



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
RESEARCH TRIANGLE PARK, NC 27711

JUN 28 2010

OFFICE OF  
AIR QUALITY PLANNING  
AND STANDARDS

**MEMORANDUM**

SUBJECT: Applicability of Appendix W Modeling Guidance for the 1-hour NO<sub>2</sub> National Ambient Air Quality Standard

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TO: Regional Air Division Directors

**INTRODUCTION**

On January 22, 2010, EPA announced a new 1-hour nitrogen dioxide (NO<sub>2</sub>) National Ambient Air Quality Standard (1-hour NO<sub>2</sub> NAAQS or 1-hour NO<sub>2</sub> standard) which is attained when the 3-year average of the 98th-percentile of the annual distribution of daily maximum 1-hour concentrations does not exceed 100 ppb at each monitor within an area. The final rule for the new 1-hour NO<sub>2</sub> NAAQS was published in the Federal Register on February 9, 2010 (75 FR 6474-6537), and the standard became effective on April 12, 2010 (EPA, 2010a). This memorandum clarifies the applicability of current guidance in the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W) for modeling NO<sub>2</sub> impacts in accordance with the Prevention of Significant Deterioration (PSD) permit requirements to demonstrate compliance with the new 1-hour NO<sub>2</sub> standard.

**SUMMARY OF CURRENT GUIDANCE**

While the new 1-hour NAAQS is defined relative to ambient concentrations of NO<sub>2</sub>, the majority of nitrogen oxides (NO<sub>x</sub>) emissions for stationary and mobile sources are in the form of nitric oxide (NO) rather than NO<sub>2</sub>. Appendix W notes that the impact of an individual source on ambient NO<sub>2</sub> depends, in part, "on the chemical environment into which the source's plume is to be emitted" (see Section 5.1.j). Given the role of NO<sub>x</sub> chemistry in determining ambient impact levels of NO<sub>2</sub> based on modeled NO<sub>x</sub> emissions, Section 5.2.4 of Appendix W recommends the following three-tiered screening approach for NO<sub>2</sub> modeling for annual averages:

- Tier 1 - assume full conversion of NO to NO<sub>2</sub> based on application of an appropriate refined modeling technique under Section 4.2.2 of Appendix W to estimate ambient NO<sub>x</sub> concentrations;

- Tier 2 - multiply Tier 1 result by empirically-derived NO<sub>2</sub>/NO<sub>x</sub> ratio, with 0.75 as the annual national default ratio (Chu and Meyer, 1991); and
- Tier 3 - detailed screening methods may be considered on a case-by-case basis, with the Ozone Limiting Method (OLM) identified as a detailed screening technique for point sources (Cole and Summerhays, 1979).

Tier 2 is often referred to as the Ambient Ratio Method, or ARM. Site-specific ambient NO<sub>2</sub>/NO<sub>x</sub> ratios derived from appropriate ambient monitoring data may also be considered as detailed screening methods on a case-by-case basis, with proper justification. Consistent with Section 4.2.2, AERMOD is the current preferred model for “a wide range of regulatory applications in all types of terrain” for purposes of estimating ambient concentrations of NO<sub>2</sub>, based on NO<sub>x</sub> emissions, under Tiers 1 and 2 above. We discuss the role of AERMOD for Tier 3 applications in more detail below.

### **APPLICABILITY OF CURRENT GUIDANCE TO 1-HOUR NO<sub>2</sub> NAAQS**

In general, the Appendix W recommendations regarding the annual NO<sub>2</sub> standard are also applicable to the new 1-hour NO<sub>2</sub> standard, but additional issues may need to be considered in the context of a 1-hour standard, depending on the characteristics of the emission sources, and depending on which tier is used, as summarized below:

- Tier 1 applies to the 1-hour NO<sub>2</sub> standard without any additional justification;
- Tier 2 may also apply to the 1-hour NO<sub>2</sub> standard in many cases, but some additional consideration will be needed in relation to an appropriate ambient ratio for peak hourly impacts since the current default ambient ratio is considered to be representative of “area wide quasi-equilibrium conditions”; and
- Tier 3 “detailed screening methods” will continue to be considered on a case-by-case basis for the 1-hour NO<sub>2</sub> standard. However, certain input data requirements and assumptions for Tier 3 applications may be of greater importance for the 1-hour standard than for the annual standard given the more localized nature of peak hourly vs. annual impacts. In addition, use of site-specific ambient NO<sub>2</sub>/NO<sub>x</sub> ratios based on ambient monitoring data will generally be more difficult to justify for the 1-hour NO<sub>2</sub> standard than for the annual standard.

