UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 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_2) National Ambient Air Quality Standard (1-hour NO_2 NAAQS or 1-hour NO_2 standard) that 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_2 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). A memorandum was issued on June 29, 2010, clarifying the applicability of current guidance in the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W) for modeling NO_2 impacts in accordance with the Prevention of Significant Deterioration (PSD) permit requirements to demonstrate compliance with the new 1-hour NO_2 standard.

This memorandum supplements the June 29, 2010 guidance memo by providing further clarification and guidance on the application of Appendix W guidance for the 1-hour NO_2 standard. Note that while the discussion of NO_x chemistry options in this memo is exclusive to the 1-hour NO_2 standard, the discussion of other topics in this memo should apply equally to the 1-hour SO_2 standard, accounting for the slight differences in the form of the 1-hour NO_2 and SO_2 standards[1]. In summary, the memo:

1. Clarifies procedures for demonstrating compliance with the 1-hour NO_2 NAAQS based on the form of the standard, including significant contribution analyses using the interim Significant Impact Level (SIL) established in the June 29, 2010 memo,

[1] The 1-hour NO_2 standard is based on the 98^{th}-percentile (8^{th}-highest) of the annual distribution of maximum daily 1-hour values, whereas the 1-hour SO_2 standard is based on the 99^{th}-percentile (4^{th}-highest) of the annual distribution of maximum daily 1-hour values.

and details updates to the AERMOD model with an internal post-processor option that supports such analyses.

2. Provides clarification on the use and acceptance of Tier 2 and Tier 3 options for NO_2, including updated model evaluation results for the OLM and PVMRM options incorporated in the AERMOD model.
3. Recommends that compliance demonstrations for the 1-hour NO_2 NAAQS address emission scenarios that can logically be assumed to be relatively continuous or which occur frequently enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations based on existing modeling guidelines, which provide sufficient discretion for reviewing authorities to not include intermittent emissions from emergency generators or startup/shutdown operations from compliance demonstrations for the 1-hour NO_2 standard under appropriate circumstances.
4. Provides additional clarification and a more detailed discussion of the factors to consider in determination of background concentrations as part of a cumulative impact assessment including identification of nearby sources to be explicitly modeled.
5. Recommends an appropriate methodology for incorporating background concentrations in the cumulative impact assessment for the 1-hour NO_2 standard and details updates to the AERMOD model with an option to include temporally-varying background concentrations within the modeling analysis.

PROCEDURES FOR DEMONSTRATING COMPLIANCE WITH 1-HOUR NO_2 NAAQS

Compliance with the 1-hour NO_2 NAAQS is based on the multiyear average of the 98th-percentile of the annual distribution of daily maximum 1-hour values not exceeding 100 ppb. The 8th-highest of the daily maximum 1-hour values across a year is an unbiased surrogate for the 98th-percentile[1]. The AERMOD dispersion model, EPA's preferred model for near-field applications under Appendix W, was recently modified (version dated 11059) to fully support the form of the 1-hour NO_2 NAAQS, as well as other analyses that may be needed in order to demonstrate that a source does not cause or contribute to a violation of the NAAQS based on the interim SIL established in the June 29, 2010, memorandum.

Application of Interim SIL to Project Impacts

Using the interim 1-hour NO_2 SIL, a permit applicant can determine: (1) whether, based on the proposed increase in NO_x emissions, a cumulative air quality analysis is required; (2) the area of impact within which a cumulative air quality analysis should focus; and (3) whether the proposed source's NO_x emissions will contribute to any modeled violation of the 1-hour NO_2 NAAQS identified in the cumulative analysis.

To determine initially whether a proposed project's emissions increase will have a significant impact (resulting in the need for a cumulative impact assessment), the June 29, 2010, memorandum recommended that the interim SIL should be compared to either of the following:

- The highest of the 5-year averages of the maximum modeled 1-hour NO_2 concentrations predicted each year at each receptor, based on 5 years of National Weather Service data; or
- The highest modeled 1-hour NO_2 concentration predicted across all receptors based on 1 year of site-specific meteorological data, or the highest of the multi-year averages of the maximum modeled 1-hour NO_2 concentrations predicted each year at each receptor, based on 2 or more years, up to 5 complete years of available site-specific meteorological data.

Since the form of the standard is based on the annual distribution of daily maximum 1-hour values, the maximum contribution that a project could make to the air quality impact at a receptor is the multiyear average of the highest 1-hour values at that receptor. If the multiyear average of the highest 1-hour values is below the SIL at all receptors, then the project could not contribute significantly to any modeled violations of the 1-hour NO_2 NAAQS, thus exempting that project from the cumulative impact assessment.

<u>Application of Interim SIL to Cumulative Impact Assessment</u>

If a project's impacts exceed the SIL at any receptors based on this initial impact analysis, then a cumulative impact assessment should be completed to determine whether the project will cause or contribute to any modeled violations of the NAAQS. While not common practice in the past, given the more complex analysis procedures associated with the form of the 1-hour NO_2 NAAQS, we deem it appropriate and acceptable in most cases to limit the cumulative impact analysis to only those receptors that have been shown to have significant impacts from a proposed new source based on the initial SIL analysis, assuming that the design of the original receptor grid was adequate to determine all areas of ambient air where the source could contribute significantly to modeled violations. This may especially be appropriate for the 1-hour NO_2 standard since the initial modeling of the project emissions without other background emission sources may have a tendency to overestimate ambient NO_2 concentrations, even under Tier 3 applications, by understating the potential ozone limiting influence of the background NO_x emissions. If modeled violations of the NAAQS are found based on the cumulative impact assessment, then the project's contribution to all modeled violations should be compared to the interim SIL to determine whether the project causes or contributes to any of the modeled violations.

