show a consistent pattern in that O_3 levels tend to be lowest during the early AM hours, increasing rapidly after sunrise. Concentrations typically reach their peak during the afternoon hours, then decrease at a fairly constant rate throughout the evening and nighttime hours.

Figure A-3 shows the seasonal pattern in the daily maximum 8-hour O_3 concentrations based on ambient monitoring data from 2000 to 2015. For each monitoring site, the median (top panel) and 95th percentile (bottom panel) values for each month of the year were calculated, and each boxplot shows the range of those values for that particular month across all monitoring sites. The whiskers of each boxplot extend to the 5th and 95th percentiles, the box represents the inter-quartile range, and the centerline represents the median value. Again, the median and 95th percentile values show a consistent pattern in that O_3 levels tend to be highest during the spring and summer months (April to September), and lower during the fall and winter months (October to March).

---

[53] 2013 ISA, section 3.2.

Figure A-2. Distribution of Median and 95th Percentile Hourly O3 Concentrations by Hour of the Day based on 2000-2015 Monitoring Data



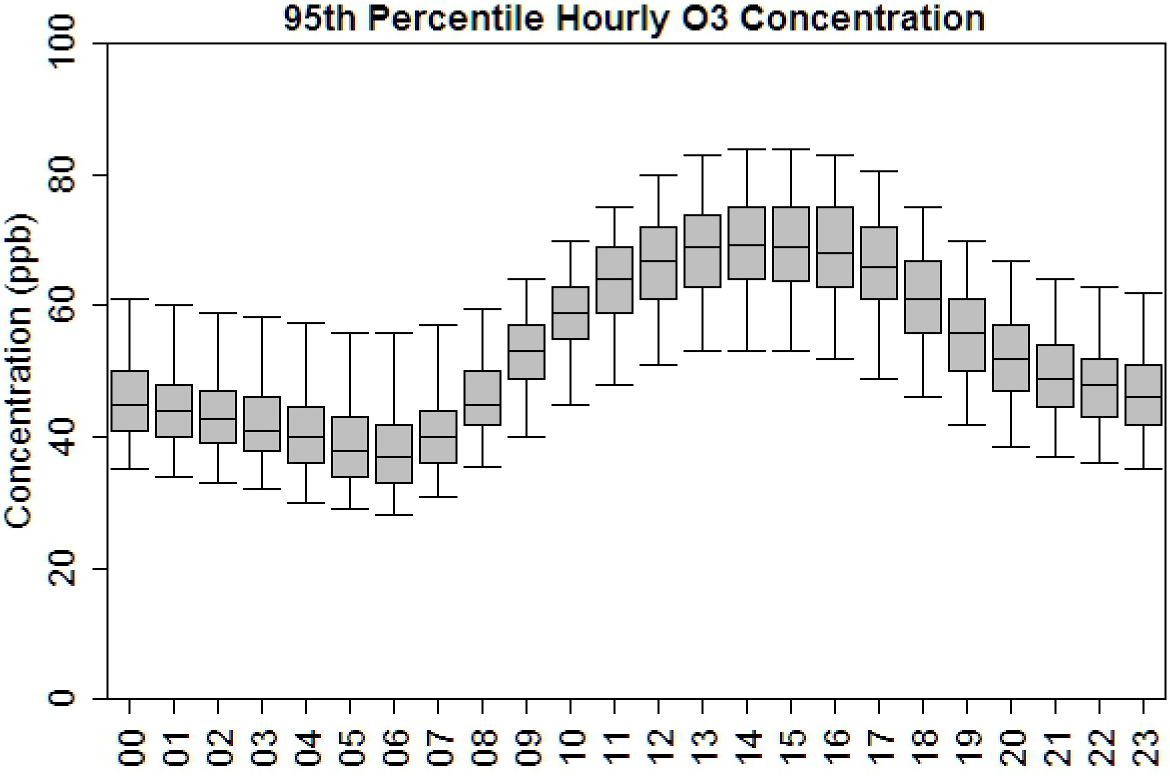
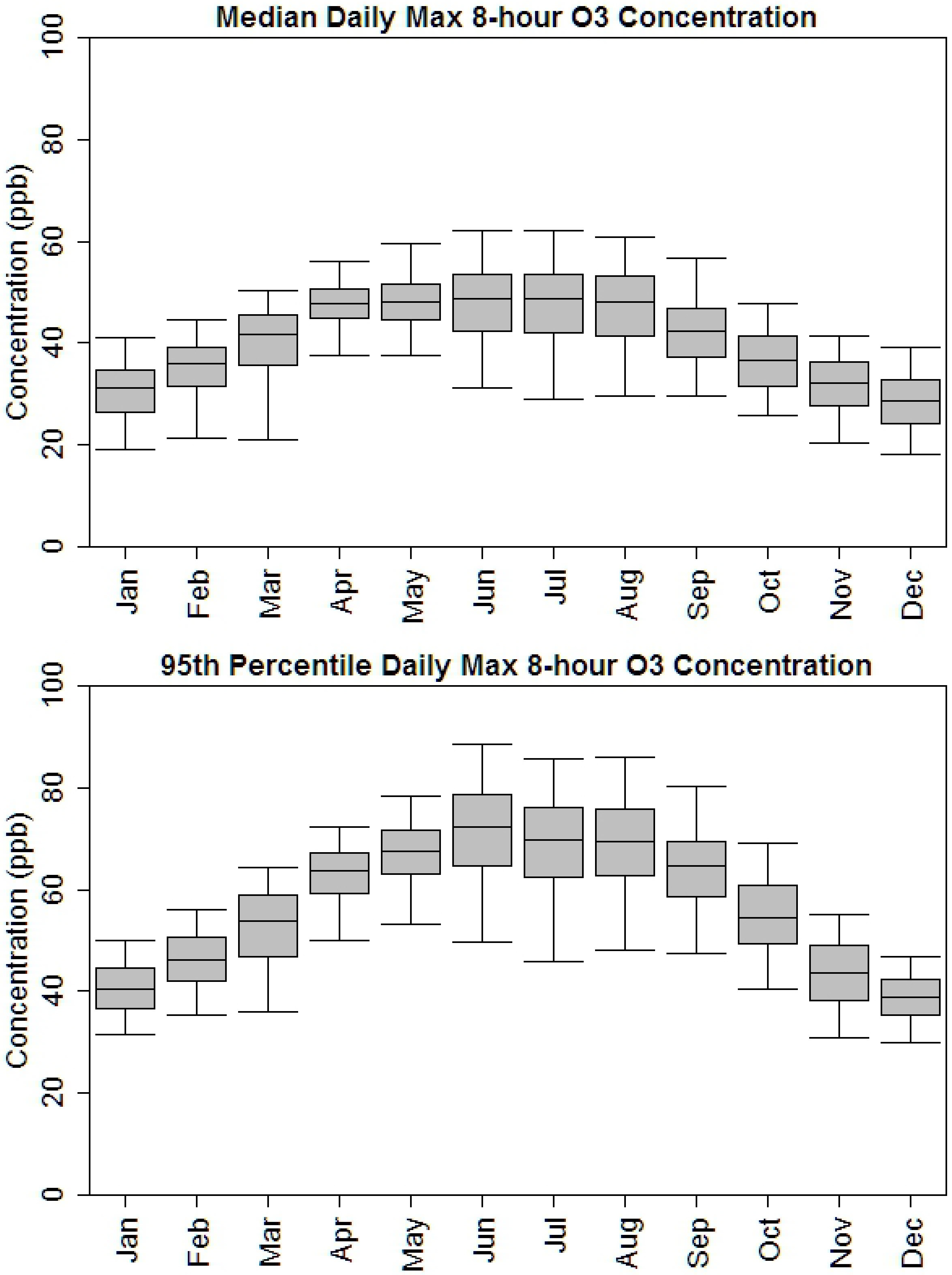


Figure A-3. Distribution of Median and 95th Percentile Daily Maximum 8-hour O_3 Concentrations by Month of the Year based on 2000-2015 Monitoring Data

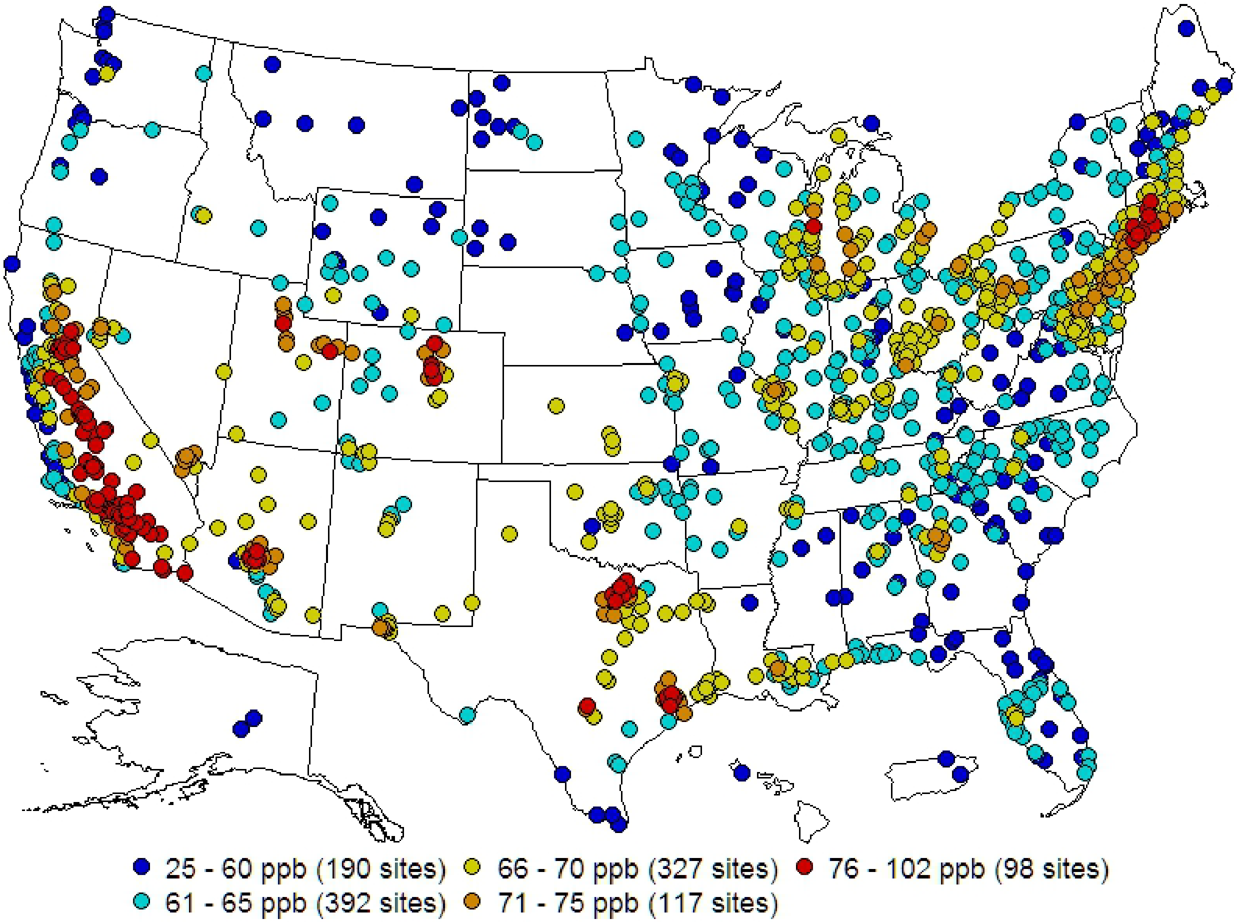


3.2. Spatial Patterns

To determine whether or not the O_3 NAAQS has been met at an ambient monitoring site, a statistic commonly referred to as a "design value" must be calculated based on three consecutive years of data collected from that site. The form of the O_3 NAAQS design value statistic is the 3-year average of the annual 4th highest daily maximum 8-hour O_3 concentration in parts per million (ppm). The O_3 NAAQS is met at an ambient monitoring site when the design value is less than or equal to 0.070 ppm. In counties or other geographic areas with multiple monitors, the area-wide design value is defined as the design value at the highest individual monitoring site, and the area is said to have met the NAAQS if all monitors in the area are meeting the NAAQS.

Figure A-4 shows a map of the O_3 design values in the U.S. based on data collected during the 2013-2015 period. The highest design values occur in California and near large metropolitan areas such as Dallas, Denver, Houston, New York City, and Phoenix. The lowest design values occur in the Pacific Northwest, the Northern Rockies, the Upper Midwest, and parts of New England and the Southeast. In general, sparsely populated areas tend to have lower design values than more urbanized areas.

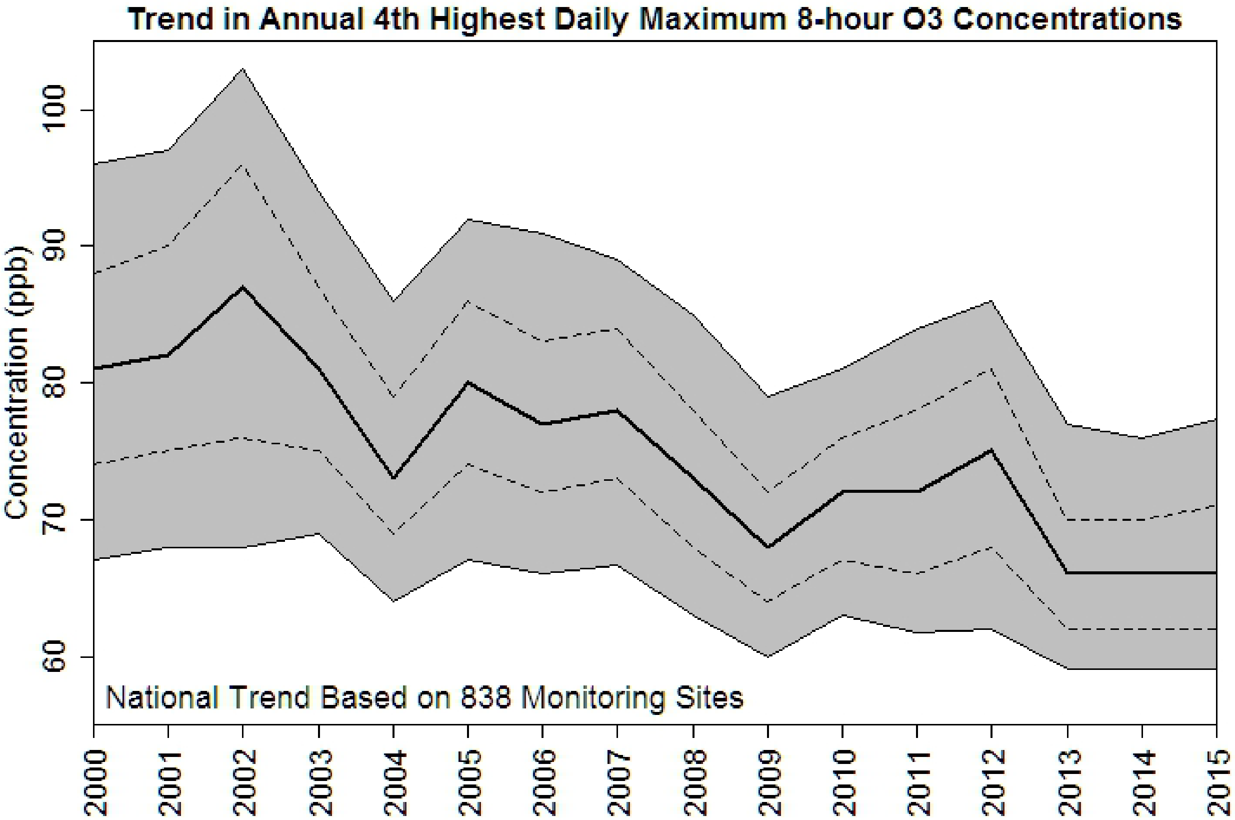
Figure A-4. Map of 2013-2015 O_3 Design Values in parts per billion (ppb)



3.3. Interannual Variability and Trends

Figure A-5 shows the national trend in the annual 4th highest daily maximum 8-hour O_3 concentration from 2000 to 2015. The solid black line represents the median value for each year based on 838 "trends" sites with complete monitoring records, the dashed lines represent the 25th and 75th percentile values for each year, and the shaded gray area covers the 10th percentile value up to the 90th percentile value for each year. While there is considerable year-to-year variability, overall the trend shows an improvement in O_3 air quality over the 15-year period. In fact, the median annual 4th highest value has decreased by 18% since the beginning of the century, and by 24% since 2002.