While Appendix W specifically mentions OLM as a detailed screening method under Tier 3, we also consider the Plume Volume Molar Ratio Method (PVMRM) (Hanrahan, 1999a) discussed under Section 5.1.j of Appendix W to be in this category at this time. Both of these options account for ambient conversion of NO to NO<sub>2</sub> in the presence of ozone, based on the following basic chemical mechanism, known as titration, although there are important differences between these methods:



As noted in Section 5.1.j, EPA is currently testing the PVMRM option to determine its suitability as a refined method. Limited evaluations of PVMRM have been completed, which show encouraging results, but the amount of data currently available is too limited to justify a

designation of PVMRM as a refined method for NO<sub>2</sub> (Hanrahan, 1999b; MACTEC, 2005). EPA is currently updating and extending these evaluations to examine model performance for predicting hourly NO<sub>2</sub> concentrations, including both the OLM and PVMRM options, and results of these additional evaluations will be provided at a later date. A sensitivity analysis of the OLM and PVMRM options in AERMOD has been conducted that compares modeled concentrations based on OLM and PVMRM with Tiers 1 and 2 for a range of source characteristics (MACTEC, 2004). This analysis serves as a useful reference to understand how ambient NO<sub>2</sub> concentrations may be impacted by application of this three-tiered screening approach, and includes comparisons for both annual average and maximum 1-hour NO<sub>2</sub> concentrations.

Key model inputs for both the OLM and PVMRM options are the in-stack ratios of NO<sub>2</sub>/NO<sub>x</sub> emissions and background ozone concentrations. While the representativeness of these key inputs is important in the context of the annual NO<sub>2</sub> standard, they will generally take on even greater importance for the new 1-hour NO<sub>2</sub> standard, as explained in more detail below. Recognizing the potential importance of the in-stack NO<sub>2</sub>/NO<sub>x</sub> ratio for hourly NO<sub>2</sub> compliance demonstrations, we recommend that in-stack ratios used with either the OLM or PVMRM options be justified based on the specific application, i.e., there is no “default” in-stack NO<sub>2</sub>/NO<sub>x</sub> ratio for either OLM or PVMRM.

The OLM and PVMRM methods are both available as non-regulatory-default options within the EPA-preferred AERMOD dispersion model (Cimorelli, *et al.*, 2004; EPA, 2004; EPA, 2009). As a result of their non-regulatory-default status, pursuant to Sections 3.1.2.c, 3.2.2.a, and A.1.a(2) of Appendix W, application of AERMOD with the OLM or PVMRM option is no longer considered a “preferred model” and, therefore, requires justification and approval by the Regional Office on a case-by-case basis. While EPA is continuing to evaluate the PVMRM and OLM options within AERMOD for use in compliance demonstrations for the 1-hour NO<sub>2</sub> standard, as long as they are considered to be non-regulatory-default options, their use as alternative modeling techniques under Appendix W should be justified in accordance with Section 3.2.2, paragraph (e), as follows:

- “e. Finally, for condition (3) in paragraph (b) of this subsection [preferred model is less appropriate for the specific application, or there is no preferred model], an alternative refined model may be used provided that:
- 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 data bases which 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
  - v. A protocol on methods and procedures to be followed has been established.”

Since AERMOD is the preferred model for dispersion for a wide range of application, the focus of the alternative model demonstration for use of the OLM and PVMRM options within

AERMOD is on the treatment of NO<sub>x</sub> chemistry within the model, and does not need to address basic dispersion algorithms within AERMOD. Furthermore, items i and iv of the alternative model demonstration for these options can be fulfilled in part based on existing documentation (Cole and Summerhays, 1979; Hanrahan, 1999a; Hanrahan, 1999b; MACTEC, 2005), and the remaining items should be routinely addressed as part of the modeling protocol, irrespective of the regulatory status of these options. The issue of applicability to the problem on a theoretical basis (item ii) is a case-by-case determination based on an assessment of the adequacy of the ozone titration mechanism utilized by these options to account for NO<sub>x</sub> chemistry within the AERMOD model based on “the chemical environment into which the source’s plume is to be emitted” (Appendix W, Section 5.1.j). The adequacy of available data bases needed for application of OLM and PVMRM (item iii), including in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios and background ozone concentrations, is a critical aspect of the demonstration which we discuss in more detail below. It should also be noted that application of the OLM or PVMRM methods with other Appendix W models or alternative models, whether as a separate post-processor or integrated within the model, would require additional documentation and demonstration that the methods have been implemented and applied appropriately within that context, including model-specific performance evaluations which satisfy item iv under Section 3.2.2.e.