In past guidance (EPA, 1988), EPA has indicated that the significant contribution analysis should be based on a source's contribution to the modeled violation paired in time and space. The form of the 1-hour NO_2 NAAQS complicates this analysis since the modeled violation is based on a multiyear average of the annual distribution of daily maximum 1-hour values, i.e., a particular modeled violation at a particular receptor represents an average based on specific hours on specific days from each of the five years of meteorological data (for National Weather Service (NWS) data). It is important to point out here that the significant contribution analysis is not limited to analyzing the source's contribution associated only with the modeled design value based on the 98^{th}-percentile cumulative air quality impact at the receptor, but rather must examine all cases where the cumulative impact exceeds the NAAQS at or below the 98^{th}-

percentile. In some cases a source's contribution to the 98th-percentile of the daily maximum 1-hour values from the cumulative impact (i.e., the cumulative impact value or modeled design value that is compared to the NAAQS) may be below the SIL, while the source's contribution to cumulative impacts below the 98th-percentile but above the NAAQS could exceed the SIL. Therefore, the significant contribution analysis should examine every multiyear average of daily maximum 1-hour values, beginning with the 8th-highest (98th-percentile)[2], continuing down the ranked distribution until the cumulative impact is below the NAAQS. Since the form of the standard is based on the annual distribution of daily maximum 1-hour values, the significant contribution analysis should be limited to the distribution of daily maximum 1-hour values, i.e., the 2nd, 3rd, 4th-highest 1-hour values during the day, and so on, are not considered in this analysis. In addition, for applications with more than one year of meteorological data, the significant contribution analysis should only examine ranks paired across the years, i.e., the multiyear average of the N^{th}-highest values across each of the years processed. The recent update to the AERMOD model (dated 11059) includes an option (the MAXDCONT keyword) to automatically perform this contribution analysis (EPA, 2010b), examining the contribution from project emissions to the cumulative impacts at each receptor across a user-specified range of ranked values, paired in time and space, as an internal post-processor within the model. Other options are available in the recent AERMOD update that identify the specific data periods contributing to the cumulative modeled impacts at each receptor.

Applicability of Ambient Monitoring Requirements to Modeling Demonstrations

The June 29, 2010 memo addressed one aspect of the applicability of ambient monitoring requirements, set forth in Appendix S to 40 CFR Part 50 in relation to the 1-hour NO_2 standard[3], to modeling applications to demonstrate compliance with the NAAQS, namely the use of 3 years of ambient monitoring data as the basis for attainment of the NAAQS using monitoring vs. the use of 5 years of meteorological data for modeling demonstrations of compliance with the NAAQS. Specifically, the June 29, 2010 memo indicated that "*Although the monitored design value for the 1-hour NO_2 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*."

We would also like to emphasize that other aspects of the ambient monitoring requirements for the 1-hour NO_2 standard should not be applied for modeling analyses to demonstrate compliance with the NAAQS. For example, Appendix S addresses the data completeness requirements for monitored NO_2 concentrations, procedures for handling missing data periods, and conventions for rounding of monitored values. Appendix S specifies that a sampling day is complete if at least 75 percent of the hourly values are valid and a quarter is complete if at least 75 percent of the sampling days have complete data, and establishes calculation procedures for identifying the monitored design value that should be compared to the

[2] For the 1-hour SO_2 standard the analysis should begin with the 4th-highest, or 99th-percentile value.
[3] Appendix T to 40 CFR Part 50 addresses ambient monitoring requirements for the 1-hour SO_2 standard.

NAAQS. While the requirements of Appendix S are appropriate in the context of ambient monitoring, application of these requirements and procedures to a dispersion modeling analysis is not appropriate and may conflict with modeling guidance in many cases. Appendix W provides guidance on data completeness for meteorological data which specifically addresses the needs of dispersion modeling, including procedures that are explicitly implemented within the meteorological processor and dispersion model to account for missing data due to calm winds or other factors. Adjustments to the calculation procedures for determining the modeled design value for comparison to the NAAQS based on Appendix S data completeness criteria is not appropriate. The EPA Model Clearinghouse has also issued guidance in the past that modeled concentrations should not be rounded before comparing the modeled design value to the NAAQS. The fundamental point to recognize here is that ambient monitoring requirements/procedures and dispersion modeling guidance/procedures address different issues and needs relative to each aspect of air quality assessment, and are often motivated by different concerns and exigencies.

APPROVAL AND APPLICATION OF TIERING APPROACH FOR NO_2

Given the stringency of the 1-hour NO_2 standard relative to the annual standard, many more permit applicants may find it necessary to use the less conservative Tier 2 or Tier 3 approaches in order to demonstrate compliance with the new NAAQS rather than relying on the Tier 1 assumption of full conversion. The June 29, 2010 memo highlighted some of the potential issues that may need to be addressed in the application of these less conservative assumptions for estimating ambient NO_2 impacts, relative to the Tier 1 option of full conversion, and clarified the status of the Tier 3 PVMRM and OLM approaches available as non-regulatory-default options within the AERMOD model.