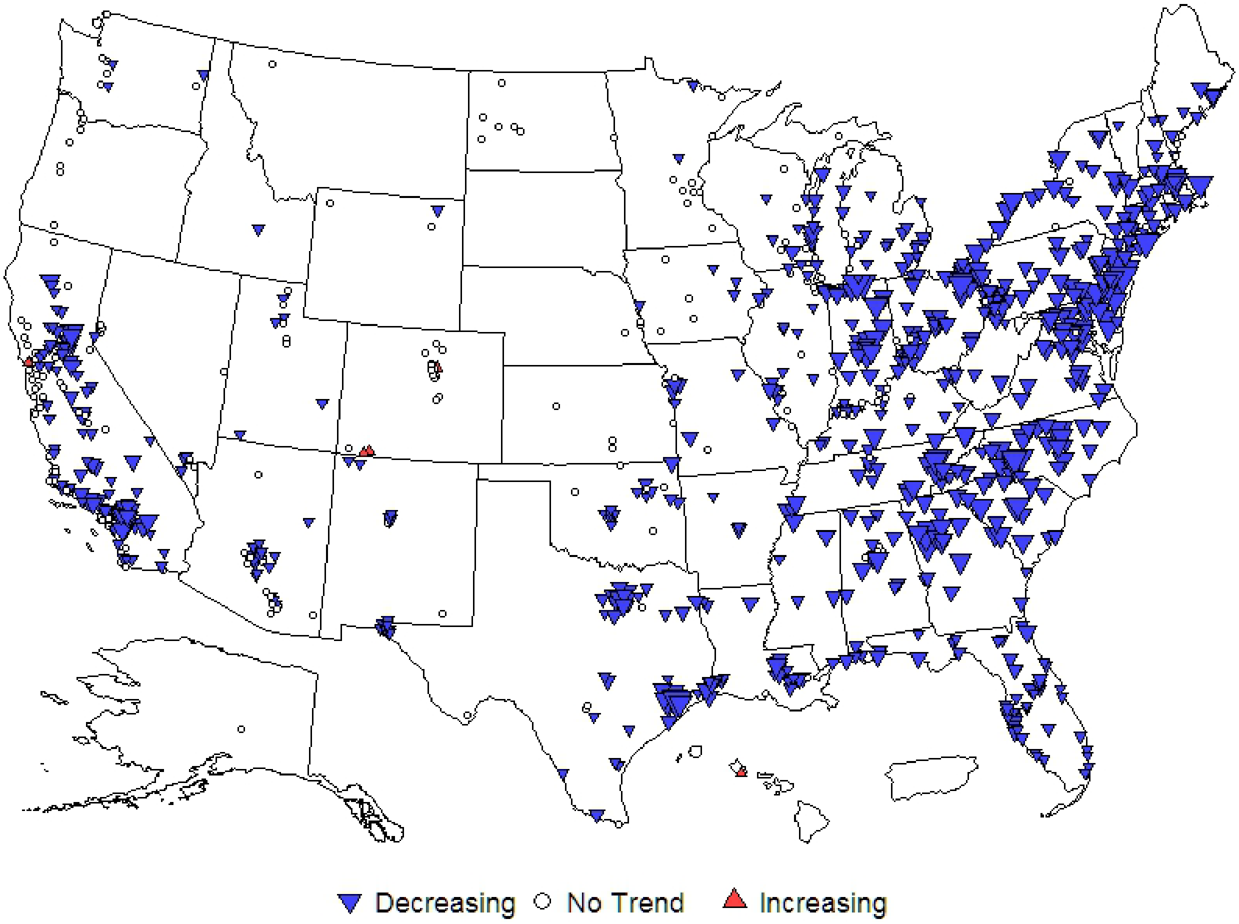
Figure A-5. National Trend in the Annual 4th Highest Daily Maximum 8-hour O_3 Concentration



Since the national trend is a simple aggregate of the site-level trends, it is also important to look at how these trends vary spatially. Figure A-6 shows a map of the trends at each monitoring site with at least 12 complete years of data from 2000-2015. The magnitude of the trend at each site is computed using the Theil-Sen slope estimator, and the Mann-Kendall statistic is calculated in order to test for statistical significance using a threshold of 0.05. The trend at each monitoring site is classified as Decreasing (p-value < 0.05, slope < 0; blue triangles), No Trend (p-value >= 0.05, white circles), or Increasing (p-value < 0.05, slope > 0; red triangles). The size of each triangle is proportional to the magnitude of the trend at each monitoring site.

Figure A-6 shows that O_3 levels have decreased across much of the eastern U.S. as a result of regional control programs such as the NOx SIP Call and the Clean Air Interstate Rule (CAIR). Large reductions have occurred near many urban areas where local control programs have been implemented in addition to the regional controls. In the western U.S., where control programs have been more localized, the reductions have occurred mostly in California and near large urban areas. In other areas most sites have not shown a significant trend, and there are only a handful of sites have shown an increasing trend.

Figure A-6. Map of site-level O_3 trends across the U.S. from 2000 to 2015



Variations in meteorological conditions play an important role in determining O_3 concentrations. Ozone is more readily formed on warm, sunny days when the air is stagnant. Conversely, O_3 generation is more limited when it is cool, rainy, cloudy, or windy. EPA uses a statistical model to adjust for the variability in seasonal average O_3 concentrations due to weather conditions to provide a more accurate assessment of the underlying trend in O_3 caused by emissions.[54] Figure A-7 shows the national trend in the May to September mean of the daily

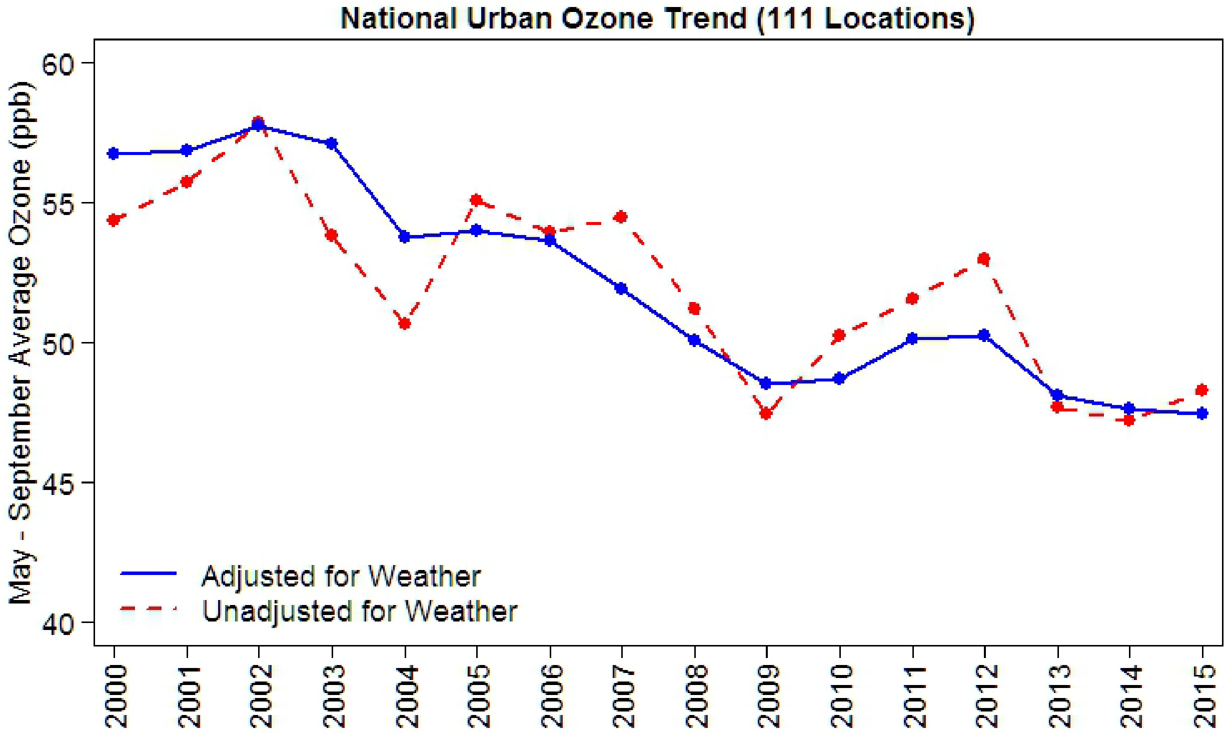
---

[54] Louise Camalier, William Cox, and Pat Dolwick (2007). The Effects of Meteorology on Ozone in Urban Areas and their use in Assessing Ozone Trends. Atmospheric Environment, Volume 41, Issue 33, October 2007, pages 7127-7137.

maximum 8-hour O_3 concentrations from 2000 to 2015 in 111 urban locations. The dotted red line shows the trend in observed O_3 concentrations at selected monitoring sites, while the solid blue line shows the underlying O_3 trend at those sites after removing the effects of weather. The solid blue lines represent O_3 levels anticipated under "typical" weather conditions and serve as a more accurate assessment of the trend in O_3 due to changes in precursor emissions.

Figure A-7 shows that after adjusting for the year-to-year variability in meteorology, the overall trend in seasonal average O_3 concentrations is much smoother. The adjusted trend clearly shows that the NO_X SIP Call program resulted in a sharp decrease in summertime O_3 concentrations starting in 2004. The adjusted trend also indicates that O_3 levels decreased between 2004 and 2009, followed by a small increase from 2009 to 2012, then continued to decrease after 2012.

Figure A-7. Trend in the May to September mean of the daily maximum 8-hour O_3 concentration before (dotted red line) and after (solid blue line) adjusting for year-to-year variability in meteorology.



Conceptual Description of $PM_{2.5}$

1. $PM_{2.5}$ Monitoring Networks

1.1. PM Mass Networks

The 1997 promulgation of a fine particulate NAAQS led to deployment of over 1,500 $PM_{2.5}$ sites (about 1,000 currently in operation) used to determine whether an area complies with the standard. These sites use a Federal Reference Method (FRM) or Federal Equivalent Method (FEM), daily sampling over 24-hours, or every third or sixth day. Nearly 200 additional measurements not meeting FRM or FEM specifications are provided by the chemical speciation sites (Figure A-8). Approximately 450 stations provide indirect measurements of continuous FEM (hourly resolution) $PM_{2.5}$ mass.

1.2. Interagency Monitoring of Protected Visual Environments (IMPROVE) Program

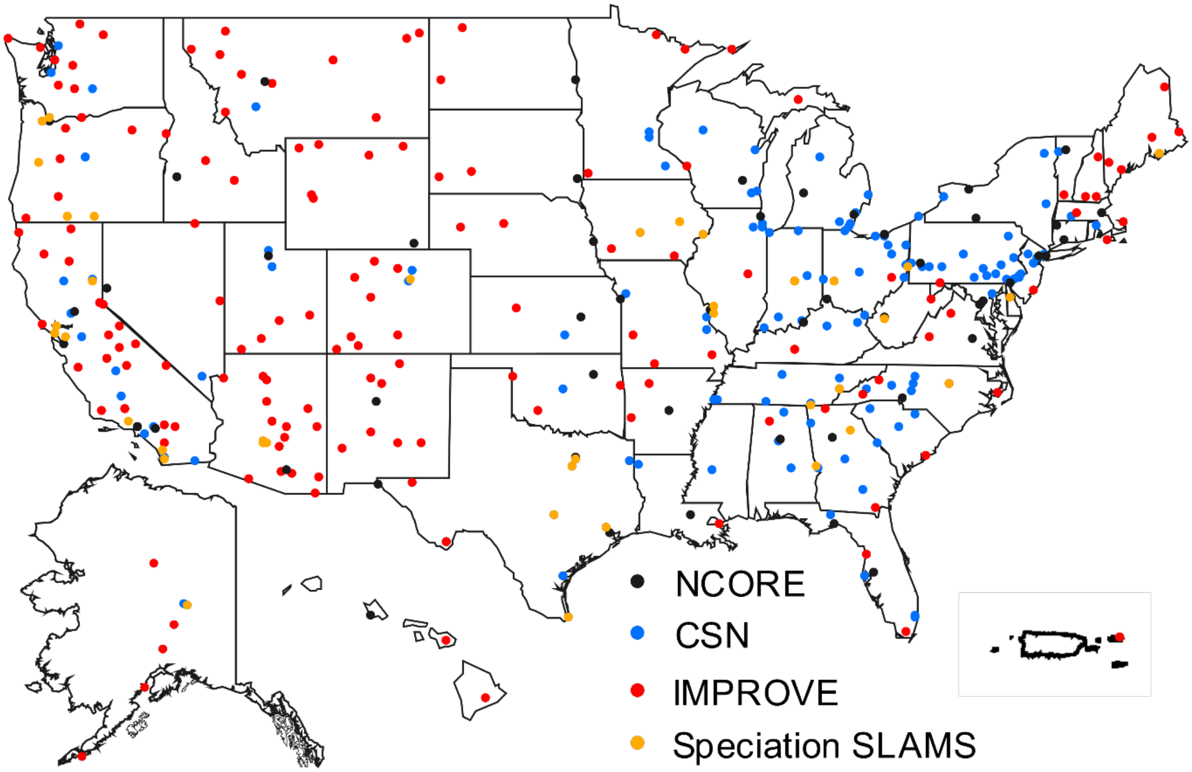
The IMPROVE network, with over 150 sites, has provided nearly a 20+ year record of major components of $PM_{2.5}$ (sulfate, nitrate, organic and elemental carbon fractions, and trace metals) in pristine areas of the United States (Figure A-8). IMPROVE is led by the National Park Service; various federal and state agencies support its operations. The primary focus of the network is to track visibility and trends in visibility.

1.3. $PM_{2.5}$ Chemical Speciation Monitoring

In addition to the IMPROVE network, approximately 200 EPA speciation sites operate in urban areas of the United States to assist $PM_{2.5}$ assessment efforts. No FRM exists for particulate speciation, which is not directly required to determine attainment, and there are slight differences between monitors and methods used in the Chemical Speciation Network (CSN). However, the network's coverage (Figure A-8) across urban and rural areas has proved essential for a wide range of research and analysis. The speciation networks typically collect a 24-hour sample every three, and sometimes six, days.

Only a handful of sites provide near continuous speciation data, usually limited to some combination of sulfate, carbon (organic and elemental splits) and nitrate. This enables insight to diurnal patterns for diagnosing various cause-effect phenomena related to emissions characterization, source attribution analysis and model evaluation.

Figure A-8. Locations of chemical speciation sites delineated by program type



2. Composition of $PM_{2.5}$

Particulate matter (PM) is a highly complex mixture of solid particles and liquid droplets distributed among numerous atmospheric gases which interact with solid and liquid phases. Particles range in size from those smaller than 1 nanometer (10^{-9} meter) to over 100 microns (1 micron is 10^{-6} meter) in diameter (for reference, a typical strand of human hair is 70 microns and particles less than about 20 microns generally are not detectable by the human eye). Particles are classified as $PM_{2.5}$ and $PM_{10\text{-}2.5}$, corresponding to their size (diameter) range in microns and referring to total particle mass under 2.5 and between 2.5 and 10 microns, respectively.

Particles span many sizes and shapes and consist of hundreds of different chemicals. Particles are emitted directly from sources and also are formed through atmospheric chemical reactions and often are referred to as primary and secondary particles, respectively. Particle pollution also varies by time of year and location and is affected by several aspects of weather such as temperature, clouds, humidity, and wind. Further complicating particles is the shifting between solid/liquid and gaseous phases influenced by concentration and meteorology, especially temperature.

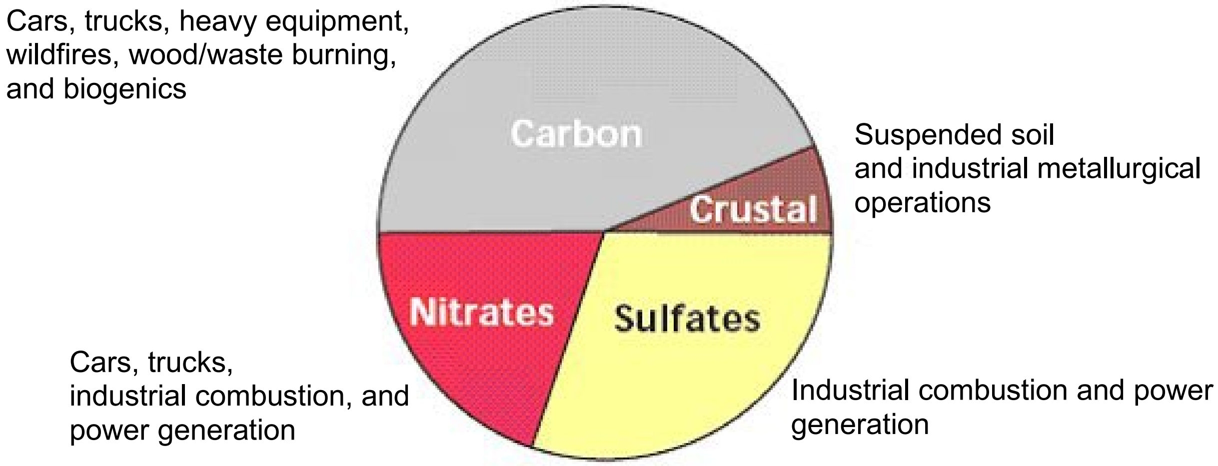
Particles are made up of different chemical components. The major components, or species, are carbon, sulfate and nitrate compounds, and crustal materials such as soil and ash (Figure A-9). The different components that make up particle pollution come from specific sources and are often formed in the atmosphere. Particulate matter includes both “primary” PM, which is directly emitted into the air, and “secondary” PM, which forms indirectly from fuel combustion and other sources. Primary PM consists of carbon (soot) emitted from cars, trucks, heavy equipment, forest fires, and burning waste and crustal material from unpaved roads, stone crushing, construction sites, and metallurgical operations. Secondary PM forms in the atmosphere from gases. Some of these reactions require sunlight and/or water vapor. Secondary PM includes:

- Sulfates formed from sulfur dioxide emissions from power plants and industrial facilities;
- Nitrates formed from nitrogen oxide emissions from cars, trucks, industrial facilities, and power plants; and
- Carbon formed from reactive organic gas emissions from cars, trucks, industrial facilities, forest fires, and biogenic sources such as trees.