Given the form of the new 1-hour NO<sub>2</sub> standard, some clarification is needed regarding the appropriate data periods for modeling demonstrations of compliance with the NAAQS vs. demonstrations of attainment of the NAAQS through ambient monitoring. While monitored design values for the 1-hour NO<sub>2</sub> standard are based on a 3-year average (in accordance with Section 1(c)(2) of Appendix S to 40 CFR Part 50), Section 8.3.1.2 of Appendix W addresses the length of the meteorological data record for dispersion modeling, stating that “[T]he use of 5 years of NWS [National Weather Service] meteorological data or at least 1 year of site specific data is required.” Section 8.3.1.2.b further states that “one year or more (including partial years), up to five years, of site specific data . . . are preferred for use in air quality analyses.” Although the monitored design value for the 1-hour NO<sub>2</sub> standard is defined in terms of the 3-year average, this definition does not preempt or alter the Appendix W requirement for use of 5 years of NWS meteorological data or at least 1 year of site specific data. The 5-year average based on use of NWS data, or an average across one or more years of available site specific data, serves as an unbiased estimate of the 3-year average for purposes of modeling demonstrations of compliance with the NAAQS. Modeling of “rolling 3-year averages,” using years 1 through 3, years 2 through 4, and years 3 through 5, is not required. Furthermore, since modeled results for NO<sub>2</sub> are averaged across the number of years modeled for comparison to the new 1-hour NO<sub>2</sub> standard, the meteorological data period should include complete years of data to avoid introducing a seasonal bias to the averaged impacts. In order to comply with Appendix W recommendations in cases where partial years of site specific meteorological data are available, while avoiding any seasonal bias in the averaged impacts, an approach that utilizes the most conservative modeling result based on the first complete-year period of the available data record vs. results based on the last complete-year period of available data may be appropriate, subject to approval by the appropriate reviewing authority. Such an approach would ensure that all available site specific data are accounted for in the modeling analysis without imposing an undue burden on the applicant and avoiding arbitrary choices in the selection of a single complete-year data period.

The form of the new 1-hour NO<sub>2</sub> standard also has implications regarding appropriate methods for combining modeled ambient concentrations with monitored background concentrations for comparison to the NAAQS in a cumulative modeling analysis. As noted in the March 23, 2010 memorandum regarding “Modeling Procedures for Demonstrating Compliance with PM<sub>2.5</sub> NAAQS” (EPA, 2010b), combining the 98<sup>th</sup> percentile monitored value with the 98<sup>th</sup> percentile modeled concentrations for a cumulative impact assessment could result in a value that is below the 98<sup>th</sup> percentile of the combined cumulative distribution and would, therefore, not be protective of the NAAQS. However, unlike the recommendations presented for PM<sub>2.5</sub>, the modeled contribution to the cumulative ambient impact assessment for the 1-hour NO<sub>2</sub> standard should follow the form of the standard based on the 98<sup>th</sup> percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled. A “first tier” assumption that may be applied without further justification is to add the overall highest hourly background NO<sub>2</sub> concentration from a representative monitor to the modeled design value, based on the form of the standard, for comparison to the NAAQS. Additional refinements to this “first tier” approach based on some level of temporal pairing of modeled and monitored values may be considered on a case-by-case basis, with adequate justification and documentation.

## **DISCUSSION OF TECHNICAL ISSUES**

While many of the same technical issues related to application of Appendix W guidance for an annual NO<sub>2</sub> standard would also apply in the context of the new 1-hour NO<sub>2</sub> standard, there are some important differences that may also need to be considered depending on the specific application. This section discusses several aspects of these technical issues related to the new 1-hour NO<sub>2</sub> NAAQS, including a discussion of source emission inventories required for modeling demonstrations of compliance with the NAAQS and other issues specific to each of the three tiers identified in Section 5.2.4 of Appendix W for NO<sub>2</sub> modeling.

### **Emission Inventories**

The source emissions data are a key input for all modeling analyses and one that may require additional considerations under the new 1-hour NO<sub>2</sub> standard is the source emissions data. Section 8.1 of Appendix W provides guidance regarding source emission input data for dispersion modeling and Table 8-2 summarizes the recommendations for emission input data that should be followed for NAAQS compliance demonstrations. Although existing NO<sub>x</sub> emission inventories used to support modeling for compliance with the annual NO<sub>2</sub> standard should serve as a useful starting point, such inventories may not always be adequate for use in assessing compliance with the new 1-hour NO<sub>2</sub> standard since some aspects of the guidance in Section 8.1 differs for long-term (annual and quarterly) standards vs. short-term ( $\leq 24$  hours) standards. In particular, since maximum ground-level concentrations may be more sensitive to operating levels and startup/shutdown conditions for an hourly standard than for an annual standard, emission rates and stack parameters associated with the maximum ground-level concentrations for the annual standard may underestimate maximum concentrations for the new 1-hour NO<sub>2</sub> standard. Due to the importance of in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios required for application of the OLM and PVMRM options within AERMOD discussed above, consideration should also be given to the potential variability of in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios under different operating conditions when those

non-regulatory-default options are applied. We also note that source emission input data recommendations in Table 8-2 of Appendix W for “nearby sources” and “other sources” that may be needed to conduct a cumulative impact assessment include further differences between emission data for long-term vs. short-term standards which could also affect the adequacy of existing annual NO<sub>x</sub> emission inventories for the new 1-hour NO<sub>2</sub> standard. The terms “nearby sources” and “other sources” used in this context are defined in Section 8.2.3 of Appendix W. Attachment A provides a more detailed discussion on determining NO<sub>x</sub> emissions for permit modeling.