In order to ease the burden on permit applicants in addressing the need to demonstrate compliance with the 1-hour NO_2 NAAQS, as well as the burden on the permitting authority in reviewing such applications, we offer additional discussion and recommendations in relation to the use of Tier 2 and Tier 3 options. Specifically, we recommend the following:

- Use of 0.80 as a default ambient ratio for the 1-hour NO_2 standard under Tier 2 without additional justification by applicants; and

- General acceptance of 0.50 as a default in-stack ratio of NO_2/NO_x for input to the PVMRM and OLM options within AERMOD, in the absence of more appropriate source-specific information on in-stack ratios.

The following sections explain these recommendations in more detail and also discuss the relative merits of the PVMRM and OLM options, clarifying that we have not indicated any preference of one option over the other. We also provide updated model evaluation results for the PVMRM and OLM options in AERMOD that lend further credence to the use of these Tier 3 options for 1-hour NO_2 compliance demonstrations. We anticipate that these recommendations and updated model evaluations will simplify and facilitate the process of gaining approval for use of these non-regulatory default options in AERMOD.

Tier 2 Ambient Ratio Method (ARM) for NO-to-NO_2 Conversion

Regarding the Tier 2 option of applying an ambient ratio to the Tier 1 result, the June 29, 2010 memo cautioned against use of the 0.75 national default ratio recommended in Appendix W for the annual standard for estimating hourly NO_2 impacts, without some justification of the appropriateness of that assumption. We still do not consider 0.75 as an appropriate default ambient ratio for the 1-hour standard, but several references cite ambient ratios of about 0.80 for hourly NO_2/NO_x (e.g., Wang, et al., 2011; Janssen, et al., 1991), and we believe it would be appropriate to accept that as a default ambient ratio for the 1-hour NO_2 standard. Consideration was given to adopting the default equilibrium ratio of 0.90 incorporated in the PVMRM option as an hourly ARM, but we do not consider that to be an appropriate choice since it is the maximum ratio applied on a source-by-source and hourly basis, irrespective of the predicted hourly NO_x concentration, whereas the Tier 2 ARM of 0.80 would be applied to the maximum cumulative hourly NO_x concentration.

Tier 3 Options for NO-to-NO_2 Conversion

The June 29, 2010 memo clarified that the OLM and PVMRM options in the AERMOD model should be considered as Tier 3 applications under Section 5.2.4 of Appendix W. Also, since the OLM and PVMRM methods are currently implemented as non-regulatory-default options within the AERMOD dispersion model (Cimorelli, *et al.*, 2004; EPA, 2004; EPA, 2010b), their use requires justification and approval by the Regional Office on a case-by-case basis, pursuant to Sections 3.1.2.c, 3.2.2.a, and A.1.a(2) of Appendix W. The June 29 memo also highlighted the importance of two key model inputs for both the OLM and PVMRM options in the context of the 1-hour NO_2 standard, namely the in-stack ratios of NO_2/NO_x emissions and background ozone concentrations. This section provides additional discussion of these key inputs for OLM and PVMRM and also clarifies the similarities and differences between these methods and discusses their relative merits for purposes of demonstrating compliance with the 1-hour NO_2 standard.

As noted in the June 29, 2010 memo, 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_2 (Hanrahan, 1999; MACTEC, 2005). Furthermore, the original evaluations focused on model performance for annual averages since the only NO_2 standard in effect at the time was annual. We have recently updated the evaluations to reflect the current AERMOD modeling system components and extended them to examine model performance for hourly NO_2 concentrations. Preliminary results from these recent evaluations are presented in Attachment A.

While the limited scope of the available field study data imposes limits on the ability to generalize conclusions regarding model performance, these preliminary results of hourly NO_2 predictions for Palaau and New Mexico show generally good performance for the PVMRM and OLM/OLMGROUP ALL options in AERMOD. We believe that these additional model evaluation results lend further credence to the use of these Tier 3 options in AERMOD for estimating hourly NO_2 concentrations, and we recommend that their use should be generally accepted provided some reasonable demonstration can be made of the appropriateness of the key inputs for these options, the in-stack NO_2/NO_x ratio and the background ozone concentrations. Although well-documented data on in-stack NO_2/NO_x ratios is still limited for many source categories, we also feel that it would be appropriate in the absence of such source-specific in-stack data to adopt a default in-stack ratio of 0.5 as being adequately conservative in most cases and a better alternative to use of the Tier 1 full conversion or Tier 2 ambient ratio options. This value appears to represent a reasonable upper bound based on the available in-stack data. We hope that over time the range of source categories for which in-stack ratio information is available increases and the quality of such information will improve.