In addition, ammonia from sources such as fertilizer and animal feed operations is part of the formation of sulfates and nitrates that exist in the atmosphere as ammonium sulfate and ammonium nitrate. Note that fine particles can be transported long distances by wind and weather and can be found in the air thousands of miles from where they were formed.

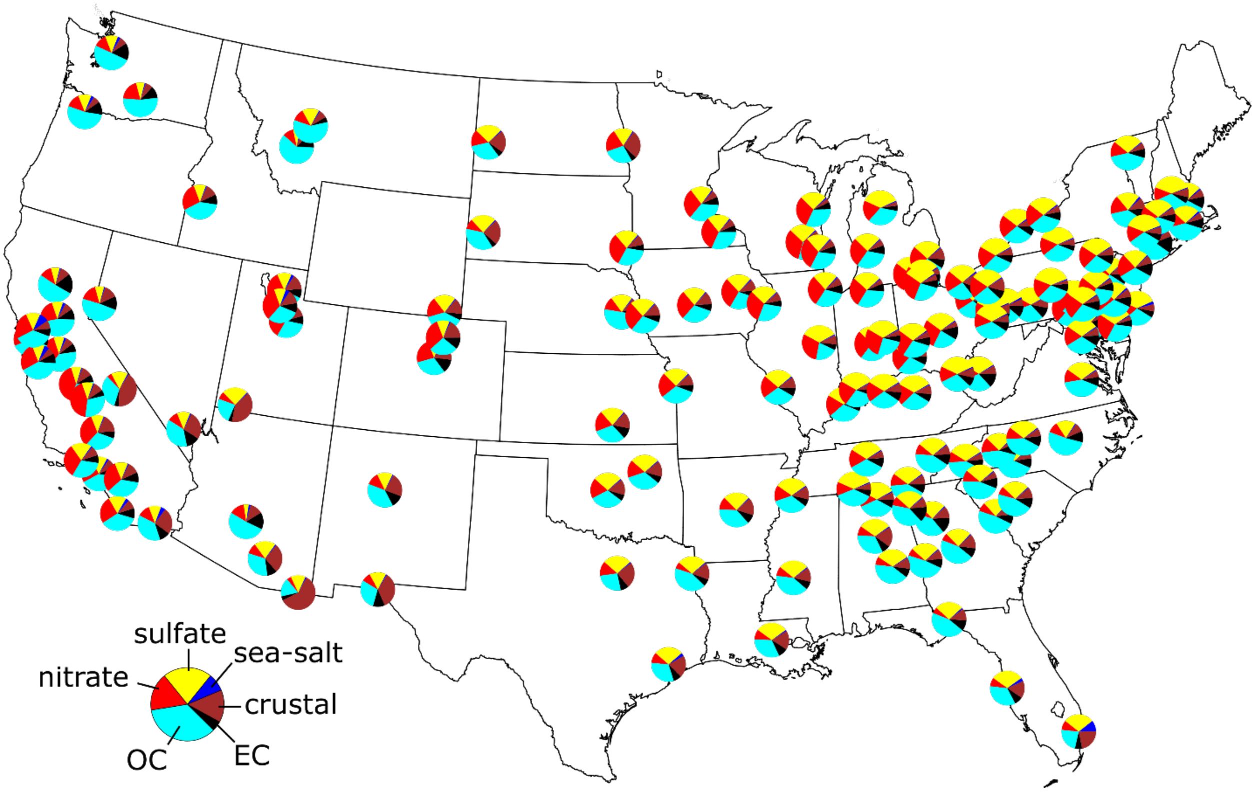
The chemical makeup of particles varies across the United States (as shown in Figure A-10). For example, fine particles in the eastern half of the United States contain more sulfates than those in the West, while fine particles in southern California contain more nitrates than other areas of the country. Organic carbon is a substantial component of fine particle mass everywhere.

Figure A-9. National Average of Source Impacts on Fine Particle Levels



Source: The Particulate Matter Report, EPA-454/R-04-002, Fall 2004. Carbon reflects both organic carbon and elemental carbon. Organic carbon accounts for automobiles, biogenics, gas-powered off-road, and wildfires. Elemental carbon is mainly from diesel powered sources.

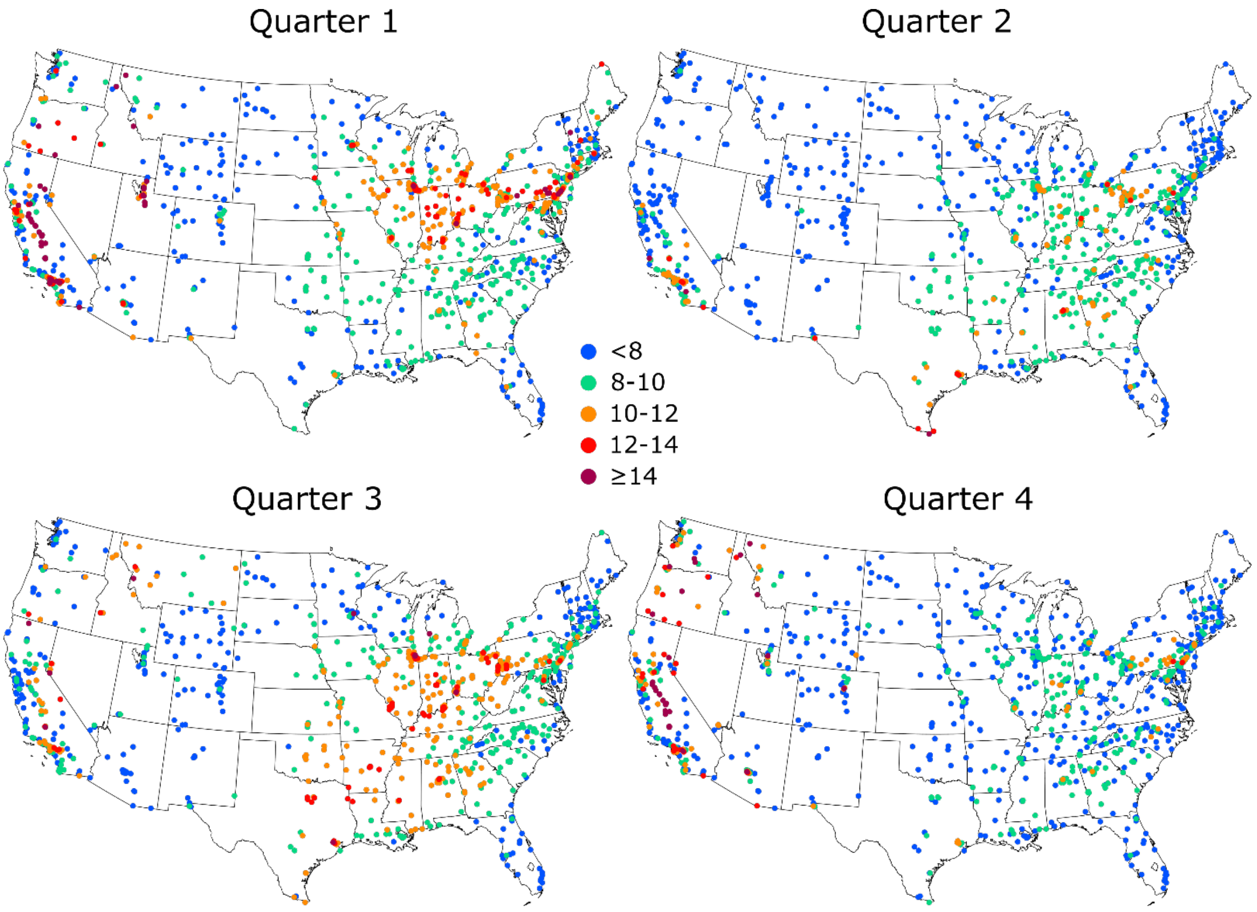
Figure A-10. Annual Average $PM_{2.5}$ Composition grouped by CBSA: 2013-2015



3. Seasonal and Daily Patterns of $PM_{2.5}$

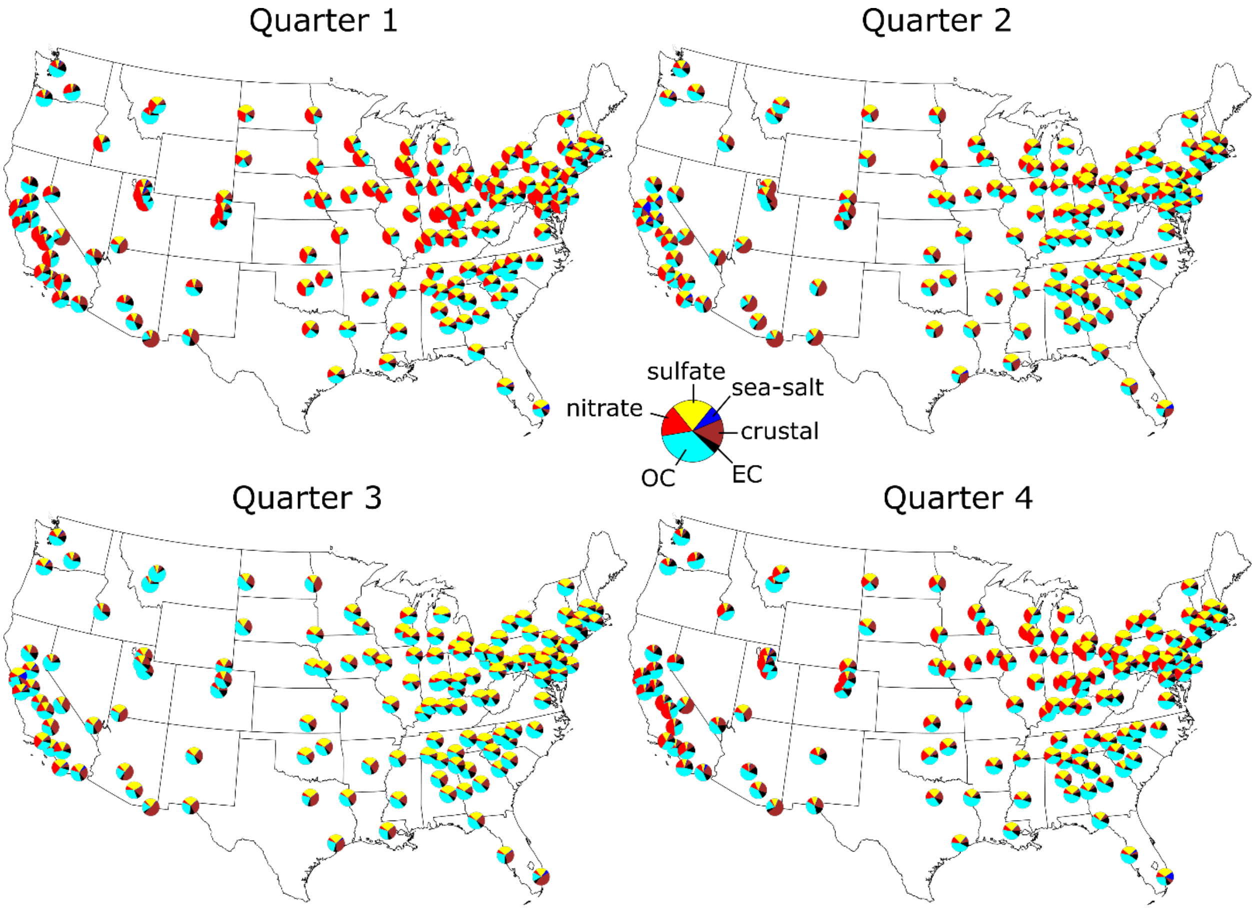
Fine particles often have a seasonal pattern. Both daily values and quarterly average of $PM_{2.5}$ also reveal patterns based on the time of year. Unlike daily O_3 levels, which are usually elevated in the summer, daily $PM_{2.5}$ values at some locations can be high at any time of the year. As shown in Figure A-11, $PM_{2.5}$ values in the eastern half of the United States are typically higher in the third calendar quarter (July-September) when sulfates are more readily formed from sulfur dioxide (SO_2) emissions from power plants in that region and when secondary organic aerosol is more readily formed in the atmosphere. Fine particle concentrations tend to be higher in the first calendar quarter (January through March) in the Midwest in part because fine particle nitrates are more readily formed in cooler weather. $PM_{2.5}$ values are high during the first (January through March) and fourth calendar quarter (October through December) in many areas of the West, in part because of fine particle nitrates and also due to carbonaceous particles which are directly emitted from wood stove and fireplace use. Average concentration from all locations reporting $PM_{2.5}$ with valid design values is shown.

Figure A-11. Quarterly Averages of PM$_{2.5}$ Concentration (μg m^{-3}): 2013-2015



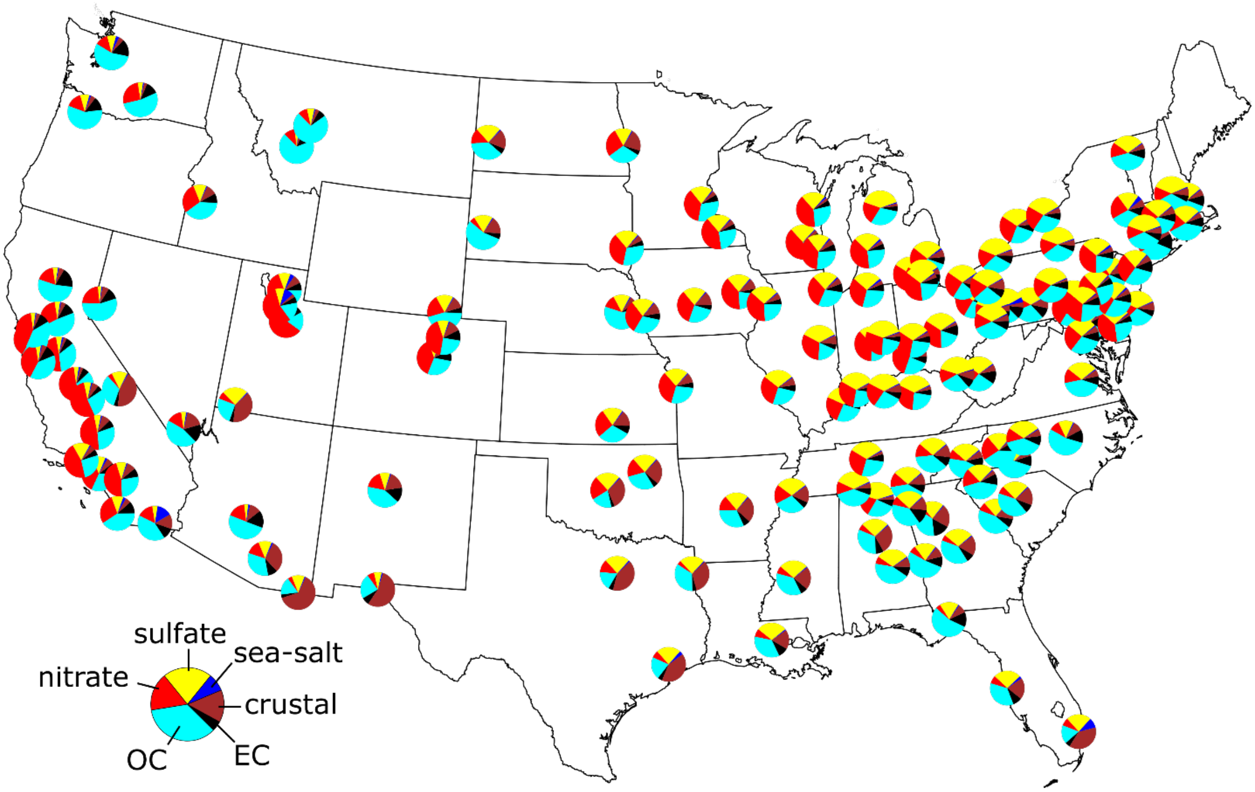
The composition of PM$_{2.5}$ also varies by season and helps explain why mass varies by season. Figure A-12 shows the average composition by season (spring, summer, fall and winter) for PM$_{2.5}$ data collected during 2013-2015. In the eastern United States, sulfate are high in the spring (March-May) and summer (July-September). Nitrates are most evident in the midwest and western cities where its percentage is moderately high in the winter and fall. Organic carbon (OC) is high throughout the year.