While Section 8.2.3 of Appendix W emphasizes the importance of professional judgment by the reviewing authority in the identification of nearby and other sources to be included in the modeled emission inventory, Appendix W establishes “a significant concentration gradient in the vicinity of the source” under consideration as the main criterion for this selection. Appendix W also indicates that “the number of such [nearby] sources is expected to be small except in unusual situations.” See Section 8.2.3.b. Since concentration gradients will vary somewhat depending on the averaging period being modeled, especially for an annual vs. 1-hour standard, the criteria for selection of “nearby” and “other” sources for inclusion in the modeled inventory may need to be reassessed for the 1-hour NO<sub>2</sub> standard.

The representativeness of available ambient air quality data also plays an important role in determining which nearby sources should be included in the modeled emission inventory. Key issues to consider in this regard are the extent to which ambient air impacts of emissions from nearby sources are reflected in the available ambient measurements, and the degree to which emissions from those background sources during the monitoring period are representative of allowable emission levels under the existing permits. The professional judgments that are required in developing an appropriate inventory of background sources should strive toward the proper balance between adequately characterizing the potential for cumulative impacts of emission sources within the study area to cause or contribute to violations of the NAAQS, while minimizing the potential to overestimate impacts by double-counting of modeled source impacts that are also reflected in the ambient monitoring data. We would also caution against the literal and uncritical application of very prescriptive procedures for identifying which background sources should be included in the modeled emission inventory for NAAQS compliance demonstrations, such as those described in Chapter C, Section IV.C.1 of the draft *New Source Review Workshop Manual* (EPA, 1990), noting again that Appendix W emphasizes the importance of professional judgment in this process. While the draft workshop manual serves as a useful general reference regarding New Source Review (NSR) and PSD programs, and such procedures may play a useful role in defining the spatial extent of sources whose emissions may need to be considered, it should be recognized that “[i]t is not intended to be an official statement of policy and standards and does not establish binding regulatory requirements.” See, Preface.

Given the range of issues involved in the determination of an appropriate inventory of emissions to include in a cumulative impact assessment, the appropriate reviewing authority should be consulted early in the process regarding the selection and proper application of appropriate monitored background concentrations and the selection and appropriate characterization of modeled background source emission inventories for use in demonstrating compliance with the new 1-hour NO<sub>2</sub> standard.

## **Tier-specific Technical Issues**

This section discusses technical issues related to application of each tier in the three-tiered screening approach for NO<sub>2</sub> modeling recommended in Section 5.2.4 Appendix W. A basic understanding of NO<sub>x</sub> chemistry and “of the chemical environment into which the source’s plume is to be emitted” (Appendix W, Section 5.1.j) will be helpful for addressing these issues based on the specific application.

### Tier 1:

Since the assumption of full conversion of NO to NO<sub>2</sub> will provide the most conservative treatment of NO<sub>x</sub> chemistry in assessing ambient impacts, there are no technical issues associated with treatment of NO<sub>x</sub> chemistry for this tier. However, the general issues related to emission inventories for the 1-hour NO<sub>2</sub> standard discussed above and in Attachment A apply to Tier 1.

### Tier 2:

As noted above, the 0.75 national default ratio for ARM is considered to be representative of “area wide quasi-equilibrium conditions” and, therefore, may not be as appropriate for use with the 1-hour NO<sub>2</sub> standard. The appropriateness of this default ambient ratio will depend somewhat on the characteristics of the sources, and as such application of Tier 2 for 1-hour NO<sub>2</sub> compliance demonstrations may need to be considered on a source-by-source basis in some cases. The key technical issue to address in relation to this tier requires an understanding of the meteorological conditions that are likely to be associated with peak hourly impacts from the source(s) being modeled. In general, for low-level releases with limited plume rise, peak hourly NO<sub>x</sub> impacts are likely to be associated with nighttime stable/light wind conditions. Since ambient ozone concentrations are likely to be relatively low for these conditions, and since low wind speeds and stable atmospheric conditions will further limit the conversion of NO to NO<sub>2</sub> by limiting the rate of entrainment of ozone into the plume, the 0.75 national default ratio will likely be conservative for these cases. A similar rationale may apply for elevated sources where plume impaction on nearby complex terrain under stable atmospheric conditions is expected to determine the peak hourly NO<sub>x</sub> concentrations. By contrast, for elevated sources in relatively flat terrain, the peak hourly NO<sub>x</sub> concentrations are likely to occur during daytime convective conditions, when ambient ozone concentrations are likely to be relatively high and entrainment of ozone within the plume is more rapid due to the vigorous vertical mixing during such conditions. For these sources, the 0.75 default ratio may not be conservative, and some caution may be needed in applying Tier 2 for such sources. We also note that the default equilibrium ratio employed within the PVMRM algorithm as an upper bound on an hourly basis is 0.9.