These preliminary model evaluation results also serve to highlight a point worth emphasizing, which is that the PVMRM option in AERMOD is not inherently superior to the OLM option for purposes of estimating cumulative ambient NO_2 concentrations. The June 29, 2010 memo indicated that both PVMRM and OLM should be considered as Tier 3 options, but did not indicate any preference between these two options. Both PVMRM and OLM simulate the same basic chemical mechanism of ozone titration, the interaction of NO with ambient ozone (O_3) to form NO_2 and O_2. The main distinction between PVMRM and OLM is the approach taken to estimate the ambient concentrations of NO and O_3 for which the ozone titration mechanism should be applied. For isolated elevated point sources, the PVMRM option does represent a more refined treatment of ozone titration since it estimates the NO and O_3 available for conversion based on simulating the actual volume of the instantaneous plume as it is transported downwind. As a result, this method will generally provide a more realistic simulation of the NO-to-NO_2 conversion rate along the path of the plume for a particular source, accounting for the influence of meteorological conditions on the entrainment of O_3 associated with growth of the plume. However, the algorithm incorporated in PVMRM for determining which plumes "compete" for available ozone for multi-source applications has not been thoroughly validated, and as shown in the model evaluation results for New Mexico, PVMRM may not always provide a "better" answer than the OLM option.

The PVMRM algorithm as currently implemented may also have a tendency to overestimate the conversion of NO to NO_2 for low-level plumes by overstating the amount of ozone available for the conversion due to the manner in which the plume volume is calculated. The plume volume calculation in PVMRM does not account for the fact that the vertical extent of the plume based on the vertical dispersion coefficient may extend below ground for low-level plumes. This overestimation of the volume of the plume could contribute to overestimating conversion to NO_2. The PVMRM option has further limitations for area source applications, especially for elongated area sources that may be used to simulate road segments. In these cases, the lateral extent of the plume used in calculating the plume volume depends on the projected width of the area source, even if only a portion of the area source actually impacts a nearby receptor. This again would tend to overestimate the volume of the plume for purposes of determining the amount of ozone available for conversion of NO to NO_2, and would likely overestimate ambient NO_2 concentrations. In light of these issues, a series of volume sources rather than elongated area sources is recommended for simulating NO_2 impacts from roadway emissions with PVMRM, especially for receptors located relatively close to the roadway. Furthermore, the OLM option with OLMGROUP ALL was used to estimate NO_2 concentrations from mobile source emissions modeled as area sources for the Atlanta area as part of the EPA's

Risk and Exposure Assessment (REA) for the most recent NO_2 NAAQS review (EPA, 2008). Results of model-to-monitor comparisons from the REA show generally good performance, suggesting that use of OLM with OLMGROUP ALL is appropriate for modeling such emissions.

TREATMENT OF INTERMITTENT EMISSIONS

Modeling of intermittent emission units, such as emergency generators, and/or intermittent emission scenarios, such as startup/shutdown operations, has proven to be one of the main challenges for permit applicants undertaking a demonstration of compliance with the 1-hour NO_2 NAAQS. Prior to promulgation of the new 1-hour NO_2 standard, the only NAAQS applicable for NO_2 was the annual standard and these intermittent emissions typically did not factor significantly into the modeled design value for the annual standard. Sources often take a 500 hour/year permit limit on operation of emergency generators for purposes of determining the potential to emit (PTE), but may actually operate far fewer hours than the permitted limit in many cases and generally have not been required to assume continuous operation of these intermittent emissions for purposes of demonstrating compliance with the annual NAAQS. Due in part to the relatively low release heights typically associated with emergency generators, an assumption of continuous operation for these intermittent emissions would in many cases result in them becoming the controlling emission scenario for determining compliance with the 1-hour standard.

EPA's guidance in Table 8-2 of Appendix W involves a degree of conservatism in the modeling assumptions for demonstrating compliance with the NAAQS by recommending the use of maximum allowable emissions, which represents emission levels that the facility could, and might reasonably be expected to, achieve if a PSD permit is granted. However, the intermittent nature of the actual emissions associated with emergency generators and startup/shutdown in many cases, when coupled with the probabilistic form of the standard, could result in modeled impacts being significantly higher than actual impacts would realistically be expected to be for these emission scenarios. The potential overestimation in these cases results from the implicit assumption that worst-case emissions will coincide with worst-case meteorological conditions based on the specific hours on specific days of each of the years associated with the modeled design value based on the form of the hourly standard. In fact, the probabilistic form of the standard is explicitly intended to provide a more stable metric for characterizing ambient air quality levels by mitigating the impact that outliers in the distribution might have on the design value. The February 9, 2010, preamble to the rule promulgating the new 1-hour NO_2 standard stated that "it is desirable from a public health perspective to have a form that is reasonably stable and insulated from the impacts of extreme meteorological events." 75 FR 6492. Also, the Clean Air Science Advisory Committee (CASAC) "recommended a 98^{th}-percentile form averaged over 3 years for such a standard, given the potential for instability in the higher percentile concentrations around major roadways." 75 FR 6493.

To illustrate the importance of this point, consider the following example. Under a deterministic 1-hour standard, where the modeled design value would be based on the highest of the second-highest hourly impacts (allowing one exceedance per year), a single emission episode lasting 2 hours for an emergency generator or other intermittent emission scenario could determine the modeled design value if that episode coincided with worst-case meteorological conditions. While the probability of a particular 2-hour emission episode actually coinciding with the worst-case meteorological conditions is relatively low, there is nonetheless a clear linkage between a specific emission episode and the modeled design value. By contrast, under the form of the 1-hour NO_2 NAAQS only one hour from that emission episode could contribute to the modeled design value, i.e., the daily maximum 1-hour value. However, by assuming continuous operation of intermittent emissions the modeled design value for the 1-hour NO_2 NAAQS effectively assumes that the intermittent emission scenario occurs on the specific hours of the specific days for each of the specific years of meteorological data included in the analysis which factor into the multiyear average of the 98th-percentile of the annual distribution of daily maximum 1-hour values. The probability of the controlling emission episode occurring on this particular temporal schedule to determine the design value under the probabilistic standard is significantly smaller than the probability of occurrence under the deterministic standard; thereby increasing the likelihood that impact estimates based on assuming continuous emissions would significantly overestimate actual impacts for these sources.