Figure A-12. Quarterly Average PM$_{2.5}$ Composition grouped by CBSA: 2013-2015



The composition of the highest daily PM$_{2.5}$ values may be different than that for the annual average. Figure A-13 provides 2013-2015 data PM$_{2.5}$ composition on high mass days across the United States. Mass is proportioned into six components: sulfates, nitrates, OC, elemental carbon (EC), crustal material, and sea-salt. Except for the southeast (where there is little nitrate in PM$_{2.5}$), nitrates are slightly higher in the top 10 percent of the PM$_{2.5}$ days. For the 2013-2015 measurements, the percent of sulfates is currently similar or slightly less on the top 10 percent of the days as compared to the annual averages. The portion of OC appears to be similar on the high days compared to the annual averages, except for the Northern Rockies and Upper Midwest where the high days are influenced by OC from wood stoves/fireplaces and wildfires.

Figure A-13. $PM_{2.5}$ Composition on 10% highest mass concentration days grouped by CBSA: 2013-2015



This Page Intentionally Left Blank

Appendix B: General Guidance on Use of Dispersion Models for Estimating Primary $PM_{2.5}$ Concentrations

This appendix provides general guidance on the application of dispersion models for estimating ambient concentrations of $PM_{2.5}$ associated with direct emissions of primary $PM_{2.5}$. This guidance is based on and is consistent with the EPA's *Guideline on Air Quality Models*, published as Appendix W of 40 CFR part 51, and focuses primarily on the application of AERMOD, the EPA's preferred dispersion model for most situations. Appendix W is the primary source of information on the regulatory application of air quality models for State Implementation Plan (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. There will be applications of dispersion models unique to specific areas, (*i.e.*, there may be areas of the country where it is necessary to model unique specific sources or types of sources). In such cases, there should be consultation with the state or appropriate permitting authority with the appropriate EPA Regional Office modeling contact to discuss how best to model a particular source.

Recently issued EPA guidance of relevance for consideration in modeling for $PM_{2.5}$ includes:

- "Model Clearinghouse Review of Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS" February 26, 2010 (U.S. EPA, 2010a);
- "Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS" March 23, 2010 (U.S. EPA, 2010b); and
- "Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas" November 2015 (U.S. EPA, 2015a).

The guidance listed above, in addition to other relevant support documents can be found on the SCRAM website at: https://www.epa.gov/scram.

The following sections will refer to the relevant sections of Appendix W and other existing guidance with summaries as necessary. Please refer to those original guidance documents for full discussion and consult with the appropriate EPA Regional Office modeling contact if questions arise about interpretation on modeling techniques and procedures.[55]

1. Model selection

Preferred air quality models for use in regulatory applications are addressed in Appendix A of the EPA's *Guideline on Air Quality Models*. If a model is to be used for a particular application, the user should follow the guidance on the preferred model for that application. These models may be used without an area specific formal demonstration of applicability as long as they are used as indicated in each model summary of Appendix A. Further recommendations for the application of these models to specific source problems are found in Appendix W. In

---

[55] A list of EPA Regional Office modeling contacts is available on the SCRAM website at: https://www.epa.gov/scram/air-modeling-regional-contacts.

2005, the EPA promulgated the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) as the Agency's preferred near-field dispersion model for a wide range of regulatory applications in all types of terrain based on extensive developmental and performance evaluation. For PSD/NSR modeling under the $PM_{2.5}$ NAAQS, AERMOD should be used to model direct $PM_{2.5}$ emissions unless use of an alternative model can be justified (section 3.2, Appendix W).

The AERMOD modeling system includes the following components:

- AERMOD: the dispersion model (U.S. EPA, 2022a);
- AERMAP: the terrain processor for AERMOD (U.S. EPA, 2018a,); and
- AERMET: the meteorological data processor for AERMOD (U.S. EPA, 2022b;).

Other components that may be used, depending on the application, are:

- BPIPPRIME: the building input processor (U.S. EPA, 2004);
- AERSURFACE: the surface characteristics processor for AERMET (U.S. EPA, 2020);
- AERSCREEN: a screening version of AERMOD (U.S. EPA, 2021; U.S. EPA, 2011); and
- AERMINUTE: a pre-processor to calculate hourly average winds from Automated Surface Observing System (ASOS) 2-minute observations (U.S. EPA, 2015b).

Before running AERMOD, the user should become familiar with the user's guides associated with the modeling components listed above and the AERMOD Implementation Guide (AIG) (U.S. EPA, 2022c). The AIG lists several recommendations for applications of AERMOD that would be applicable for SIP and PSD permit modeling.

1.2. Receptor grid

The model receptor grid is unique to the particular situation and depends on the size of the modeling domain, the number of modeled sources, and complexity of the terrain. Receptors should be placed in areas that are considered ambient air (*i.e.*, outside of buildings and where the public generally has access) and placed out to a distance such that areas of violation can be detected from the model output to help determine the size of nonattainment areas. Receptor placement should be of sufficient density to provide resolution needed to detect significant gradients in the concentrations with receptors placed closer together near the source to detect local gradients and placed farther apart away from the source. In addition, the user may want to place receptors at key locations such as around facility "fence lines"[56] (which define the ambient air boundary for a particular source) or monitor locations (for comparison to monitored concentrations for model evaluation purposes). The receptor network should cover the modeling

---

[56] It should be noted that the term "fence line" for modeling purposes generally makes reference to a source's property boundary and may not refer literally to the existence of a fence at such boundary. The EPA's "ambient air" policy does not mandate that public access to a source's property be precluded by a fence; other measures that effectively preclude public access may be approved for establishing an ambient air exclusion for PSD modeling purposes.

domain. States may already have existing receptor placement strategies in place for regulatory dispersion modeling under NSR/PSD permit programs.

If modeling indicates elevated levels of $PM_{2.5}$ (near the standard) near the edge of the receptor grid, consideration should be given to expanding the grid or conducting an additional modeling run centered on the area of concern. As noted above, terrain complexity should also be considered when setting up the receptor grid. If complex terrain is included in the model calculations, AERMOD requires that receptor elevations be included in the model inputs. In those cases, the AERMAP terrain processor (U.S. EPA, 2018a) should be used to generate the receptor elevations and hill heights. The latest version of AERMAP (version 09040 or later) can process either Digitized Elevation Model (DEM) or National Elevation Data (NED) data files. The AIG recommends the use of NED data since it is more up to date than DEM data, which is no longer updated (Section 4.3 of the AIG).

2. Source inputs

This section provides guidance on source characterization to develop appropriate inputs for dispersion modeling with the AERMOD modeling system. Section 2.1 provides guidance on use of emission, Section 2.2 covers guidance on Good Engineering Practice (GEP) stack heights, Section 2.3 provides details on source configuration and source types, Section 2.4 provides details on urban/rural determination of the sources, and Section 2.5 provides general guidance on source grouping, which may be important for design value calculations.

2.1. Emissions

Consistent with Appendix W, dispersion modeling for the purposes of PSD permitting should be based on the use of continuous operation at maximum allowable emissions or federally enforceable permit limits (see Table 8-2 of Appendix W) for the project source for all applicable averaging periods. Also consistent with past and current guidance, in the absence of maximum allowable emissions or federally enforceable permit limits, potential to emit emissions (*i.e.*, design capacity) should be used. Maximum allowable emissions and continuous operation should also be assumed for nearby sources included in the modeled inventory for the 24-hr $PM_{2.5}$ NAAQS, while maximum allowable emissions and the actual operating factor averaged over the most recent 2 years, unless it is determined that this period is not representative, should be used for modeled nearby sources for the annual $PM_{2.5}$ NAAQS.

2.2. Good Engineering Practice (GEP) stack height

Consistent with previous modeling guidance and section 7.2.2.1 of Appendix W, for stacks with heights that are within the limits of Good Engineering Practice (GEP), actual heights should be used in modeling. Under the EPA's regulations at 40 CFR 51.100, GEP height, H_g, is determined to be the greater of:

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

$H_g=2.5H$

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

- for all other stacks,

  $H_g=H + 1.5L$,

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

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

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

If stack heights exceed GEP, then GEP heights should be used with the individual stack's other parameters (temperature, diameter, exit velocity). For stacks modeled with actual heights below GEP that may be subject to building downwash influences, building downwash should be considered as this can impact concentrations near the source (section 7.2.2.1(b), Appendix W). If building downwash is being considered, the BPIPPRIME program (U.S. EPA, 2004) should be used to input building parameters for AERMOD.

2.3. Source configurations and source types

An accurate characterization of the modeled facilities is critical for refined dispersion modeling, including accurate stack parameters and physical plant layout. Accurate stack parameters should be determined for the emissions being modeled. Since modeling would be done with maximum allowable or potential emissions levels at each stack, the stack's parameters such as exit temperature, diameter, and exit velocity should reflect those emissions levels. Accurate locations (*i.e.*, latitude and longitude or Universal Transverse Mercator (UTM) coordinates and datum)[57] of the modeled emission sources are also important, as this can affect the impact of an emission source on receptors, determination of stack base elevation, and relative location to any nearby building structures. Not only are accurate stack locations needed, but accurate information for any nearby buildings is important. This information would include

---

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

location and orientation relative to stacks and building size parameters (height, and corner coordinates of tiers) as these parameters are input into BPIPPRIME to calculate building parameters for AERMOD. If stack locations and or building information are not accurate, downwash will not be accurately accounted for in AERMOD.

Emission source type characterization within the modeling environment is also important. As stated in the AERMOD User's Guide (U.S. EPA, 2019a), emissions sources can be characterized as several different source types: POINT sources, capped stacks (POINTCAP), horizontal stacks (POINTHOR), VOLUME sources, OPENPIT sources, LINE sources, buoyant lines sources (BUOYLINE), rectangular AREA sources, circular area sources (AREACIRC), and irregularly shaped area sources (AREAPOLY). While most sources can be characterized as POINT sources, some sources, such as fugitive releases or nonpoint sources (emissions from ports/ships, airports, or smaller point sources with no accurate locations), may be best characterized as VOLUME or AREA type sources. Sources such as flares can be modeled in AERMOD using the parameter input methodology described in Section 2.1.2 of the AERSCREEN User's Guide (U.S. EPA, 2021). If questions arise about proper source characterization or typing, users should consult the appropriate EPA Regional Office modeling contact.

2.4. Urban/rural determination

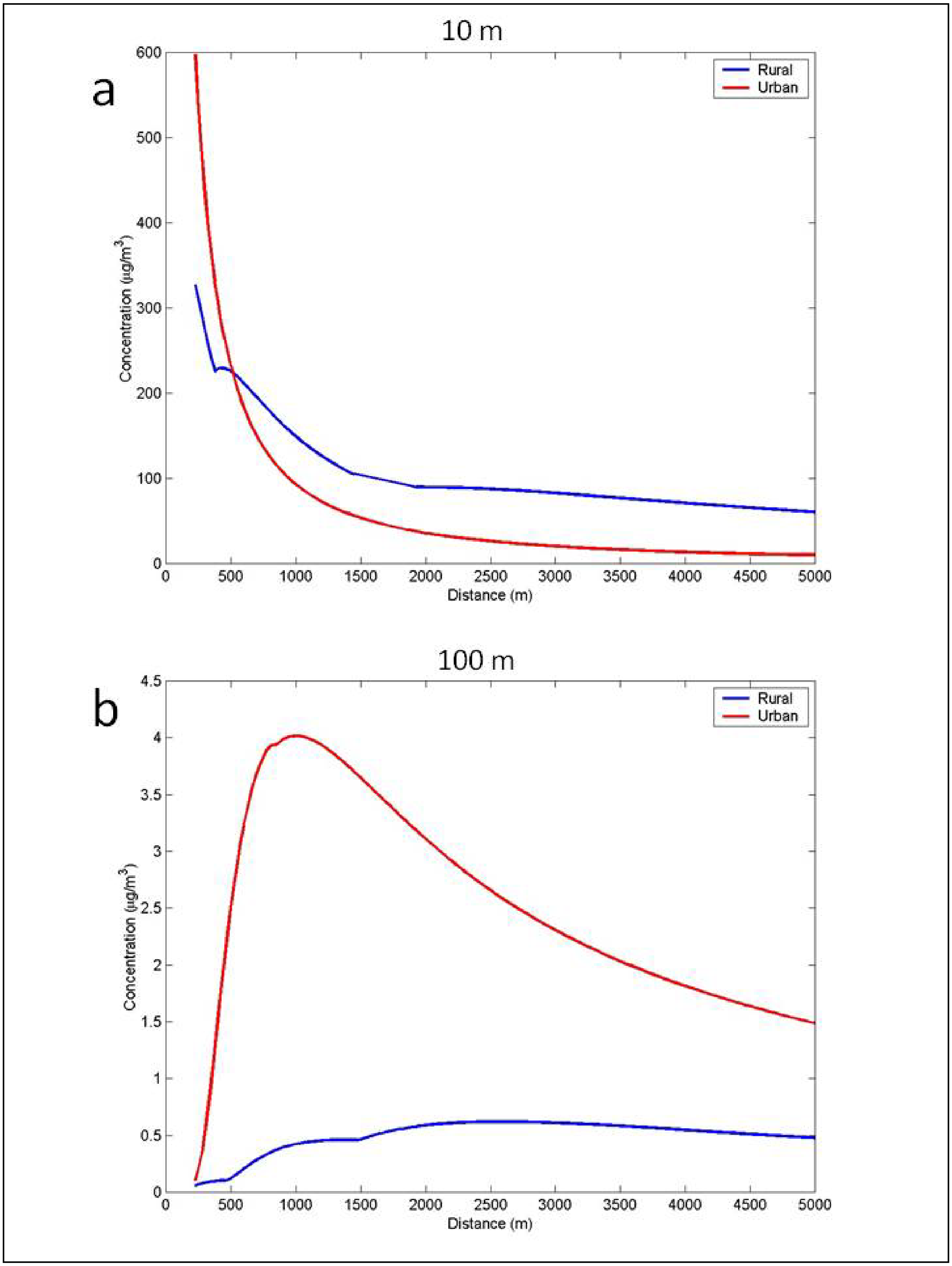
For any dispersion modeling exercise, the urban or rural determination of a source is important in determining the boundary layer characteristics that affect the model's prediction of downwind concentrations. Figure B-1 gives example maximum 24-hour concentration profiles for a 10 meter stack (Figure B-1a) and a 100 m stack (Figure B-1b) based on urban vs. rural designation. The urban population used for the examples is 100,000. In Figure B-1a, the urban concentration is much higher than the rural concentration for distances less than 750 m from the stack but then drops below the rural concentration beyond 750 m. For the taller stack in Figure B-1b, the urban concentration is much higher than the rural concentration even as distances increase from the source. These profiles show that the urban or rural designation of a source can be quite important.

Determining whether a source is urban or rural can be done using the methodology outlined in section 7.2.1.1 of Appendix W and recommendations outlined in Sections 5.1 through 5.3 in the AIG (U.S. EPA, 2022c). In summary, there are two methods of urban/rural classification described in section 7.2.3 of Appendix W.

The first method of urban determination is a land use method (Appendix W, section 7.2.2.1.1(b)(i)). In the land use method, the user analyzes the land use within a 3 km radius of the source using the meteorological land use scheme described by Auer (1978). Using this methodology, a source is considered urban if the land use types I1 (heavy industrial), I2 (light-moderate industrial), C1 (commercial), R2 (common residential), and R3 (compact residential) are 50 percent or more of the area within the 3 km radius circle. Otherwise, the source is considered a rural source. The second method uses population density and is described in section 7.2.2.1.1(b)(ii) of Appendix W. As with the land use method, a circle of 3 km radius is used. If the population density within the circle is greater than 750 people/km^2, then the source is considered urban. Otherwise, the source is modeled as a rural source. Of the two methods, the land use method is considered more definitive (section 7.2.1.1.b, Appendix W).

Caution should be exercised with either classification method. As stated in Section 5.1 of the AIG (U.S. EPA, 2009), when using the land use method, a source may be in an urban area but located close enough to a body of water or other non-urban land use category to result in an erroneous rural classification for the source. The AIG in Section 5.1 cautions users against using the land use scheme on a source by source basis, but advises considering the potential for urban heat island influences across the full modeling domain. When using the population density method, section 7.2.2.1.1(b)(ii)of Appendix W states, “Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied...” With either method, section 7.2.1.1(f) of Appendix W recommends modeling all sources within an urban complex as urban, even if some sources within the complex would be considered rural using either the land use or population density method.

Figure B-1. Urban (red) and rural (blue) concentration profiles for (a) 10 m buoyant stack release, and (b) 100 m buoyant stack release



Another consideration that may need attention by the user, and is discussed in Section 5.1 of the AIG, relates to tall stacks located within or adjacent to small to moderate size urban areas. In such cases, the stack height or effective plume height for very buoyant sources may extend above the urban boundary layer height. The application of the urban option in AERMOD for these types of sources may artificially limit the plume height. The use of the urban option may not be appropriate for these sources, since the actual plume is likely to be transported over the urban boundary layer. Section 5.1 of the AIG gives details on determining if a tall stack should be modeled as urban or rural based on comparing the stack or effective plume height to the urban boundary layer height. The 100 m stack illustrated in Figure B-1b, may be such an example as the urban boundary layer height for this stack would be 189 m (based on a population of 100,000) and equation 104 of the AERMOD formulation document (Cimorelli, et al., 2004). This equation is:

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

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

Given that the stack is a buoyant release, the plume may extend above the urban boundary layer and may be best characterized as a rural source, even if it were near an urban complex. However, beginning with version 15181 of AERMOD, a formulation bug fix was incorporated that modified the treatment of plume rise for urban sources, especially for tall stacks in urban areas. See Section 5.1 of the AIG for more information. Even with the bug fix in AERMOD 15181, exclusion of these elevated sources from application of the urban option would need to be justified on a case-by-case basis in consultation with the appropriate permitting authority.