### Tier 3:

This tier represents a general category of “detailed screening methods” which may be considered on a case-by-case basis. Section 5.2.4(b) of Appendix W cites two specific examples

of Tier 3 methods, namely OLM and the use of site-specific ambient NO<sub>2</sub>/NO<sub>x</sub> ratios supported by ambient measurements. As noted above, we also believe it is appropriate to consider the PVMRM option as a Tier 3 detailed screening method at this time. The discussion here focuses primarily on the OLM and PVMRM methods, but we also note that the use of site-specific ambient NO<sub>2</sub>/NO<sub>x</sub> ratios will be subject to the same issues discussed above in relation to the Tier 2 default ARM, and as a result it will generally be much more difficult to determine an appropriate ambient NO<sub>2</sub>/NO<sub>x</sub> ratio based on monitoring data for the new 1-hour NO<sub>2</sub> standard than for the annual standard.

While OLM and PVMRM are both based on the same simple chemical mechanism of titration to account for the conversion of NO emissions to NO<sub>2</sub> (see Eq. 1) and therefore entail similar technical issues and considerations, there are some important differences that also need to be considered when assessing the appropriateness of these methods for specific applications. While the titration mechanism may capture the most important aspects of NO-to-NO<sub>2</sub> conversion in many applications, both methods will suffer from the same limitations for applications in which other mechanisms, such as photosynthesis, contribute significantly to the overall process of chemical transformation. Sources located in areas with high levels of VOC emissions may be subject to these limitations of OLM and PVMRM. Titration is generally a much faster mechanism for converting NO to NO<sub>2</sub> than photosynthesis, and as such is likely to be appropriate for characterizing peak 1-hour NO<sub>2</sub> impacts in many cases.

Both OLM and PVMRM rely on the same key inputs of in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios and hourly ambient ozone concentrations. Although both methods can be applied within the AERMOD model using a single “representative” background ozone concentration, it is likely that use of a single value would result in very conservative estimates of peak hourly ambient concentrations since its use for the 1-hour NO<sub>2</sub> standard would be contingent on a demonstration of conservatism for all hours modeled. Furthermore, hourly monitored ozone concentrations used with the OLM and PVMRM options must be concurrent with the meteorological data period used in the modeling analysis, and thus the temporal representativeness of the ozone data for estimating ambient NO<sub>2</sub> concentrations could be a factor in determining the appropriateness of the meteorological data period for a particular application. As noted above, the representativeness of these key inputs takes on somewhat greater importance in the context of a 1-hour NO<sub>2</sub> standard than for an annual standard, for obvious reasons. In the case of hourly background ozone concentrations, methods used to substitute for periods of missing data may play a more significant role in determining the 1-hour NO<sub>2</sub> modeled design value, and should therefore be given greater scrutiny, especially for data periods that are likely to be associated with peak hourly concentrations based on meteorological conditions and source characteristics. In other words, ozone data substitution methods that may have been deemed appropriate in prior applications for the annual standard may not be appropriate to use for the new 1-hour standard.

While these technical issues and considerations generally apply to both OLM and PVMRM, the importance of the in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios may be more important for PVMRM than for OLM in some cases, due to differences between the two methods. The key difference between the two methods is that the amount of ozone available for conversion of NO to NO<sub>2</sub> is based simply on the ambient ozone concentration and is independent of source characteristics for OLM, whereas the amount of ozone available for conversion in PVMRM is based on the amount



of ozone within the volume of the plume for an individual source or group of sources. The plume volume used in PVMRM is calculated on an hourly basis for each source/receptor combination, taking into account the dispersive properties of the atmosphere for that hour. For a low-level release where peak hourly NO<sub>x</sub> impacts occur close to the source under stable/light wind conditions, the plume volume will be relatively small and the ambient NO<sub>2</sub> impact for such cases will be largely determined by the in-stack NO<sub>2</sub>/NO<sub>x</sub> ratio, especially for sources with relatively close fence-line or ambient air boundaries. This example also highlights the fact that the relative importance of the in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios may be greater for some applications than others, depending on the source characteristics and other factors. Assumptions regarding in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios that may have been deemed appropriate in the context of the annual standard may not be appropriate to use for the new 1-hour standard. In particular, it is worth reiterating that the 0.1 in-stack ratio often cited as the “default” ratio for OLM should not be treated as a default value for hourly NO<sub>2</sub> compliance demonstrations.

Another difference between OLM and PVMRM that is worth noting here is the treatment of the titration mechanism for multiple sources of NO<sub>x</sub>. There are two possible modes that can be used for applying OLM to multiple source scenarios within AERMOD: (1) apply OLM to each source separately and assume that each source has all of the ambient ozone available for conversion of NO to NO<sub>2</sub>; and (2) assume that sources whose plumes overlap compete for the available ozone and apply OLM on a combined plume basis. The latter option can be applied selectively to subsets of sources within the modeled inventory or to all modeled sources using the OLMGROUP keyword within AERMOD, and is likely to result in lower ambient NO<sub>2</sub> concentrations in most cases since the ambient NO<sub>2</sub> levels will be more ozone-limited. One of the potential refinements in application of the titration method incorporated in PVMRM is a technique for dynamically determining which sources should compete for the available ozone based on the relative locations of the plumes from individual sources, both laterally and vertically, on an hourly basis, taking into account wind direction and plume rise. While this approach addresses one of the implementation issues associated with OLM by making the decision of which sources should compete for ozone, there is only very limited field study data available to evaluate the methodology.