Given the implications of the probabilistic form of the 1-hour NO_2 NAAQS discussed above, we are concerned that assuming continuous operations for intermittent emissions would effectively impose an additional level of stringency beyond that intended by the level of the standard itself. As a result, we feel that it would be inappropriate to implement the 1-hour NO_2 standard in such a manner and recommend that compliance demonstrations for the 1-hour NO_2 NAAQS be based on emission scenarios that can logically be assumed to be relatively continuous or which occur frequently enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. EPA believes that existing modeling guidelines provide sufficient discretion for reviewing authorities to exclude certain types of intermittent emissions from compliance demonstrations for the 1-hour NO_2 standard under these circumstances.

EPA's *Guideline on Air Quality Models* provides recommendations regarding air quality modeling techniques that should be applied in preparation or review of PSD permit applications and serves as a "common measure of acceptable technical analysis when supported by sound scientific judgment." 40 C.F.R. Part 51, Appendix W, section 1.0.a. While the guidance establishes principles that may be controlling in certain circumstances, the guideline is not "a strict modeling 'cookbook'" so that, as the guideline notes, "case-by-case analysis and judgment are frequently required." Section 1.0.c. In particular, with respect to emissions input data, section 8.0.a. of Appendix W establishes the general principle that "the most appropriate data available should always be selected for use in modeling analyses," and emphasizes the importance of "the exercise of professional judgement by the appropriate reviewing authority" in determining which nearby sources should be included in the model emission inventory. Section 8.2.3.b.

For the reasons discussed above, EPA believes the most appropriate data to use for compliance demonstrations for the 1-hour NO_2 NAAQS are those based on emissions scenarios that are continuous enough or frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. Section 8.1.1.b of the guideline also provides that "[t]he appropriate reviewing authority should be consulted to determine appropriate source definitions and for guidance concerning the determination of emissions from and techniques for modeling various source types." When EPA is the reviewing authority for a permit, for the reasons described above, we will consider it acceptable to limit the emission scenarios included in the modeling compliance demonstration for the 1-hour NO_2 NAAQS to those emissions that are continuous enough or frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. Consistent with this rationale, the language in Section 8.2.3.d of Appendix W states that "*[i]t is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) being modeled.*" While we recognize that these intermittent emission sources could operate at the same time as the primary source(s), the discussion above highlights the additional level of conservatism in the modeled impacts inherent in an assumption that they do in fact operate simultaneously and continuously with the primary source(s).

The rationale regarding treatment of intermittent emissions applies for both project emissions and any nearby or other background sources included in the modeling analysis. However, this rationale does not apply to the load analysis recommended in Table 8-2 of Appendix W, since various operating loads are not by design intended to be intermittent. Appendix W, Section 8.1.2.a. With respect to the operating level, for the proposed new or modified source, Table 8-2 calls for using "[d]esign capacity or federally enforceable permit condition." With respect to nearby sources, the guidelines call for estimating emissions based on "[a]ctual or design capacity (whichever is greater), or federally enforceable permit condition." Footnote 3 to the table notes that "[o]perating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration." The justification for not including certain intermittent operations described in this memo does not apply to these guidelines that address analyzing the load causing the highest concentration.

We recognize that case-specific issues and factors may arise that affect the application of this guidance, and that not all facilities required to demonstrate compliance with the 1-hour NO_2 NAAQS will fit within the scenario described above with clearly defined continuous/normal operations vs. intermittent/infrequent emissions. Additional discretion may need to be exercised in such cases to ensure that public health is protected. For example, an intermittent source that is permitted to operate up to 500 hours per year, but typically operates much less than 500 hours per year and on a random schedule that cannot be controlled would be appropriate to consider under this guidance. On the other hand, an "intermittent" source that is permitted to operate only 365 hours per year, but is operated as part of a process that typically occurs every day, would be less suitable for application of this guidance since the single hour of emissions from each day could contribute significantly to the modeled design value based on the annual distribution of daily maximum 1-hour concentrations. Similarly, the frequency of startup/shutdown emission scenarios may vary significantly depending on the type of facility. For example, a large base-load power plant may experience startup/shutdown events on a relatively infrequent basis whereas as a peaking unit may go through much more frequent startup/shutdown cycles. It may be appropriate to apply this guidance in the former case, but not the latter.