AERMOD requires the input of urban population when utilizing the urban option. Population can be entered to one or two significant digits (*i.e.*, an urban population of 1,674,365 can be entered as 1,700,000). Users can enter multiple urban areas and populations using the URBANOPT keyword in the runstream file (U.S. EPA, 2022a). If multiple urban areas are entered, AERMOD requires that each urban source be associated with a particular urban area or AERMOD model calculations will abort. Urban populations can be determined by using a method described in Section 5.2 of the AIG (U.S. EPA, 2022c).

2.5. Source groups

In AERMOD, individual emission sources' concentration results can be combined into groups using the SRCGROUP keyword (Section 3.3.11 of the AERMOD User's Guide (U.S, EPA, 2019a). The user can automatically calculate a total concentration (from all sources) using the SRCGROUP ALL keyword. For the purposes of design value calculations, source group ALL should be used, especially if all sources in the modeling domain are modeled in one AERMOD run. Design values should be calculated from the total concentrations (all sources and background). Individual source impacts on the total concentration may be necessary to determine the culpability to any NAAQS violations.

3. Meteorological data

This section gives guidance on the selection of meteorological data for input into AERMOD. Much of the guidance from section 8.4 of Appendix W is applicable to SIP and PSD permit modeling and is summarized here. In Section 3.2.1, the use of the tool, AERMINUTE (U.S. EPA, 2015b), is introduced. AERMINUTE is an AERMET pre-processor that calculates hourly averaged winds from ASOS 1-minute winds. Section 3.2.4 discusses the use of prognostic meteorological data.

3.1. Surface characteristics and representativeness

The selection of meteorological data that are input into a dispersion model should be considered carefully. The selection of data should be based on spatial and climatological (temporal) representativeness (Appendix W, section 8.4). The representativeness of the data is based on: 1) the proximity of the meteorological monitoring site to the area under consideration, 2) the complexity of terrain, 3) the exposure of the meteorological site, and 4) the period of time during which data are collected. Sources of meteorological data are: National Weather Service (NWS) stations, site-specific or onsite data, and other sources such as universities, Federal Aviation Administration (FAA), military stations, and others. In specific cases, prognostic meteorological data may be appropriate for use and obtained from similar sources. Appendix W addresses spatial representativeness issues in sections 8.4.1.a and 8.4.2.b.

Spatial representativeness of the meteorological data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area (Appendix W, sections 8.4.1.a and 8.4.2.b). If the modeling domain is large enough such that conditions vary drastically across the domain, then the selection of a single station to represent the domain should be carefully considered. Also, care should be taken when selecting a station if the area has complex terrain. While a source and meteorological station may be in close proximity, there may be complex terrain between them such that conditions at the meteorological station may not be representative of the source. An example would be a source located on the windward side of a mountain chain with a meteorological station a few kilometers away on the leeward side of the mountain. Spatial representativeness for off-site data should also be assessed by comparing the surface characteristics (albedo, Bowen ratio, and surface roughness) of the meteorological monitoring site and the analysis area. When processing meteorological data in AERMET (U.S. EPA, 2022b), the surface characteristics of the meteorological site or the prognostic meteorological model output grid cell should be used (section 8.4.2.b of Appendix W and the AERSURFACE User's Guide (U.S. EPA, 2020)). Spatial representativeness should also be addressed for each meteorological variable separately. For example, temperature data from a meteorological station several kilometers from the analysis area may be considered adequately representative, while it may be necessary to collect wind data near the plume height (section 8.4.2.b of Appendix W).

Surface characteristics can be calculated in several ways. For details, see Section 3.1.2 of the AIG (U.S. EPA, 2022c). The EPA has developed a tool, AERSURFACE (U.S. EPA, 2020) to aid in the determination of surface characteristics for observed meteorological data. Note that the use of AERSURFACE is not a regulatory requirement, but the methodology outlined in

Section 3.1.2 of the AIG should be followed unless an alternative method can be justified. For prognostic meteorological output, the surface characteristics of the representative grid cell should be used.

3.2. Meteorological inputs

Appendix W states in section 8.4.2.e that the user should acquire enough meteorological data to ensure that worst-case conditions are adequately represented in the model results. Appendix W states that 5 years of NWS meteorological data, at least 1 year of site-specific data, or at least 3 years of prognostic data should be used and should be adequately representative of the study area. If 1 or more years of site-specific data are available, those data are preferred. While the form of the $PM_{2.5}$ NAAQS contemplates obtaining 3 years of monitoring data, this does not preempt the use of 5 years of NWS data or at least 1 year of site-specific data in the modeling. The 5-year average based on the use of NWS data, an average across 3 or more years of prognostic data, or an average across 1 or more years of available site specific data, serves as an unbiased estimate of the 3-year average for purposes of modeling demonstrations of compliance with the NAAQS.

3.2.1. NWS data

NWS data are available from the National Climatic Data Center (NCDC) in many formats, with the most common one in recent years being the Integrated Surface Hourly data (ISH). Most available formats can be processed by AERMET. As stated in Section 3.1, when using data from an NWS station alone or in conjunction with site-specific data, the data should be spatially and temporally representative of conditions at the modeled sources. Key points regarding the use of NWS data can be found in the EPA's March 8, 2013 clarification memo "Use of ASOS meteorological data in AERMOD dispersion modeling" (U.S. EPA, 2013). The key points are:

- The EPA has previously analyzed the effects of ASOS implementation on dispersion modeling and found that generally AERMOD was less sensitive than ISCST3 to the implementation of ASOS.
- The implementation of the ASOS system over the conventional observation system should not preclude the consideration of NWS stations in dispersion modeling.
- The EPA has implemented an adjustment factor (0.5 knots) in AERMET to adjust for wind speed truncation in ASOS winds
- The EPA has developed the AERMINUTE processor (U.S. EPA, 2015b) to process 2-minute ASOS winds and calculate an hourly average for input into AERMET. The use of hourly averaged winds better reflect actual conditions over the hour as opposed to a single 2-minute observation.

3.2.2. Site-specific data

The use of site-specific meteorological data is the best way to achieve spatial representativeness. AERMET can process a variety of formats and variables for site-specific data. The use of site-specific data for regulatory applications is discussed in detail in section

8.4.4 of Appendix W. Due to the range of data that can be collected onsite and the range of formats of data input to AERMET, the user should consult Appendix W, the AERMET User's Guide (U.S. EPA, 2022b), and Meteorological Monitoring Guidance for Regulatory Modeling Applications (U.S. EPA, 2000). Also, when processing site-specific data for an urban application, Section 3.3 of the AERMOD Implementation Guide offers recommendations for data processing. In summary, the guide recommends that site-specific turbulence measurements should not be used when applying AERMOD's urban option in order to avoid double counting the effects of enhanced turbulence due to the urban heat island.

3.2.3. Upper air data

AERMET requires full upper air soundings to calculate the convective mixing height. For AERMOD applications in the U.S., the early morning sounding, usually the 1200 UTC (Universal Time Coordinate) sounding, is typically used for this purpose. Upper air soundings can be obtained from the Radiosonde Data of North America CD for the period 1946-1997. Upper air soundings for 1994 through the present are also available for free download from the Radiosonde Database Access website. Users should choose all levels or mandatory and significant pressure levels[58] when selecting upper air data. Selecting mandatory levels only would not be adequate for input into AERMET as the use of just mandatory levels would not provide an adequate characterization of the potential temperature profile.

3.2.3. Prognostic data

In specific situations where it is infeasible or cost prohibitive to collect adequately representative site-specific data or there is not a representative NWS or comparable meteorological station available, it may be appropriate to use prognostic meteorological data, if deemed adequately representative. However, if prognostic data are not representative of the transport and dispersion conditions in the area of concern, the collection of site-specific data is necessary (section 8.4.5.1 of Appendix W). To facilitate the use of prognostic meteorological data, EPA has developed a processor, Mesoscale Model Interface Program, MMIF (Environ, 2015), to process MM5 (Mesoscale Model 5) or WRF (Weather Research Forecast) 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. For regulatory applications, MMIF should be run to create inputs for AERMET input as described in section 8.4.5.1.b of Appendix W and MMIF guidance (U.S. EPA, 2018b). Specific guidance on running MMIF for AERMOD applications can be found in U.S. EPA, 2018b.

4. Running AERMOD and implications for design value calculations

Recent enhancements to AERMOD include options to aid in the calculation of design values for comparison with the $PM_{2.5}$ NAAQS and to aid in determining whether emissions from the project source caused or contributed to any modeled violations. These enhancements include:

---

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

- The MAXDCONT option, which shows the impact of each user-specified source group to the high ranked values for a specified target source group paired in time and space. The user can specify a range of ranks to analyze or specify an upper bound rank, *i.e.*, 8th highest, corresponding to the 98th percentile for the 24-hour $PM_{2.5}$ NAAQS, and a lower threshold concentration value, such as the NAAQS for the target source group. The model will process each rank within the range specified, but will stop after the first rank (in descending order of concentration) that is below the threshold value if specified by the user. A warning message will be generated if the threshold is not reached within the range of ranks analyzed (based on the range of ranks specified on the RECTABLE keyword). This option may be needed to aid in determining which sources should be considered for controls.

For more details about the enhancements, see the AERMOD User's Guide (U.S. EPA, 2022a).

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

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

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

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

In the two situations listed above, the MAXDCONT option would not be useful as the different AERMOD runs do not include a total concentration with impacts from all facilities. In these situations, the use of 24-hour POSTFILES, which can be quite large, and external post-processing would be needed to calculate design values.

Situations in which the MAXDCONT options may be used but may necessitate some external post-processing afterwards to calculate a design value include:

- The receptor network is divided into sections and an AERMOD run, with all sources and years, is made for each sub-network.
    - A receptor network of 1,000 receptors is divided into four 250 receptor sub-networks. 10 facilities are modeled with 5 years of NWS data in one AERMOD run for each receptor network, resulting in four AERMOD runs. After the AERMOD runs are complete, the MAXDCONT results for each network can be re-combined into the larger network.
- All sources and receptors are modeled in an AERMOD run for each year.
- Ten facilities are modeled with 5 years of NWS data. All facilities are modeled with all receptors for each year individually, resulting in five AERMOD runs. MAXDCONT output can be used and post-processed to generate the necessary design value concentrations. The receptor network is divided and each year is modeled separately for each sub-network with all sources.
- Ten facilities are modeled with 5 years of NWS data for 1,000 receptors. The receptor network is divided into four 250 receptor networks. For each sub-network, all ten facilities are modeled for each year separately, resulting in twenty AERMOD runs. MAXDCONT output can be used and post-processed to generate the necessary design value concentrations.

5. References

Auer, Jr., A.H., 1978. Correlation of Land Use and Cover with Meteorological Anomalies. Journal of Applied Meteorology, 17(5), 636-643.

Brode, R., K. Wesson, J. Thurman, and C. Tillerson, 2008: AERMOD Sensitivity to the Choice of Surface Characteristics, Paper 811, Air And Waste Management Association Annual Conference.

Cimorelli, A. J., S. G. Perry, A. Venkatram, J. C. Weil, R. J. Paine, R. B. Wilson, R. F. Lee, W. D. Peters, R. W. Brode, and J. O. Paumier, 2004. AERMOD: Description of Model Formulation, EPA-454/R-03-004. U.S. Environmental Protection Agency, Research Triangle Park, NC. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_mfd_454-R-03-004.pdf.

U.S. EPA, 1985. Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations), Revised. EPA-450/4-80-023R. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://www.epa.gov/sites/production/files/2020-09/documents/gep.pdf.

U.S. EPA, 1992. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources. EPA-454/R-92-019. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://www.epa.gov/sites/production/files/2020-09/documents/epa-454r-92-019_ocr.pdf.

U.S. EPA, 1994. SO_2 Guideline Document. EPA-452/R-95-008. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

U.S. EPA, 2000. Meteorological Monitoring Guidance for Regulatory Modeling Applications. EPA-454/R-99-005. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://www.epa.gov/sites/production/files/2020-10/documents/mmgrma_0.pdf.

U.S. EPA, 2004. User's Guide to the Building Profile Input Program. EPA-454/R-93-038. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

U.S. EPA, 2010a. Model Clearinghouse Review of Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS. Tyler Fox Memorandum dated February 26, 2010. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/mchisrs/MCmemo_Region6_PM25_NAAQS_Compliance.pdf.

U.S. EPA, 2010b. Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS. Stephen Page Memorandum dated March 23, 2010. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 27711. https://www.epa.gov/sites/production/files/2020-10/documents/official_signed_modeling_proc_for_demo_compli_w_pm2.5.pdf.

U.S. EPA, 2011. AERSCREEN Released as the EPA Recommended Screening Model. Tyler Fox Memorandum dated April 11, 2011. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/20110411_aerscreen_release_memo.pdf.

U.S. EPA, 2013. Use of ASOS meteorological data in AERMOD dispersion modeling. Tyler Fox Memorandum dated March 8, 2013. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://www.epa.gov/sites/production/files/2020-10/documents/20130308_met_data_clarification_0.pdf.

U.S. EPA, 2015a. Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas. November 2015. EPA-420-B-15-084. U.S. Environmental Protection Agency, Ann Arbor, Michigan 48105. http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NMXM.pdf. and http://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100NN22.pdf.

U.S. EPA, 2015b. AERMINUTE User's Guide. U.S. Environmental Protection Agency, EPA-454/B-15-006. Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/aerminute/aerminute_userguide.pdf.

U.S. EPA, 2017. *Guideline on Air Quality Models*. 40 CFR part 51 Appendix W. https://www.epa.gov/sites/production/files/2020-09/documents/appw_17.pdf.

U.S. EPA, 2018a. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-18-004. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aermap/aermap_userguide_v18081.pdf.

U.S. EPA, 2018b. Guidance on the Use of the Mesoscale Model Interface Program (MMIF) for AERMOD Applications. EPA-454/B-18-005. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/mmif/MMIF_Guidance.pdf.

U.S. EPA, 2020. AERSURFACE User's Guide. EPA-454/B-20-008. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aersurface/aersurface_ug_v20060.pdf.

U.S. EPA, 2021. AERSCREEN User's Guide. EPA-454/B-21-005. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/screening/aerscreen/aerscreen_userguide.pdf.

U.S. EPA, 2022a. User's Guide for the AMS/EPA Regulatory Model – AERMOD. EPA-454/B-22-007. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_userguide.pdf.

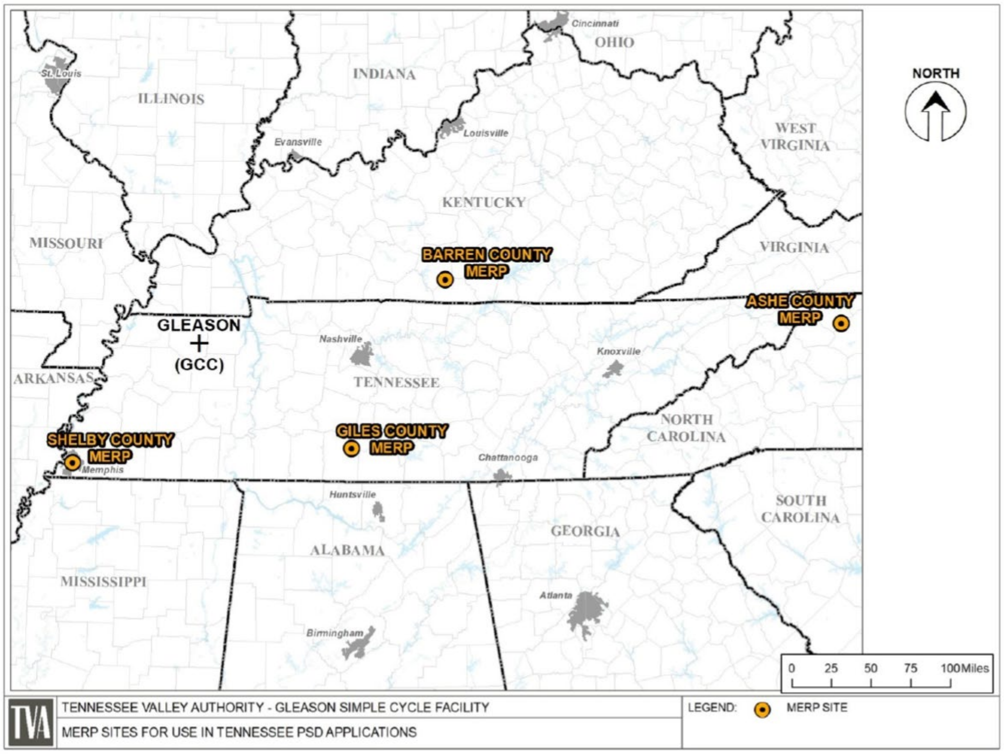
U.S. EPA, 2022b. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-22-006. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/aermet/aermet_userguide.pdf.