Given the importance of the issue of whether to combine plumes for the OLM option, EPA has addressed the issue in the past through the Model Clearinghouse process. The general guidance that has emerged in those cases is that the OLM option should be applied on a source-by-source basis in most cases and that combining plumes for application of OLM would require a clear demonstration that the plumes will overlap to such a degree that they can be considered as “merged” plumes. However, much of that guidance was provided in the context of applying the OLM method outside the dispersion model in a post-processing mode on an annual basis. The past guidance on this issue is still appropriate in that context since there is no realistic method to account for the degree of plume merging on an hourly basis throughout the modeling analysis when applied as a post-processor. However, the implementation of the OLM option within the AERMOD model applies the method on a source-by-source, receptor-by-receptor, and hour-by-hour basis. As a result, the application of the OLMGROUP option within AERMOD is such that the sources only compete for the available ozone to the extent that each source contributes to the cumulative NO<sub>x</sub> concentration at each receptor for that hour. Sources which contribute significantly to the ambient NO<sub>x</sub> concentration at the receptor will compete for available ozone

in proportion to their contribution, while sources that do not contribute significantly to the ambient NO<sub>x</sub> concentration will not compete for the ozone. Thus, the OLMGROUP option implemented in AERMOD will tend to be “self-correcting” with respect to concerns that combining plumes for OLM will overestimate the degree of ozone limiting potential (and therefore underestimate ambient NO<sub>2</sub> concentrations). As a result of these considerations, we recommend that use of the “OLMGROUP ALL” option, which specifies that all sources will potentially compete for the available ozone, be routinely applied and accepted for all approved applications of the OLM option in AERMOD. This recommendation is supported by model-to-monitor comparisons of hourly NO<sub>2</sub> concentrations from the application of AERMOD for the Atlanta NO<sub>2</sub> risk and exposure assessment (EPA, 2008), and recent re-evaluations of hourly NO<sub>2</sub> impacts from the two field studies (New Mexico and Palau) that were used in the evaluation of PVMRM (MACTEC, 2005). These model-to-monitor comparisons of hourly NO<sub>2</sub> concentrations show reasonably good performance using the "OLMGROUP ALL" option within AERMOD, with no indication of any bias to underestimate hourly NO<sub>2</sub> concentrations with OLMGROUP ALL. Furthermore, model-to-monitor comparisons based on OLM without the OLMGROUP option do exhibit a bias to overestimate hourly NO<sub>2</sub> concentrations. We will provide further details regarding these recent hourly NO<sub>2</sub> model-to-monitor comparisons at a later date.

## **SUMMARY**

To summarize, we emphasize the following points:

1. The 3-tiered screening approach recommended in Section 5.2.4 of Appendix W for annual NO<sub>2</sub> assessments generally applies to the new 1-hour NO<sub>2</sub> standard.
2. While generally applicable, application of the 3-tiered screening approach for assessments of the new 1-hour NO<sub>2</sub> standard may entail additional considerations, such as the importance of key input data, including appropriate emission rates for the 1-hour standard vs. the annual standard for all tiers, and the representativeness of in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios and hourly background ozone concentrations for Tier 3 detailed screening methods.
3. Since the OLM and PVMRM methods in AERMOD are currently considered non-regulatory-default options, application of these options requires justification and approval by the Regional Office on a case-by-case basis as alternative modeling techniques, in accordance with Section 3.2.2, paragraph (e), of Appendix W.
4. Applications of the OLM option in AERMOD, subject to approval under Section 3.2.2.e of Appendix W, should routinely utilize the “OLMGROUP ALL” option for combining plumes.
5. While the 1-hour NAAQS for NO<sub>2</sub> is defined in terms of the 3-year average for monitored design values to determine attainment of the NAAQS, this definition does not preempt or alter the Appendix W requirement for use of 5 years of NWS meteorological data or at least 1 year of site specific data.

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## ATTACHMENT A

### Background on Hourly NO<sub>x</sub> Emissions for Permit Modeling for the 1-hour NO<sub>2</sub> NAAQS

#### Introduction

The purpose of this attachment is to address questions about availability of hourly NO<sub>x</sub> emissions for permit modeling under the new NO<sub>2</sub> NAAQS. It summarizes existing guidance regarding emission input data requirements for NAAQS compliance modeling, and provides background on the historical approach to development of inventories for NO<sub>2</sub> permit modeling and computation of hourly emissions appropriate for assessing the new 1-hour NO<sub>2</sub> standard. Although the NAAQS is defined in terms of ambient NO<sub>2</sub> concentrations, source emission estimates for modeling are based on NO<sub>x</sub>.