Another aspect of intermittent emissions worth noting is the distinction between intermittent emissions that can be scheduled with some degree of flexibility vs. intermittent emissions that cannot be scheduled. For example, a portion of emissions from an emergency generator are likely to be associated with regular testing of the equipment that may be required to ensure its reliable operation, while that portion of emergency generator emissions associated with actual emergency use typically cannot be scheduled. In this case it may be appropriate to include a permit condition that restricts operation of the emergency generator during testing to certain hours of the day, which may mitigate that source's contribution to ambient NO_2 levels based on dispersion conditions. Limiting operation to specific time periods is an appropriate permit condition under Appendix W guidance and would not constitute a "dispersion technique" subject to Section 123 of the CAA. In this case the portion of the emissions associated with scheduled testing can be accounted for more realistically by limiting the hours modeled to account for meteorological conditions that are more representative of actual operations.

Another approach that may be considered in cases where there is more uncertainty regarding the applicability of this guidance would be to model impacts from intermittent emissions based on an average hourly rate, rather than the maximum hourly emission. For example, if a proposed permit includes a limit of 500 hours/year or less for an emergency generator, a modeling analysis could be based on assuming continuous operation at the average hourly rate, i.e., the maximum hourly rate times 500/8760. This approach would account for potential worst-case meteorological conditions associated with emergency generator emissions by assuming continuous operation, while use of the average hourly emission represents a simple approach to account for the probability of the emergency generator actually operating for a given hour. Also note that the contribution of intermittent emissions to annual impacts should continue to be addressed as in the past to demonstrate compliance with the annual NO_2 standard.

A final point of clarification regarding intermittent emissions that deserves some emphasis is that the guidance provided here in relation to determining compliance with the 1-hour NO_2 NAAQS through dispersion modeling has no effect on or relevance to the existing policies and guidance regarding excess emissions that may occur during startup and shutdown, where such excess emissions violate applicable emission limitations[4]. In other words, all emissions from a new or modified source are subject to the applicable permitted emission limits and may be subject to enforcement action regarding such excess emissions, regardless of whether a portion of those emissions are not included in the modeling demonstration based on the guidance provided here.

Given the added complexity of the technical issues that arise in the context of demonstrating compliance with the 1-hour NO_2 NAAQS through dispersion modeling, we strongly encourage adherence to the recommendations in Section 10.2.1. of Appendix W that "*[e]very effort should be made by the Regional Office to meet with all parties involved in either a SIP revision or a PSD permit application prior to the start of any work on such a project. During this meeting, a protocol should be established between the preparing and reviewing parties to define the procedures to be followed, the data to be collected, the model to be used, and the analysis of the source and concentration data.*"

[4] While excess emissions during malfunctions are also addressed in the policy related to excess emissions, Appendix W explicitly excludes emissions due to malfunction from the modeling analysis to demonstrate compliance with the NAAQS, unless the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions. See Section 8.1.2.a, footnote a.

DETERMINING BACKGROUND CONCENTRATIONS

Unless a facility can demonstrate that ambient impacts associated from its emissions will not exceed the appropriate SIL, a cumulative analysis of ambient impacts will be necessary, and the determination of background concentrations to include in that cumulative impact assessment will be a critical component of the analysis. The June 29, 2010 memorandum addressed some aspects of this issue, but given the stringency of the new 1-hour NO_2 standard, the “margin for error” in this aspect of the analysis is much smaller than it has been in the past. As a result, we believe it is necessary to provide additional clarification and a more detailed discussion of the factors associated with this aspect of the permitting process. We hope that this additional discussion will serve to more clearly define some of the key steps and considerations in the process that could form the basis of a generic modeling protocol. We also provide suggestions regarding some of the documentation related to this component of the modeling analysis that may facilitate and expedite the review process.

The goal of the cumulative impact assessment should be to demonstrate with an adequate degree of confidence in the result that the proposed new or modified emissions will not cause or significantly contribute to violations of the NAAQS. In general, the more conservative the assumptions on which the cumulative analysis is based, the more confidence there will be that the goal has been achieved and the less controversial the review process will be from the perspective of the reviewing authority. As less conservative assumptions are implemented in the analysis, the more scrutiny those assumptions may require and the review process may tend to be lengthier and more controversial as a result. We expect that by providing a more detailed discussion of the factors to be considered in the cumulative impact assessment, permit applicants and permitting authorities will be able to find the proper balance of the competing factors that contribute to this analysis.

Identifying Nearby Sources to Include in Modeled Inventory

As noted in the June 29, 2010 memo, 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, and establishes “a significant concentration gradient in the vicinity of the source” under consideration as the main criterion for this selection. Appendix W also suggests that “the number of such [nearby] sources is expected to be small except in unusual situations.” See Section 8.2.3.b. In light of this guidance, the June 29, 2010 memo cautioned 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). This caution should not be taken to imply that the procedures outlined in the NSR Workshop Manual are flawed or inappropriate in themselves. Cumulative impact assessments based on following such procedures will generally be acceptable as the basis for permitting decisions, contingent on an appropriate accounting for the monitored contribution. Our main concern is that following such procedures in a literal and uncritical manner may in many cases result in cumulative impact assessments that are overly conservative and could unnecessarily complicate the permitting process in some cases. Such procedures might be characterized as being sufficient in most cases, but not always necessary to fulfill the requirements of a cumulative impact assessment.