U.S. EPA, 2022c. AERMOD Implementation Guide. EPA-454/B-22-008. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_implementation_guide.pdf.

Appendix C: Example of a Tier 1 Demonstration of the Potential for O_3 and Secondary $PM_{2.5}$ Formation

In 2018, a permit applicant, the Tennessee Valley Authority (TVA) Gleason Combustion Turbine Plant (GCC), worked closely with the Tennessee Department of Environment and Conservation (TDEC) and EPA Region 4 to develop a compliance demonstration for a major facility modification, including the use of a Tier 1 assessment of O_3 and secondary $PM_{2.5}$ impacts. This Tier 1 assessment was based on the application of Modeled Emission Rates for Precursors (MERPs) and related modeling guidance released by the EPA. In April 2018, the TDEC published state modeling guidance that can be used by PSD applicants in Tennessee that largely restated the technical aspects of the guidance presented in the EPA's 2016 Draft MERPs Guidance.[59] In support of the 2016 Draft MERPs Guidance and subsequently the 2019 MERPs Guidance, the EPA performed photochemical modeling for four hypothetical sources from within Tennessee or in close proximity to Tennessee (Shelby County, TN, Giles County, TN, Barren County, KY and Ashe County, NC), that can be used to represent the O_3 and secondary $PM_{2.5}$ pollutant formation from other large sources in Tennessee (Figure 1).

FIGURE 1



---

[59] The EPA released a draft version of the "Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program" on December 2, 2016, for public review and comment. Based on the feedback gained from this draft, the EPA released a non-draft or final version of the "MERPs Guidance" on April 30, 2019. The information in the 2016 draft MERPs Guidance from which the TDEC based their April 2018 modeling guidance did not substantively change and is representative of information contained in the current 2019 final version of the MERPs Guidance. The 2019 final MERPs Guidance is available at: https://www.epa.gov/sites/production/files/2020-09/documents/epa-454_r-19-003.pdf.

Assessment of $PM_{2.5}$

Based on information in the EPA's MERPs Guidance, the lowest, most conservative MERPs from these four hypothetical source locations were established in the TDEC state modeling guidance as the default MERPs that can be used throughout Tennessee without the need for further justification (Table 1). The TVA used these default MERPs to assess secondary $PM_{2.5}$ impacts for the proposed modification at the GCC facility.

TABLE 1
Default MERPs for Use in TN PSD Applications

Precursor	MERPs for 8-hr O_3 (tons/yr)	MERPs for Daily $PM_{2.5}$ (tons/year)	MERPs for Annual $PM_{2.5}$ (tons/year)
NO_X	156	4,000	7,407
SO_2	-	667	6,061
VOC	1,339	-	-

The combined primary and secondary impacts of $PM_{2.5}$ for the source impact analysis were assessed using the highest (AERMOD) modeled primary $PM_{2.5}$ concentration (HMC), the Class II SIL, precursor emissions, and the default MERPs. If the sum of the ratios in Equation 1 below is less than 1, then the combined $PM_{2.5}$ impacts are below the $PM_{2.5}$ SIL, an adequate compliance demonstration has been performed, and no additional analyses are necessary.

The following equation was used for this assessment:

EQUATION 1

$$\left(\frac{HMC}{SIL}\right) + \left(\frac{NO_X\_Em}{NO_X\_MERP}\right) + \left(\frac{SO_2\_Em}{SO_2\_MERP}\right) < 1$$

Where:

HMC = Highest modeled primary $PM_{2.5}$ impact using AERMOD and project related $PM_{2.5}$ emissions ($\mu g/m^3$)
SIL = Significant Impact Level ($\mu g/m^3$)
NO_X _Em = Project related NOx Emissions (tons per year – tpy)
NO_X _MERP = NO_X Emissions from Table 1 (tpy)
SO_2_Em = Project related SO_2 Emissions (tpy)
SO_2_MERP = SO_2 Emissions from Table 1 (tpy)

The TVA's 24-hour and annual $PM_{2.5}$ inputs to Equation 1 are provided in Table 2 below, and the resulting combined $PM_{2.5}$ impacts are calculated in Equation 2 and Equation 3 below, respectively.

TABLE 2
Primary and Secondary $PM_{2.5}$ Inputs for the SILs in Class II Areas

Secondary $PM_{2.5}$ Impacts	**24-hr Average**	**Annual Average**
Highest Modeled Primary $PM_{2.5}$ Concentration ($\mu g/m^3$) [1]	0.49	0.053
SILs for the NAAQS and PSD Increments in Class II areas ($\mu g/m^3$) [2]	1.2	0.2
GCC NO_x Emissions (tons/yr) [3]	2,270	2,270
Default NO_x MERPs [4]	4,000	7,407
GCC SO_2 Emissions (tons/yr) [3]	14.2	14.2
Default SO_2 MERPs [4]	667	6,061

Notes:

1. TVA GCC facility project primary $PM_{2.5}$ modeling results.
2. SILs for the NAAQS in Class I and Class II areas and for PSD increments in Class II areas. Based on the April 17, 2018 EPA memo, *Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program*.
3. TVA GCC facility project emissions.
4. Default MERPs information from Table 1

Combined Impacts for 24-hour $PM_{2.5}$ for the SIL in Class II Areas:

EQUATION 2

$$\left(\frac{0.49}{1.2}\right) + \left(\frac{2{,}270}{4{,}000}\right) + \left(\frac{14.2}{667}\right) = 0.997$$

Combined Impacts for Annual $PM_{2.5}$ for the SIL in Class II Areas:

EQUATION 3

$$\left(\frac{0.053}{0.2}\right) + \left(\frac{2{,}270}{7{,}407}\right) + \left(\frac{14.2}{6061}\right) = 0.573$$

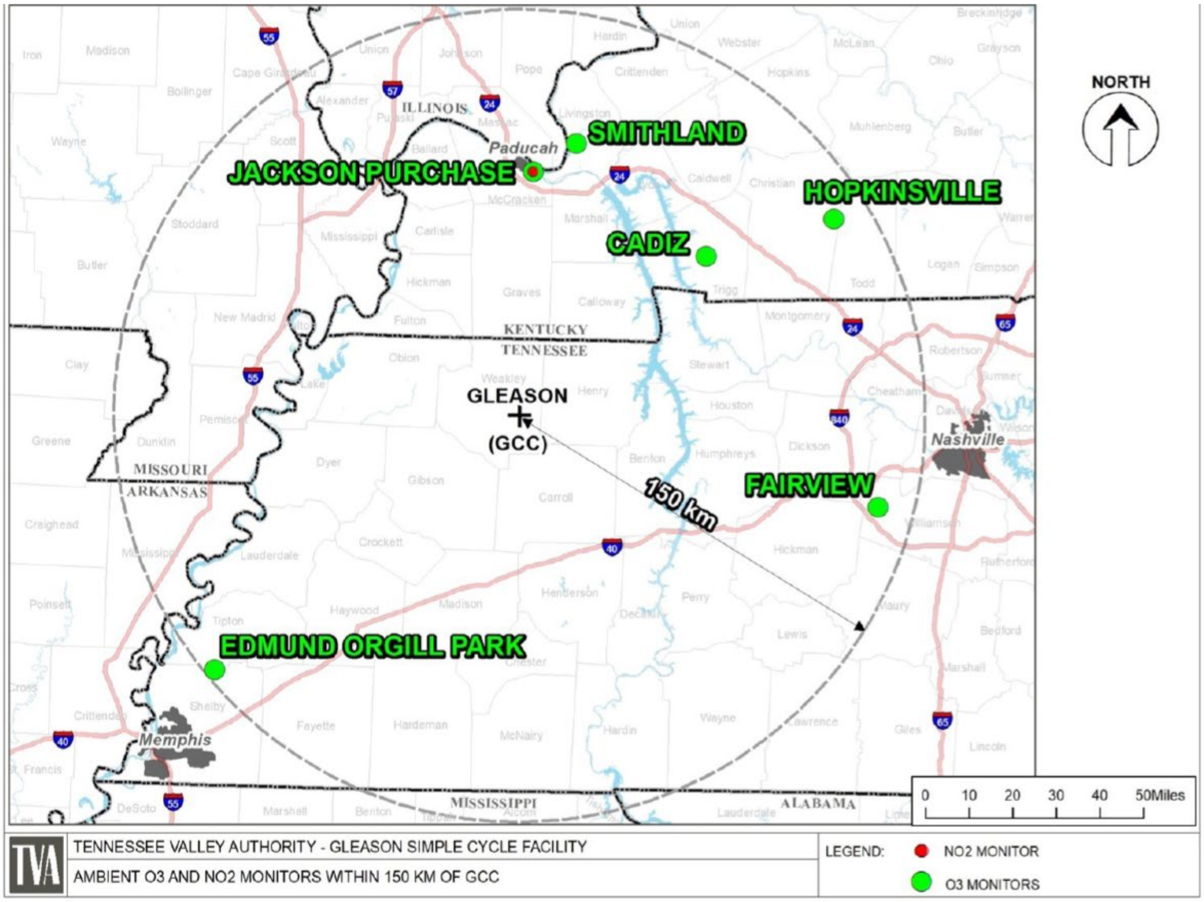
Both the 24-hour and annual $PM_{2.5}$ combined impacts as presented in Equation 2 and Equation 3 were less than 1, which indicated that 24-hour and annual $PM_{2.5}$ impacts were expected to be below the Class II SILs for the NAAQS and PSD increments. From this source impact $PM_{2.5}$ assessment, it was determined that emissions from TVA GCC facility would not cause or contribute to a violation of the $PM_{2.5}$ NAAQS in Class II areas.

Assessment of O_3

A somewhat more refined analysis was performed to assess the impacts of the proposed project on O_3 concentrations in the area around the TVA GCC facility. Application of the TDEC default NO_X and VOC MERPs for O_3 shown in Table 1 above indicated that O_3 impacts would be greater than the 8-hour O_3 SIL of 1 ppb and that a cumulative O_3 assessment would be necessary to demonstrate whether the facility modification would cause or contribute to a violation of a the O_3 NAAQS.

The O_3 assessment first examined ambient O_3 concentrations in the region surrounding the TVA GCC facility. There are no ambient O_3 monitors in the immediate vicinity of GCC, but there are six monitors within 150 km of the facility (Figure 2 and Tables 3 and 4). The Cadiz, KY, monitor was selected as the most representative background site due to its proximity to GCC, its comparable levels of precursor emissions in the county, and it has the largest measurement scale indicating it is representative of regional air quality. The three-year average (2015- 2017) of the fourth-highest 8-hour O_3 concentration was 61 ppb, well below the 70 ppb NAAQS.

FIGURE 2



Ambient O_3 Monitors and NO_2 Monitors within 150 km of GCC

TABLE 3
Ambient O_3 Monitors within 150 km of GCC

Site Name	Site ID	Distance to GCC (km)	Measurement Scale (km)	County NO_X Emissions (tons/year) [1]	County VOC Emissions (tons/year) [1]
Weakley County	NA	0	NA	1,216	9,061
Jackson Purchase	21-145-1024	90	0.5 to 4	15,395	6,542
Cadiz	21-221-9991	91	50 to 100	1,424	14,173
Smithland	21-139-0003	103	4 to 50	1,441	5,933
Fairview	47-187-0106	137	4 to50	5,721	13,557
Hopkinsville	21-047-0006	138	50 to 100	3,589	11,806
Edmund Orgill Park	47-157-1004	147	4 to 50	32,260	38,104

Notes:

1. EPA's National Emissions Inventory, 2014 v.2.

TABLE 4
2015-2017 Ambient O_3 Monitoring Data

Site Name	Site ID	3 Year Avg. 4th High 8-Hr Ozone Conc. (ppb) [1]
Jackson Purchase	21-145-1024	62
Cadiz	21-221-9991	61
Smithland	21-139-0003	64
Fairview	47-187-0106	60
Hopkinsville	21-047-0006	61
Edmund Orgill Park	47-157-1004	65

Notes:

1. EPA Air Quality System (AQS) Data Mart: https://www.epa.gov/outdoor-air-quality-data.

As previously discussed, in April 2018, TDEC published modeling guidance on the use of EPA's MERPs in Tennessee that identified four hypothetical sites, located in Shelby County, TN, Giles County, TN, Barren County, KY and Ashe County, NC, to represent Tennessee sources (Figure 1). Precursor emissions in these four counties were compared to Weakley County, where the TVA GCC facility is located. Weakley County precursor emissions are comparable to emissions in the three rural counties (Giles, Barren and Ashe) and are much lower than Shelby County which is urban (Table 5). Ashe County is much further from GCC and is located in mountainous terrain, unlike the relatively flat terrain around GCC. Both Giles County and Barren County have similar terrain features to Weakley County. NO_X MERPs at these two sites are also lower than in Shelby County and Ashe County, which makes the analysis more conservative as ozone impacts from GCC are dominated by NO_X emissions.

TABLE 5
Comparison of Weakley County O_3 MERPs Sites for Use in TN

County	Distance to GCC (km)	Urban/ Rural	Elevation (m)	County NO_X Emissions (tons/year) [1]	County VOC Emissions (tons/year) [1]	NO_X MERP (ton/year) [2]	VOC MERP (ton/year) [2]
Weakly, TN	--	Rural	110	1,216	9,061	NA	NA
Shelby, TN	177	Urban	94	32,260	38,104	714	1,339
Giles, TN	188	Rural	240	1,913	11,298	156	4,000
Barren, KY	257	Rural	256	2,122	7,580	169	3,333
Ashe, NC	650	Rural	926	730	6,507	267	8,333

Notes:

1. EPA's National Emissions Inventory, 2014 v.2.
2. Lowest, most conservative MERP at each site.

For the two most representative hypothetical sources selected, as part of EPA's MERPs Guidance, the EPA performed photochemical modeling for two hypothetical source heights (low and high stack releases) and three hypothetical emission rates (500, 1000, and 3000 tons per year). As can be seen in Table 6 below, predicted O_3 impacts are nonlinear with respect to precursor emissions. At these hypothetical sources, the amount of O_3 formed from 3,000 tons of NO_X is substantially less than six times the amount formed from 500 tons of NO_X on a per ton basis, so using a MERP based on 500 tons of NO_X would significantly over-estimate the O_3 impacts from GCC. Therefore, this analysis used the most conservative MERPs based on emission rates most similar to emissions from GCC (hypothetical source emissions of 3,000 tons per year for NO_X and 500 tons per year for VOCs) at the two most representative sites (Giles County and Barren County) (Table 7).

TABLE 6

Precursor	Pollutant	State	County	FIPS	TPY	Stack Height (m)	Conc. (ppb)	MERP (tons/year)
NO_X	O_3	Kentucky	Barren	21009	500	10	2.908	172
NO_X	O_3	Kentucky	Barren	21009	500	90	2.946	170
NO_X	O_3	Kentucky	Barren	21009	1000	90	5.026	199
NO_X	O_3	Kentucky	Barren	21009	3000	90	10.687	281
NO_X	O_3	Tennessee	Giles	47055	500	10	2.616	191
NO_X	O_3	Tennessee	Giles	47055	500	90	3.208	156
NO_X	O_3	Tennessee	Giles	47055	1000	90	5.387	186
NO_X	O_3	Tennessee	Giles	47055	3000	90	10.356	290

TCA GCC project emissions are 2,270 for NO_X and 158 tpy for VOC.

TABLE 7
O3 MERPs for Various Emissions Rates in Giles County and Barren County

County	Stack	NO_X Emissions (tons/year)	NO_X MERP (ton/year)	VOC Emissions (tons/yr)	VOC MERP (ton/year)
Giles, TN	Low	500	163	500	12,500
Giles, TN	High	500	156	500	NA
Giles, TN	Low	1,000	NA	1,000	11,111
Giles, TN	High	1,000	186	1,000	10,000
Giles, TN	High	3,000	290	3,000	4,000
Barren, KY	Low	500	172	500	8,333
Barren, KY	High	500	169	500	8,333
Barren, KY	High	1,000	199	1,000	7,692
Barren, KY	High	3,000	281	3,000	3,333
Most Conservative for Emissions Similar to GCC [1]			281		8,333

Notes:

1. Hypothetical sources with NO_X emissions of 3,000 tons per year and VOC emissions of 500 tons per year.

The O_3 impacts for the source impact assessment were calculated as the sum of the ratio of precursor emissions to the MERPs. If the sum of the ratios is less than 1, then the O_3 impacts are below the O_3 SIL and no cumulative analysis is necessary.

EQUATION 4

$$\left(\frac{NO_X\_Em}{NO_X\_MERP}\right) + \left(\frac{VOC\_Em}{VOC\_MERP}\right) < 1$$

Where:

NO_X _Em = Project related NOx Emissions (tons per year – tpy)
NO_X _MERP = NO_X Emissions from Table 7 (tpy)
VOC_Em = Project related VOC Emissions (tpy)
VOC_MERP = VOC Emissions from Table 7 (tpy)

The TVA GCC facility’s ozone inputs to Equation 4 are provided in Table 8, and the resulting impacts are calculated in Equation 5 below.