Under the PSD program, the owner or operator of the source is required to demonstrate that the source does not cause or contribute to a violation of a NAAQS (40 CFR 51.166 (k)(1) and 40 CFR 52.21 (k)(1)) and/or PSD increments (40 CFR 51.166 (k)(2) and 52.21 (k)(2)). However, estimation of the necessary emission input data for NAAQS compliance modeling entails consideration of numerous factors, and the appropriate reviewing authority should be consulted early in the process to determine the appropriate emissions data for use in specific modeling applications (see 40 CFR 51, Appendix W, 8.1.1.b and 8.2.3.b)

#### Summary of Current Guidance

Section 8.1 of the *Guideline on Air Quality Models*, Appendix W to 40 CFR Part 51, provides recommendations regarding source emission input data needed to support dispersion modeling for NAAQS compliance demonstrations. Table 8-2 of Appendix W provides detailed guidance regarding the specific components of the emission input data, including the appropriate emission limits (pounds/MMBtu), operating level (MMBtu/hr), and operating factor (e.g., hr/yr or hr/day), depending on the averaging time of the standard. Table 8-2 also distinguishes between the emission input data needed for the new or modified sources being assessed, and “nearby” and “other” background sources included in the modeled emission inventory.

Based on Table 8-2, emission input data for new or modified sources for annual and quarterly standards are essentially the same as for short-term standards ( $\leq 24$  hours), based on maximum allowable or federally enforceable emission limits, design capacity or federally enforceable permit conditions, and the assumption of continuous operation. However, there are a few additional considerations cited in Appendix W that could result in different emission input data for the 1-hour vs. annual NO<sub>2</sub> NAAQS. For example, while design capacity is listed as the recommended operating level for the emission calculation, peak hourly ground-level concentrations may be more sensitive than annual average concentrations to changes in stack parameters (effluent exit temperature and exit velocity) under different operating capacities. Table 8-2 specifically recommends modeling other operating levels, such as 50 percent or 75

percent of capacity, for short-term standards (see footnote 3). Another factor that may affect maximum ground-level concentrations differently between the 1-hour vs. annual standard are restrictions on operating factors based on federally enforceable permit conditions. While federally enforceable operating factors other than continuous operation may be accounted for in the emission input data (e.g., if operation is limited to 8 am to 4 pm each day), Appendix W also states that modeled emissions should not be averaged across non-operating time periods (see footnote 2 of Table 8-2).

While emission input data recommendations for “nearby” and “other” background sources included in the modeled emission inventory are similar to the new or modified source emission inputs in many respects, there is an important difference in the operating factor between annual and short-term standards. Emission input data for nearby and other sources may reflect actual operating factors (averaged over the most recent 2 years) for the annual standard, while continuous operation should be assumed for short-term standards. This could result in important differences in emission input data for modeled background sources for the 1-hour NO<sub>2</sub> NAAQS relative to emissions used for the annual standard.

### **Model Emission Inventory for NO<sub>2</sub> Modeling**

For the existing annual NO<sub>2</sub> NAAQS, the permit modeling inventory has generally been compiled from the annual state emission inventory questionnaire (EIQ) or Title V permit applications on file with the relevant permitting authority (state or local air program). Since a state uses the annual EIQ for Title V fee assessment, the state EIQ typically requires reporting of unit capacity, total fuel combusted, and/or hours of operation to help verify annual emissions calculations for fee accuracy purposes. Likewise, Title V operating permit applications contain all of the same relevant information for calculating emissions. While these emission inventories are important resources for gathering emission input data on background sources for NAAQS compliance modeling, inventories which are based on actual operations may not be sufficient for short-term standards, such as the new 1-hour NO<sub>2</sub> NAAQS. However, appropriate estimates of emissions from background sources for the 1-hour NO<sub>2</sub> standard may be derived in many cases from information in these inventories regarding permitted emission limits and operating capacity.

Historically, it has not been a typical practice for an applicant to use the EPA’s national emission inventory (NEI) as the primary source for compiling the permit modeling inventory. Since the emission data submitted to the NEI represents annual emission totals, it may not be suitable for use in NAAQS compliance modeling for short-term standards since modeling should be based on continuous operation, even for modeled background sources. Although the NEI may provide emission data for background sources that are more appropriate for the annual NO<sub>2</sub> standard, the utility of the NEI for purposes of NAAQS compliance modeling is further limited due to the fact that additional information regarding stack parameters and operating rates required for modeling may not be available from the NEI. While records exist in the NEI for reporting stack data necessary for point source modeling (i.e., stack coordinates, stack heights, exit temperatures, exit velocities), some states do not report such information to the NEI, or there are may be errors in the location data submitted to the NEI. Under such conditions, default stack information based upon SIC is substituted and use of such data could invalidate modeling results.

Building locations and dimensions, which may be required to account for building downwash influences in the modeling analysis, may also be missing or incomplete in many cases.