A fundamental challenge in developing more detailed general guidance on the issue of determining background concentrations as part of a cumulative impact assessment is that the factors that need to be considered are very case-specific in nature. These factors include foremost the nature of the source being permitted, including the source characteristics and local meteorological and topographical factors that determine the spatial and temporal patterns of the source's ambient impacts. The initial significant impact assessment should serve to characterize these factors, and we would suggest the following:

1. As a standard practice contour plots of modeled concentrations should be prepared which clearly depict the impact area of the source, preferably overlaid on a map of the area that identifies key geographical features that may influence the dispersion patterns. The concentration contour plot also serves to visually depict the concentration gradients associated with the source's impact.
2. We also recommend that the controlling meteorological conditions for the project impacts be identified as clearly as possible. The probabilistic form of the 1-hour NO_2 standard complicates this assessment somewhat, but the recent update to the AERMOD model includes new model output options (MAXDAILY and MXDYBYYR keywords) that identify the specific time periods on which the modeled design value is based.
3. As an aid to interpreting this information, we also suggest including the location of the meteorological monitoring station used in the modeling analysis on the plot of source impacts, as well as a wind rose depicting general flow patterns.

If a cumulative impact assessment is required due to the source's impacts exceeding the interim SIL, the applicant will need to identify and acquire data on the two main components of the cumulative impact assessment, namely the location and emissions from nearby background sources that may need to be included in the modeled component of the cumulative ambient impact assessment, and the location and magnitude of air quality data from ambient NO_2 monitors located within the area. Section 8.2.1.b of Appendix W states that "[t]ypically, air quality data should be used to establish background concentrations in the vicinity of the source(s) under consideration." Section 8.2.1.c further states that "[i]f the source is not isolated, it may be necessary to use a multi-source model to establish the impact of nearby sources." While many applications will be required to include both monitored and modeled contributions to adequately account for background concentrations in the cumulative analysis, we believe that these statements imply a preference for use of ambient air quality data to account for background concentrations where possible.

Many of the challenges and more controversial issues related to cumulative impact assessments arise in the context of how best to combine a monitored and modeled contribution to account for background concentrations. Addressing these issues requires an assessment of the spatial and temporal representativeness of the background monitored concentrations for purposes of the cumulative impact assessment and the potential for double counting of impacts from modeled sources that may be contributing to the monitored concentrations. This assessment may involve significant technical details which could complicate the review process. Therefore, the more thoroughly and clearly these issues are documented the more efficient and effective the review process is likely to be.

A key point to remember when assessing these issues is their interconnectedness – the question of which nearby background sources should be included in the cumulative modeling analysis is inextricably linked with the question of what ambient monitoring data is available and what that data represents in relation to the application. Furthermore, the question of how to appropriately combine monitored and modeled concentrations (temporally and spatially) to determine the cumulative impact depends on a clear understanding of what the ambient monitored data represents in relation to the modeled emission inventory. A more detailed temporal pairing of monitored and modeled concentrations may be acceptable in one case given the extent of the modeled emission inventory, while a more conservative assumption for combining monitored and modeled concentrations using high ranked monitored concentrations may be sufficient to justify a more limited modeling inventory. As noted above, the stringency of the new standard may require a more detailed and refined analysis of these issues in order to demonstrate compliance with the standards than was necessary in the past, and these refinements will generally increase the burden on the applicant to adequately demonstrate that the net result of the analysis is protective of the standard. A detailed analysis and explanation of any potential bias to the net result introduced by proposed refinements will be important to facilitate the review process. The issues associated with determining an appropriate method for combining modeled and monitored contributions to a cumulative impact assessment are discussed in more detail in the next section.

Building on the geographical information recommended above for the initial SIL analysis, we suggest including the following documentation:

1. A geographical depiction of the location and magnitude of nearby emission sources, along with the location and magnitude of any ambient monitored data as part of the documentation submitted with a cumulative impact assessment.
2. Depicting the impact area and pattern of the project impacts on such a figure along with a wind rose should be useful in assessing many of the issues touched on above, such as what nearby sources are likely to cause significant concentration gradients in the vicinity of the project source, or more specifically in the areas of high impacts associated with the project source. This figure should also help to identify what nearby source's impacts are likely to be adequately represented in the available monitored data and the potential for double counting of impacts from modeled background sources if certain ambient background data are used.
3. In addition to a standard wind rose, pollution roses (i.e., a depiction of monitored pollutant concentrations as a function of wind direction and/or other meteorological factors) should also be useful for purposes of assessing the representativeness of the monitoring background concentrations in relation to the cumulative impact assessment.

Finally, we reiterate the importance of close coordination with the appropriate reviewing authority in the determination of nearby or other sources to include in the modeled emission inventory.

<u>Significant Concentration Gradient Criterion</u>

While Appendix W (Section 8.2.3.b) identifies "a significant concentration gradient in the vicinity of the source" as the sole criterion in relation to determining which nearby sources should be explicitly modeled as part of the cumulative impact assessment, little else has been written to explain what "significant" means in this context or even what the relevance of a "significant concentration gradient" is for this purpose. In fact, Appendix W states that no attempt was made to "comprehensively define" the term, "owing to both the uniqueness of each modeling situation and the large number of variables involved in identifying nearby sources." Section 8.2.3.b. Nothing has fundamentally changed to alter this characterization, but given the issues and challenges arising from the implementation of the new 1-hour NO_2 standard, we feel compelled to offer some additional explanation regarding what this guidance means and how it should be applied.