TABLE 8
O3 Inputs for the SIL in Class II Areas

O_3 Precursor	GCC Emissions (tons/year) [1]	MERP (tons/year) [1]
NO_X	2,270	281 [2]
VOC	158	8,333 [3]

Notes:

1. TVA GCC facility project emissions.
2. Most conservative MERP for NO_X emissions of 3,000 tons per year at Giles County or Barren County.
3. Most conservative MERP for VOC emissions of 500 tons per year at Giles County or Barren County.

Combined Impacts for O_3 for the SIL in Class II Areas:

EQUATION 5

$$\left(\frac{2{,}270}{281}\right) + \left(\frac{158}{8{,}333}\right) = 8.10$$

According to Equation 5, the sum of the ratios was greater than 1, and the combined O_3 impacts were above the SIL. Therefore, a cumulative O_3 analysis was necessary and performed, which added background O_3 and compared the combined impacts to the NAAQS, as shown in Equation 6.

EQUATION 6

$$Background\ O_3 + \left(\left(\left(\frac{NOx\_Em}{NOx\_MERP}\right) + \left(\frac{VOC\_Em}{VOC\_MERP}\right)\right) \times SIL\right) \leq \ NAAQS$$

Where:

Background Ozone = 2015-2017 8-hour O_3 design value (ppb) for Cadiz monitor
NO_X _Em = Project related NOx Emissions (tons per year – tpy)
NO_X _MERP = NO_X Emissions from Table 7 (tpy)
VOC_Em = Project related VOC Emissions (tpy)
VOC_MERP = VOC Emissions from Table 7 (tpy)
SIL = 1 ppb O_3
NAAQS = 8-hour O_3 NAAQS (70 ppb)

The cumulative O_3 impacts from the TCA GCC facility are calculated in Equation 7 below.

Cumulative O_3 Impacts:

EQUATION 7

$$61\ ppb\ + \left(\left(\left(\frac{2{,}270}{281} \right) + \left(\frac{158}{8{,}333} \right) \right) \times 1 \right) = 69.1\ ppb$$

Using the 3-year 8-hour O_3 design value of 61 ppb from Cadiz, KY, the ratios defined in Equation 5, and the O_3 SIL of 1 ppb, the cumulative O_3 impacts was calculated to be 69.1 ppb and did not exceed the O_3 NAAQS. From this cumulative O_3 assessment, it was determined that emissions from the TCA GCC facility would not cause or contribute to a violation of the O_3 NAAQS.

This Page Intentionally Left Blank

Appendix D: Example of the background monitoring data calculations for a Second Level 24-hour modeling analysis

This appendix provides an illustrative example of the calculations and data sorting recommendations for the background monitoring data to be used in a Second Level 24-hour $PM_{2.5}$ modeling analysis. In this example, it was determined through discussion and coordination with the appropriate permitting authority that the impacts from the project source's direct $PM_{2.5}$ emissions were most prominent during the cool season and were not temporally correlated with background $PM_{2.5}$ levels that were typical highest during the warm season. So, combining the modeled and monitored levels through a First Level 24-hour $PM_{2.5}$ modeling analysis was determined to be potentially overly conservative. Extending the compliance demonstration to a Second Level analysis allows for a more refined and appropriate assessment of the cumulative impacts on the direct $PM_{2.5}$ emissions in this particular situation.

The example provided is from an idealized Federal Reference Method (FRM) $PM_{2.5}$ monitoring site that operates on a daily (1-in-1 day) frequency with 100% data completeness. In this case, the annual 98th percentile concentration is the 8th highest concentration of the year. In most cases, the FRM monitoring site will likely operate on a 1-and-3 day frequency and will also likely have missing data due to monitor maintenance or collected data not meeting all of the quality assurance criteria. Please reference Appendix N to 40 CFR part 50 to determine the appropriate 98th percentile rank of the monitored data based on the monitor sampling frequency and valid number of days sampled during each year.

The appropriate seasonal (or quarterly) background concentrations to be included as inputs to the AERMOD model per a Second Level 24-hour $PM_{2.5}$ modeling analysis are as follows:

- Step 1 – Start with the most recent 3-years of representative background $PM_{2.5}$ ambient monitoring data that are being used to develop the monitored background $PM_{2.5}$ design value. In this example, the 3-years of 2008 to 2010 are being used to determine the monitored design value.

- Step 2 – For each year, determine the appropriate rank for the daily 98th percentile $PM_{2.5}$ concentration. Again, this idealized example is from a 1-in-1 day monitor with 100% data completeness. So, the 8th highest concentration of each year is the 98th percentile $PM_{2.5}$ concentration. The 98th percentile $PM_{2.5}$ concentration for 2008 is highlighted in Table D-1. The full concentration data from 2009 and 2010 are not shown across the steps in this Appendix for simplicity but would be similar to that of 2008.

- Step 3 – Remove from further consideration in this analysis the $PM_{2.5}$ concentrations from each year that are greater than the 98th percentile $PM_{2.5}$ concentration. In the case presented for a 1-in-1 day monitor, the top 7 concentrations are removed. If the monitor were a 1-in-3 day monitor, only the top 2 concentrations would be removed. The resultant dataset after the top 7 concentrations have been removed from further consideration in this analysis for 2008 is presented in Table D-2.

- Step 4 – For each year, divide the resultant annual dataset of the monitored data equal to or less than the 98th percentile $PM_{2.5}$ concentration into each season (or quarter). For 2008, the seasonal subsets are presented in Table D-3.

- Step 5 – Determine the maximum $PM_{2.5}$ concentration from each of the seasonal (or quarterly) subsets created in Step 4 for each year. The maximum $PM_{2.5}$ concentration from each season for 2008 is highlighted in Table D-3.

- Step 6 – Average the seasonal (or quarterly) maximums from Step 5 across the three years of monitoring data to create the four seasonal background PM2.5 concentrations to be included as inputs to the AERMOD model. These averages for the 2008 to 2010 dataset used in this example are presented in Table D-4. As noted above, the full concentration data from 2009 and 2010 are not shown across the steps in this Appendix for simplicity, but the seasonal maximums from 2009 and 2010 presented in Table D-4 were determined by following the previous five steps similar to that of 2008.

Table D-1. 2008 Daily PM$_{2.5}$ Concentrations

Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1	2-Apr	10.5	18-May	11.1	3-Jul	17.1	18-Aug	18.7	3-Oct	12.3	18-Nov	4.4
2-Jan	5.4	17-Feb	11.8	3-Apr	8.2	19-May	7.7	4-Jul	19.8	19-Aug	21.5	4-Oct	19.5	19-Nov	8.2
3-Jan	10.0	18-Feb	3.4	4-Apr	9.7	20-May	13.6	5-Jul	14.3	20-Aug	20.1	5-Oct	23.7	20-Nov	11.1
4-Jan	16.4	19-Feb	4.5	5-Apr	6.9	21-May	12.1	6-Jul	11.5	21-Aug	18.4	6-Oct	19.8	21-Nov	5.3
5-Jan	11.2	20-Feb	4.8	6-Apr	6.3	22-May	10.0	7-Jul	14.3	22-Aug	16.7	7-Oct	21.7	22-Nov	8.9
6-Jan	11.1	21-Feb	11.9	7-Apr	7.9	23-May	13.3	8-Jul	12.2	23-Aug	13.8	8-Oct	12.2	23-Nov	14.0
7-Jan	10.2	22-Feb	20.1	8-Apr	9.8	24-May	11.2	9-Jul	11.1	24-Aug	19.0	9-Oct	5.1	24-Nov	12.7
8-Jan	11.4	23-Feb	11.4	9-Apr	16.5	25-May	17.7	10-Jul	9.7	25-Aug	17.6	10-Oct	10.2	25-Nov	9.7
9-Jan	8.1	24-Feb	19.3	10-Apr	13.3	26-May	14.2	11-Jul	16.4	26-Aug	15.4	11-Oct	10.7	26-Nov	12.8
10-Jan	9.4	25-Feb	18.2	11-Apr	11.0	27-May	15.4	12-Jul	21.5	27-Aug	12.6	12-Oct	5.6	27-Nov	16.6
11-Jan	5.7	26-Feb	12.8	12-Apr	8.8	28-May	13.9	13-Jul	25.1	28-Aug	12.1	13-Oct	5.9	28-Nov	17.2
12-Jan	8.9	27-Feb	5.5	13-Apr	6.3	29-May	9.3	14-Jul	11.7	29-Aug	10.1	14-Oct	9.7	29-Nov	16.6
13-Jan	18.1	28-Feb	9.7	14-Apr	5.1	30-May	14.5	15-Jul	18.9	30-Aug	17.2	15-Oct	12.8	30-Nov	4.5
14-Jan	11.0	29-Feb	12.1	15-Apr	7.9	31-May	20.5	16-Jul	28.9	31-Aug	19.9	16-Oct	16.4	1-Dec	7.5
15-Jan	11.8	1-Mar	9.6	16-Apr	8.2	1-Jun	15.3	17-Jul	27.6	1-Sep	19.4	17-Oct	12.0	2-Dec	10.6
16-Jan	10.7	2-Mar	5.6	17-Apr	14.7	2-Jun	11.5	18-Jul	12.8	2-Sep	18.2	18-Oct	7.9	3-Dec	16.7
17-Jan	10.0	3-Mar	12.5	18-Apr	22.5	3-Jun	17.9	19-Jul	6.2	3-Sep	24.0	19-Oct	6.6	4-Dec	12.5
18-Jan	15.6	4-Mar	7.1	19-Apr	12.8	4-Jun	21.1	20-Jul	20.1	4-Sep	15.4	20-Oct	8.1	5-Dec	7.3
19-Jan	18.0	5-Mar	4.9	20-Apr	6.9	5-Jun	17.9	21-Jul	26.5	5-Sep	12.4	21-Oct	12.2	6-Dec	10.4
20-Jan	6.6	6-Mar	9.9	21-Apr	7.5	6-Jun	17.6	22-Jul	16.9	6-Sep	12.5	22-Oct	4.6	7-Dec	13.4
21-Jan	7.4	7-Mar	11.2	22-Apr	6.0	7-Jun	15.0	23-Jul	12.8	7-Sep	15.8	23-Oct	6.1	8-Dec	10.5
22-Jan	13.5	8-Mar	5.5	23-Apr	9.1	8-Jun	22.3	24-Jul	7.9	8-Sep	23.4	24-Oct	4.6	9-Dec	9.3
23-Jan	16.0	9-Mar	8.8	24-Apr	10.3	9-Jun	27.9	25-Jul	15.7	9-Sep	11.5	25-Oct	4.5	10-Dec	6.5
24-Jan	9.4	10-Mar	11.0	25-Apr	12.0	10-Jun	21.6	26-Jul	24.9	10-Sep	6.0	26-Oct	10.5	11-Dec	3.0
25-Jan	12.6	11-Mar	12.1	26-Apr	12.5	11-Jun	19.4	27-Jul	22.2	11-Sep	11.8	27-Oct	6.4	12-Dec	3.5
26-Jan	13.6	12-Mar	9.7	27-Apr	11.3	12-Jun	21.2	28-Jul	17.5	12-Sep	10.7	28-Oct	4.6	13-Dec	10.2
27-Jan	16.1	13-Mar	15.1	28-Apr	7.6	13-Jun	29.1	29-Jul	19.1	13-Sep	7.6	29-Oct	5.6	14-Dec	17.6
28-Jan	10.0	14-Mar	21.6	29-Apr	7.4	14-Jun	15.6	30-Jul	21.1	14-Sep	7.5	30-Oct	7.6	15-Dec	12.4
29-Jan	10.4	15-Mar	16.6	30-Apr	11.4	15-Jun	14.8	31-Jul	18.0	15-Sep	7.1	31-Oct	11.2	16-Dec	9.7
30-Jan	6.9	16-Mar	7.9	1-May	12.6	16-Jun	17.8	1-Aug	16.3	16-Sep	7.7	1-Nov	16.2	17-Dec	7.0
31-Jan	4.9	17-Mar	9.6	2-May	10.0	17-Jun	12.6	2-Aug	19.3	17-Sep	11.3	2-Nov	17.3	18-Dec	7.9
1-Feb	5.4	18-Mar	10.3	3-May	11.2	18-Jun	10.5	3-Aug	17.9	18-Sep	16.8	3-Nov	18.3	19-Dec	6.9
2-Feb	7.1	19-Mar	8.4	4-May	10.4	19-Jun	15.0	4-Aug	25.1	19-Sep	14.8	4-Nov	8.9	20-Dec	8.1
3-Feb	10.9	20-Mar	4.9	5-May	15.7	20-Jun	22.7	5-Aug	29.3	20-Sep	8.0	5-Nov	5.8	21-Dec	4.9
4-Feb	12.1	21-Mar	8.7	6-May	16.1	21-Jun	18.7	6-Aug	19.1	21-Sep	10.8	6-Nov	8.6	22-Dec	7.7
5-Feb	17.1	22-Mar	13.3	7-May	16.8	22-Jun	15.2	7-Aug	14.0	22-Sep	14.5	7-Nov	15.0	23-Dec	7.7
6-Feb	10.3	23-Mar	12.2	8-May	14.5	23-Jun	16.8	8-Aug	10.8	23-Sep	21.2	8-Nov	8.3	24-Dec	10.5
7-Feb	4.0	24-Mar	10.3	9-May	11.7	24-Jun	15.1	9-Aug	15.0	24-Sep	8.6	9-Nov	10.0	25-Dec	6.5
8-Feb	9.7	25-Mar	11.9	10-May	9.0	25-Jun	20.7	10-Aug	21.7	25-Sep	1.2	10-Nov	12.8	26-Dec	7.6
9-Feb	11.5	26-Mar	20.1	11-May	6.7	26-Jun	23.0	11-Aug	14.3	26-Sep	16.0	11-Nov	11.8	27-Dec	13.3
10-Feb	3.0	27-Mar	22.5	12-May	7.9	27-Jun	17.8	12-Aug	14.7	27-Sep	12.1	12-Nov	14.8	28-Dec	6.4
11-Feb	5.5	28-Mar	18.2	13-May	8.3	28-Jun	12.4	13-Aug	13.0	28-Sep	18.0	13-Nov	14.5	29-Dec	3.7
12-Feb	18.9	29-Mar	10.8	14-May	12.2	29-Jun	12.7	14-Aug	13.5	29-Sep	17.8	14-Nov	7.7	30-Dec	4.7
13-Feb	17.6	30-Mar	6.4	15-May	13.1	30-Jun	8.9	15-Aug	17.5	30-Sep	16.4	15-Nov	3.6	31-Dec	4.4
14-Feb	11.2	31-Mar	3.3	16-May	8.8	1-Jul	7.1	16-Aug	23.9	1-Oct	12.3	16-Nov	4.6		
15-Feb	14.4	1-Apr	7.8	17-May	8.2	2-Jul	13.8	17-Aug	18.4	2-Oct	8.2	17-Nov	7.8		

Annual 98th Percentile Concentration = 25.1 $\mu g/m^3$

Table D-2. 2008 Daily $PM_{2.5}$ Concentrations Less Than or Equal to the 98th Percentile

Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1	2-Apr	10.5	18-May	11.1	3-Jul	17.1	18-Aug	18.7	3-Oct	12.3	18-Nov	4.4
2-Jan	5.4	17-Feb	11.8	3-Apr	8.2	19-May	7.7	4-Jul	19.8	19-Aug	21.5	4-Oct	19.5	19-Nov	8.2
3-Jan	10.0	18-Feb	3.4	4-Apr	9.7	20-May	13.6	5-Jul	14.3	20-Aug	20.1	5-Oct	23.7	20-Nov	11.1
4-Jan	16.4	19-Feb	4.5	5-Apr	6.9	21-May	12.1	6-Jul	11.5	21-Aug	18.4	6-Oct	19.8	21-Nov	5.3
5-Jan	11.2	20-Feb	4.8	6-Apr	6.3	22-May	10.0	7-Jul	14.3	22-Aug	16.7	7-Oct	21.7	22-Nov	8.9
6-Jan	11.1	21-Feb	11.9	7-Apr	7.9	23-May	13.3	8-Jul	12.2	23-Aug	13.8	8-Oct	12.2	23-Nov	14.0
7-Jan	10.2	22-Feb	20.1	8-Apr	9.8	24-May	11.2	9-Jul	11.1	24-Aug	19.0	9-Oct	5.1	24-Nov	12.7
8-Jan	11.4	23-Feb	11.4	9-Apr	16.5	25-May	17.7	10-Jul	9.7	25-Aug	17.6	10-Oct	10.2	25-Nov	9.7
9-Jan	8.1	24-Feb	19.3	10-Apr	13.3	26-May	14.2	11-Jul	16.4	26-Aug	15.4	11-Oct	10.7	26-Nov	12.8
10-Jan	9.4	25-Feb	18.2	11-Apr	11.0	27-May	15.4	12-Jul	21.5	27-Aug	12.6	12-Oct	5.6	27-Nov	16.6
11-Jan	5.7	26-Feb	12.8	12-Apr	8.8	28-May	13.9	13-Jul	RC	28-Aug	12.1	13-Oct	5.9	28-Nov	17.2
12-Jan	8.9	27-Feb	5.5	13-Apr	6.3	29-May	9.3	14-Jul	11.7	29-Aug	10.1	14-Oct	9.7	29-Nov	16.6
13-Jan	18.1	28-Feb	9.7	14-Apr	5.1	30-May	14.5	15-Jul	18.9	30-Aug	17.2	15-Oct	12.8	30-Nov	4.5
14-Jan	11.0	29-Feb	12.1	15-Apr	7.9	31-May	20.5	16-Jul	RC	31-Aug	19.9	16-Oct	16.4	1-Dec	7.5
15-Jan	11.8	1-Mar	9.6	16-Apr	8.2	1-Jun	15.3	17-Jul	RC	1-Sep	19.4	17-Oct	12.0	2-Dec	10.6
16-Jan	10.7	2-Mar	5.6	17-Apr	14.7	2-Jun	11.5	18-Jul	12.8	2-Sep	18.2	18-Oct	7.9	3-Dec	16.7
17-Jan	10.0	3-Mar	12.5	18-Apr	22.5	3-Jun	17.9	19-Jul	6.2	3-Sep	24.0	19-Oct	6.6	4-Dec	12.5
18-Jan	15.6	4-Mar	7.1	19-Apr	12.8	4-Jun	21.1	20-Jul	20.1	4-Sep	15.4	20-Oct	8.1	5-Dec	7.3
19-Jan	18.0	5-Mar	4.9	20-Apr	6.9	5-Jun	17.9	21-Jul	RC	5-Sep	12.4	21-Oct	12.2	6-Dec	10.4
20-Jan	6.6	6-Mar	9.9	21-Apr	7.5	6-Jun	17.6	22-Jul	16.9	6-Sep	12.5	22-Oct	4.6	7-Dec	13.4
21-Jan	7.4	7-Mar	11.2	22-Apr	6.0	7-Jun	15.0	23-Jul	12.8	7-Sep	15.8	23-Oct	6.1	8-Dec	10.5
22-Jan	13.5	8-Mar	5.5	23-Apr	9.1	8-Jun	22.3	24-Jul	7.9	8-Sep	23.4	24-Oct	4.6	9-Dec	9.3
23-Jan	16.0	9-Mar	8.8	24-Apr	10.3	9-Jun	RC	25-Jul	15.7	9-Sep	11.5	25-Oct	4.5	10-Dec	6.5
24-Jan	9.4	10-Mar	11.0	25-Apr	12.0	10-Jun	21.6	26-Jul	24.9	10-Sep	6.0	26-Oct	10.5	11-Dec	3.0
25-Jan	12.6	11-Mar	12.1	26-Apr	12.5	11-Jun	19.4	27-Jul	22.2	11-Sep	11.8	27-Oct	6.4	12-Dec	3.5
26-Jan	13.6	12-Mar	9.7	27-Apr	11.3	12-Jun	21.2	28-Jul	17.5	12-Sep	10.7	28-Oct	4.6	13-Dec	10.2
27-Jan	16.1	13-Mar	15.1	28-Apr	7.6	13-Jun	RC	29-Jul	19.1	13-Sep	7.6	29-Oct	5.6	14-Dec	17.6
28-Jan	10.0	14-Mar	21.6	29-Apr	7.4	14-Jun	15.6	30-Jul	21.1	14-Sep	7.5	30-Oct	7.6	15-Dec	12.4
29-Jan	10.4	15-Mar	16.6	30-Apr	11.4	15-Jun	14.8	31-Jul	18.0	15-Sep	7.1	31-Oct	11.2	16-Dec	9.7
30-Jan	6.9	16-Mar	7.9	1-May	12.6	16-Jun	17.8	1-Aug	16.3	16-Sep	7.7	1-Nov	16.2	17-Dec	7.0
31-Jan	4.9	17-Mar	9.6	2-May	10.0	17-Jun	12.6	2-Aug	19.3	17-Sep	11.3	2-Nov	17.3	18-Dec	7.9
1-Feb	5.4	18-Mar	10.3	3-May	11.2	18-Jun	10.5	3-Aug	17.9	18-Sep	16.8	3-Nov	18.3	19-Dec	6.9
2-Feb	7.1	19-Mar	8.4	4-May	10.4	19-Jun	15.0	4-Aug	25.1	19-Sep	14.8	4-Nov	8.9	20-Dec	8.1
3-Feb	10.9	20-Mar	4.9	5-May	15.7	20-Jun	22.7	5-Aug	RC	20-Sep	8.0	5-Nov	5.8	21-Dec	4.9
4-Feb	12.1	21-Mar	8.7	6-May	16.1	21-Jun	18.7	6-Aug	19.1	21-Sep	10.8	6-Nov	8.6	22-Dec	7.7
5-Feb	17.1	22-Mar	13.3	7-May	16.8	22-Jun	15.2	7-Aug	14.0	22-Sep	14.5	7-Nov	15.0	23-Dec	7.7
6-Feb	10.3	23-Mar	12.2	8-May	14.5	23-Jun	16.8	8-Aug	10.8	23-Sep	21.2	8-Nov	8.3	24-Dec	10.5
7-Feb	4.0	24-Mar	10.3	9-May	11.7	24-Jun	15.1	9-Aug	15.0	24-Sep	8.6	9-Nov	10.0	25-Dec	6.5
8-Feb	9.7	25-Mar	11.9	10-May	9.0	25-Jun	20.7	10-Aug	21.7	25-Sep	1.2	10-Nov	12.8	26-Dec	7.6
9-Feb	11.5	26-Mar	20.1	11-May	6.7	26-Jun	23.0	11-Aug	14.3	26-Sep	16.0	11-Nov	11.8	27-Dec	13.3
10-Feb	3.0	27-Mar	22.5	12-May	7.9	27-Jun	17.8	12-Aug	14.7	27-Sep	12.1	12-Nov	14.8	28-Dec	6.4
11-Feb	5.5	28-Mar	18.2	13-May	8.3	28-Jun	12.4	13-Aug	13.0	28-Sep	18.0	13-Nov	14.5	29-Dec	3.7
12-Feb	18.9	29-Mar	10.8	14-May	12.2	29-Jun	12.7	14-Aug	13.5	29-Sep	17.8	14-Nov	7.7	30-Dec	4.7
13-Feb	17.6	30-Mar	6.4	15-May	13.1	30-Jun	8.9	15-Aug	17.5	30-Sep	16.4	15-Nov	3.6	31-Dec	4.4
14-Feb	11.2	31-Mar	3.3	16-May	8.8	1-Jul	7.1	16-Aug	23.9	1-Oct	12.3	16-Nov	4.6		
15-Feb	14.4	1-Apr	7.8	17-May	8.2	2-Jul	13.8	17-Aug	18.4	2-Oct	8.2	17-Nov	7.8		

Annual 98th Percentile Concentration = 25.1 $\mu g/m^3$

RC = Above 98th Percentile and Removed from Consideration

Table D-3. 2008 Daily PM$_{2.5}$ Concentrations Less Than or Equal to the 98th Percentile by Quarter

Season / Quarter 1			
Date	**Conc.**	**Date**	**Conc.**
1-Jan	10.4	16-Feb	15.1
2-Jan	5.4	17-Feb	11.8
3-Jan	10.0	18-Feb	3.4
4-Jan	16.4	19-Feb	4.5
5-Jan	11.2	20-Feb	4.8
6-Jan	11.1	21-Feb	11.9
7-Jan	10.2	22-Feb	20.1
8-Jan	11.4	23-Feb	11.4
9-Jan	8.1	24-Feb	19.3
10-Jan	9.4	25-Feb	18.2
11-Jan	5.7	26-Feb	12.8
12-Jan	8.9	27-Feb	5.5
13-Jan	18.1	28-Feb	9.7
14-Jan	11.0	29-Feb	12.1
15-Jan	11.8	1-Mar	9.6
16-Jan	10.7	2-Mar	5.6
17-Jan	10.0	3-Mar	12.5
18-Jan	15.6	4-Mar	7.1
19-Jan	18.0	5-Mar	4.9
20-Jan	6.6	6-Mar	9.9
21-Jan	7.4	7-Mar	11.2
22-Jan	13.5	8-Mar	5.5
23-Jan	16.0	9-Mar	8.8
24-Jan	9.4	10-Mar	11.0
25-Jan	12.6	11-Mar	12.1
26-Jan	13.6	12-Mar	9.7
27-Jan	16.1	13-Mar	15.1
28-Jan	10.0	14-Mar	21.6
29-Jan	10.4	15-Mar	16.6
30-Jan	6.9	16-Mar	7.9
31-Jan	4.9	17-Mar	9.6
1-Feb	5.4	18-Mar	10.3
2-Feb	7.1	19-Mar	8.4
3-Feb	10.9	20-Mar	4.9
4-Feb	12.1	21-Mar	8.7
5-Feb	17.1	22-Mar	13.3
6-Feb	10.3	23-Mar	12.2
7-Feb	4.0	24-Mar	10.3
8-Feb	9.7	25-Mar	11.9
9-Feb	11.5	26-Mar	20.1
10-Feb	3.0	27-Mar	22.5
11-Feb	5.5	28-Mar	18.2
12-Feb	18.9	29-Mar	10.8
13-Feb	17.6	30-Mar	6.4
14-Feb	11.2	31-Mar	3.3
15-Feb	14.4		
Seasonal / Quarterly Maximum			**22.5**

Season / Quarter 2			
Date	**Conc.**	**Date**	**Conc.**
1-Apr	7.8	17-May	8.2
2-Apr	10.5	18-May	11.1
3-Apr	8.2	19-May	7.7
4-Apr	9.7	20-May	13.6
5-Apr	6.9	21-May	12.1
6-Apr	6.3	22-May	10.0
7-Apr	7.9	23-May	13.3
8-Apr	9.8	24-May	11.2
9-Apr	16.5	25-May	17.7
10-Apr	13.3	26-May	14.2
11-Apr	11.0	27-May	15.4
12-Apr	8.8	28-May	13.9
13-Apr	6.3	29-May	9.3
14-Apr	5.1	30-May	14.5
15-Apr	7.9	31-May	20.5
16-Apr	8.2	1-Jun	15.3
17-Apr	14.7	2-Jun	11.5
18-Apr	22.5	3-Jun	17.9
19-Apr	12.8	4-Jun	21.1
20-Apr	6.9	5-Jun	17.9
21-Apr	7.5	6-Jun	17.6
22-Apr	6.0	7-Jun	15.0
23-Apr	9.1	8-Jun	22.3
24-Apr	10.3	9-Jun	RC
25-Apr	12.0	10-Jun	21.6
26-Apr	12.5	11-Jun	19.4
27-Apr	11.3	12-Jun	21.2
28-Apr	7.6	13-Jun	RC
29-Apr	7.4	14-Jun	15.6
30-Apr	11.4	15-Jun	14.8
1-May	12.6	16-Jun	17.8
2-May	10.0	17-Jun	12.6
3-May	11.2	18-Jun	10.5
4-May	10.4	19-Jun	15.0
5-May	15.7	20-Jun	22.7
6-May	16.1	21-Jun	18.7
7-May	16.8	22-Jun	15.2
8-May	14.5	23-Jun	16.8
9-May	11.7	24-Jun	15.1
10-May	9.0	25-Jun	20.7
11-May	6.7	26-Jun	23.0
12-May	7.9	27-Jun	17.8
13-May	8.3	28-Jun	12.4
14-May	12.2	29-Jun	12.7
15-May	13.1	30-Jun	8.9
16-May	8.8		
Seasonal / Quarterly Maximum			**23.0**

Season / Quarter 3			
Date	**Conc.**	**Date**	**Conc.**
1-Jul	7.1	16-Aug	23.9
2-Jul	13.8	17-Aug	18.4
3-Jul	17.1	18-Aug	18.7
4-Jul	19.8	19-Aug	21.5
5-Jul	14.3	20-Aug	20.1
6-Jul	11.5	21-Aug	18.4
7-Jul	14.3	22-Aug	16.7
8-Jul	12.2	23-Aug	13.8
9-Jul	11.1	24-Aug	19.0
10-Jul	9.7	25-Aug	17.6
11-Jul	16.4	26-Aug	15.4
12-Jul	21.5	27-Aug	12.6
13-Jul	RC	28-Aug	12.1
14-Jul	11.7	29-Aug	10.1
15-Jul	18.9	30-Aug	17.2
16-Jul	RC	31-Aug	19.9
17-Jul	RC	1-Sep	19.4
18-Jul	12.8	2-Sep	18.2
19-Jul	6.2	3-Sep	24.0
20-Jul	20.1	4-Sep	15.4
21-Jul	RC	5-Sep	12.4
22-Jul	16.9	6-Sep	12.5
23-Jul	12.8	7-Sep	15.8
24-Jul	7.9	8-Sep	23.4
25-Jul	15.7	9-Sep	11.5
26-Jul	24.9	10-Sep	6.0
27-Jul	22.2	11-Sep	11.8
28-Jul	17.5	12-Sep	10.7
29-Jul	19.1	13-Sep	7.6
30-Jul	21.1	14-Sep	7.5
31-Jul	18.0	15-Sep	7.1
1-Aug	16.3	16-Sep	7.7
2-Aug	19.3	17-Sep	11.3
3-Aug	17.9	18-Sep	16.8
4-Aug	25.1	19-Sep	14.8
5-Aug	RC	20-Sep	8.0
6-Aug	19.1	21-Sep	10.8
7-Aug	14.0	22-Sep	14.5
8-Aug	10.8	23-Sep	21.2
9-Aug	15.0	24-Sep	8.6
10-Aug	21.7	25-Sep	1.2
11-Aug	14.3	26-Sep	16.0
12-Aug	14.7	27-Sep	12.1
13-Aug	13.0	28-Sep	18.0
14-Aug	13.5	29-Sep	17.8
15-Aug	17.5	30-Sep	16.4
Seasonal / Quarterly Maximum			**25.1**

Season / Quarter 4			
Date	**Conc.**	**Date**	**Conc.**
1-Oct	12.3	16-Nov	4.6
2-Oct	8.2	17-Nov	7.8
3-Oct	12.3	18-Nov	4.4
4-Oct	19.5	19-Nov	8.2
5-Oct	23.7	20-Nov	11.1
6-Oct	19.8	21-Nov	5.3
7-Oct	21.7	22-Nov	8.9
8-Oct	12.2	23-Nov	14.0
9-Oct	5.1	24-Nov	12.7
10-Oct	10.2	25-Nov	9.7
11-Oct	10.7	26-Nov	12.8
12-Oct	5.6	27-Nov	16.6
13-Oct	5.9	28-Nov	17.2
14-Oct	9.7	29-Nov	16.6
15-Oct	12.8	30-Nov	4.5
16-Oct	16.4	1-Dec	7.5
17-Oct	12.0	2-Dec	10.6
18-Oct	7.9	3-Dec	16.7
19-Oct	6.6	4-Dec	12.5
20-Oct	8.1	5-Dec	7.3
21-Oct	12.2	6-Dec	10.4
22-Oct	4.6	7-Dec	13.4
23-Oct	6.1	8-Dec	10.5
24-Oct	4.6	9-Dec	9.3
25-Oct	4.5	10-Dec	6.5
26-Oct	10.5	11-Dec	3.0
27-Oct	6.4	12-Dec	3.5
28-Oct	4.6	13-Dec	10.2
29-Oct	5.6	14-Dec	17.6
30-Oct	7.6	15-Dec	12.4
31-Oct	11.2	16-Dec	9.7
1-Nov	16.2	17-Dec	7.0
2-Nov	17.3	18-Dec	7.9
3-Nov	18.3	19-Dec	6.9
4-Nov	8.9	20-Dec	8.1
5-Nov	5.8	21-Dec	4.9
6-Nov	8.6	22-Dec	7.7
7-Nov	15.0	23-Dec	7.7
8-Nov	8.3	24-Dec	10.5
9-Nov	10.0	25-Dec	6.5
10-Nov	12.8	26-Dec	7.6
11-Nov	11.8	27-Dec	13.3
12-Nov	14.8	28-Dec	6.4
13-Nov	14.5	29-Dec	3.7
14-Nov	7.7	30-Dec	4.7
15-Nov	3.6	31-Dec	4.4
Seasonal / Quarterly Maximum			**23.7**

Seasonal / Quarterly Maximum Concentration

RC = Above 98th Percentile and Removed from Consideration

Table D-4. Resulting Average of Seasonal (or Quarterly) Maximums for Inclusion into AERMOD

Seasonal / Quarterly Average Highest Monitored Concentration

(From Annual Datasets Equal To and Less Than the 98th Percentile)

	Q1	**Q2**	**Q3**	**Q4**
2008	22.5	23.0	25.1	23.7
2009	21.1	20.7	21.2	19.8
2010	20.7	22.6	23.5	20.7
Average	**21.433**	**22.100**	**23.267**	**21.400**

(Note, the complete datasets for 2009 and 2010 are not shown in Appendix D but would follow the same steps as for 2008)

United States
Environmental Protection
Agency

Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, NC

Publication No. EPA-454/R-22-005
July 2022