A common and relatively straightforward approach for compiling the necessary information to develop an inventory of emissions from background sources for a permit modeling demonstration is as follows, patterned after the draft *New Source Review Workshop Manual* (EPA, 1990). The applicant completes initial modeling of allowable emission increases associated with the proposed project and determines the radii of impact (ROI) for each pollutant and averaging period, based on the maximum distance at which the modeled ambient concentration exceeds the Significant Impact Level (SIL) for each pollutant and averaging period. Typically, the largest ROI is selected and then a list of potential background sources within the ROI plus a screening distance beyond the ROI is compiled by the permitting authority and supplied to the applicant. The applicant typically requests permit applications or EIQ submittals from the records department of the permitting authority to gather stack data and source operating data necessary to compute emissions for the modeled inventory. Once the applicant has gathered the relevant data from the permitting authorities, model emission rates are calculated. While this approach is fairly common, it should be noted that the draft workshop manual “is not intended to be an official statement of policy and standards and does not establish binding regulatory requirements” (see, Preface), and the appropriate reviewing authority should be consulted early in the process regarding the selection of appropriate background source emission inventories for the 1-hour NO<sub>2</sub> standard. We also note that Appendix W establishes “a significant concentration gradient in the vicinity of the source” under consideration as the main criterion for selection of nearby sources for inclusion in the modeled inventory, and further indicates that “the number of such [nearby] sources is expected to be small except in unusual situations.” See Section 8.2.3.b.

As mentioned previously, modeled emission rates for short-term NAAQS are computed consistent with the recommendations of Section 8.1 of Appendix W, summarized in Table 8-2. The maximum allowable (SIP-approved process weight rate limits) or federally enforceable permit limit emission rates assuming design capacity or federally enforceable capacity limitation are used to compute hourly emissions for dispersion modeling against short-term NAAQS such as the new 1-hour NO<sub>2</sub> NAAQS. If a source assumes an enforceable limit on the hourly firing capacity of a boiler, this is reflected in the calculations. Otherwise, the design capacity of the source is used to compute the model emission rate. A load analysis is typically necessary to determine the load or operating condition that causes the maximum ground-level concentrations. In addition to 100 percent load, loads such as 50 percent and 75 percent are commonly assessed. As noted above, the load analysis is generally more important for short-term standards than for annual standards. For an hourly standard, other operating scenarios of relatively short duration such as “startup” and “shutdown” should be assessed since these conditions may result in maximum hourly ground-level concentrations, and the control efficiency of emission control devices during these operating conditions may also need to be considered in the emission estimation.

## Emission Calculation Example

The hourly emissions are most commonly computed from AP-42 emission factors based on unit design capacity. For a combustion unit, the source typically reports both the unit capacity and the actual total amount of fuel combusted annually (gallons, millions of cubic feet of gas, etc.) to the permitting authority for the EI. Likewise, Title V operating permit applications will contain similar information that can be used to compute hourly emissions.

For example, assume you are modeling an uncontrolled natural gas package boiler with a design firing rate of 30 MMBtu/hr. The AP-42 emission factor for an uncontrolled natural gas external combustion source (AP-42, Section 1.4) for firing rates less than 100 MMBtu/hr is 100 lbs. NO<sub>x</sub>/10<sup>6</sup> SCF natural gas combusted. The hourly emission rate is derived by converting the emission factor expressed in terms of lbs. NO<sub>x</sub>/10<sup>6</sup> SCF to lbs. NO<sub>x</sub>/MMBtu. The conversion is done by dividing the 100 lbs. NO<sub>x</sub>/10<sup>6</sup> SCF by 1,020 to convert the AP-42 factor to lbs. NO<sub>x</sub>/MMBtu. The new emission factor is now 0.098 lbs. NO<sub>x</sub>/MMBtu.

For this example, the source has no limit on the hourly firing rate of the boiler; therefore, the maximum hourly emissions are computed by multiplying the design firing rate of the boiler by the new emission factor.

$$E_{\text{hourly}} = 0.098 \text{ lbs/MMBtu} \times 30 \text{ MMBtu/hr} = 2.94 \text{ lbs/hr}$$

Thus 2.94 lbs/hr represents the emission rate that would be input into the dispersion model for modeling against the 1-hour NO<sub>2</sub> NAAQS to comport with emission rate recommendations of Section 8.1 of Appendix W.

It is important to note that data derived for the annual state emission inventory (EI) is based on actual levels of fuel combusted for the year, and is therefore different than how allowable emissions are computed for near-field dispersion modeling. For the annual EI report, a source computes their annual emissions based upon the AP-42 emission factor multiplied by the actual total annual throughput or total fuel combusted.

In the 30 MMBtu/hr boiler example, the annual NO<sub>x</sub> emissions reported to the NEI is computed by:

$$E_{\text{annual}} = (\text{AP-42 emission factor}) \times (\text{total annual fuel combusted})$$

$$E_{\text{annual}} = (100 \text{ lbs}/10^6 \text{ SCF}) \times (100 \times 10^6 \text{ SCF/yr}) = 10,000 \text{ lbs. NO}_x/\text{yr} \text{ or } 5 \text{ tons NO}_x/\text{yr}$$