One definition of the term "gradient" that applies in this context is "the rate of change of a physical quantity . . . with distance[5]." In this case the physical quantity is the ground-level concentration of the pollutant being assessed. The first point worth noting is that the gradient of the ground-level concentration has two dimensions, a longitudinal (along-wind) gradient and a lateral (cross-wind) gradient. Appendix W makes no distinction as to which gradient is more important or whether both gradients should be considered. Before offering any suggestions on that question, it might be helpful to offer some thoughts on the question of why a significant concentration gradient is mentioned as the sole criterion. Since an ambient monitor is limited to characterizing air quality at a fixed location, the impact from a nearby source that causes a significant concentration gradient in the vicinity of the project source is not likely to be characterized very well by the monitored concentration in terms of its potential for contributing to the cumulative modeled design value due to the high degree of variability of the source's impact. In this sense both the longitudinal and lateral gradients could be of importance. However, since the location of impacts from a particular source relative to other sources being modeled or relative to the ambient monitor location is strongly influenced by the transport wind direction, relatively minor changes in wind direction can result in significant changes in modeled concentrations at a particular time and point in space, such as the monitor location. The longitudinal gradient will also vary as a result of changes in wind speed and atmospheric stability, but in general the impact of this longitudinal variability on concentrations at a particular time and point in space will be less significant than the variability associated with the lateral gradient. From this perspective it would appear that the lateral gradient may be more important to consider for purposes of assessing which background sources should be explicitly modeled.

Concentration gradients associated with a particular source will generally be largest between the source location and the distance to the maximum ground-level concentrations from the source. Beyond the maximum impact distance, concentration gradients will generally be much smaller and more spatially uniform. A general "rule of thumb" for estimating the distance

[5] Webster's New World College Dictionary, Copyright © 2010 by Wiley Publishing, Inc., Cleveland, Ohio.

to maximum 1-hour impact and the region of significant concentration gradients that may apply in relatively flat terrain is approximately 10 times the source release height. For example, the maximum impact area and region of significant concentration gradients associated with a 100 meter stack in flat terrain would be approximately 1,000 meters downwind of the source, with some variation depending on the source characteristics affecting plume rise. However, the potential influence of terrain on maximum 1-hour pollutant impacts may also significantly affect the location and magnitude of concentration gradients associated with a particular source. Even accounting for some terrain influences on the location and gradients of maximum 1-hour concentrations, these considerations suggest that the emphasis on determining which nearby sources to include in the modeling analysis should focus on the area within about 10 kilometers of the project location in most cases. The routine inclusion of all sources within 50 kilometers of the project location, the nominal distance for which AERMOD is applicable, is likely to produce an overly conservative result in most cases.

The relative importance of the lateral vs. the longitudinal gradient will also depend on terrain effects and other factors, such as the atmospheric stability associated with worst-case impacts. The importance of the lateral gradient relative to the longitudinal gradient will generally increase for sources where maximum hourly impacts occur under stable conditions due to the narrowness of the plume under such conditions. The contour plots of modeled design values suggested above provide a method for examining concentration gradients more explicitly. The AERSCREEN model should also serve as a useful tool for identifying the worst-case meteorological conditions for individual sources, as well as determining locations of maximum impact and areas of significant concentration gradients.

A final point to mention in relation to this topic is that the pattern of concentration gradients can vary significantly based on the averaging period being assessed. In general, concentration gradients will be smaller and more spatially uniform for annual averages than for short-term averages, especially hourly averages. The spatial distribution of annual impacts around a source will typically have a single peak "downwind" of the source based on the prevailing wind direction, except in cases where terrain or other geographical effects are important. By contrast, the spatial distribution of peak hourly impacts will typically show several localized concentration peaks with more significant gradients. The number of peaks and the magnitude of the gradients will be somewhat smaller for modeled design values based on the form of the 1-hour NO_2 standard than for overall peak hourly values, due to the smoothing effect of using a multiyear average of the 98^{th}-percentile from the annual distribution of daily maximum values. One implication of these differences between long-term and short-term concentration patterns is that the factors affecting which sources should be included in the modeled inventory and the method for combining modeled with monitored concentrations are more complex for the 1-hour NO_2 standard than for the annual standard.

While we hope this discussion provides some useful insight into this issue, we also caution against interpreting this guidance too literally or too narrowly, and emphasize that a "large number of variables" (Appendix W, Section 8.2.3.b) are involved in this assessment.

COMBINING MODELED RESULTS AND MONITORED BACKGROUND TO DETERMINE COMPLIANCE

One important aspect of the cumulative impact assessment that also deserves further discussion and entails new challenges with the 1-hour NO_2 NAAQS is the method for combining modeled concentrations with monitored background concentrations to determine the cumulative ambient impact. The June 29, 2010 memo indicated that a “first tier” assumption for a uniform monitored background contribution that may be applied without further justification is to add the overall highest hourly background NO_2 concentration (across the most recent three years) from a representative monitor to the modeled design value[6] for comparison to the NAAQS. Use of a single uniform monitored background contribution is the simplest approach to implement since it can be applied outside of the modeling system. We recognize that use of the overall highest hourly background concentration may be overly conservative in many cases, but that conservatism also provided the basis for indicating that this approach could be used without further justification. As explained above, the more conservative the assumptions on which the cumulative analysis is based, the more confidence there will be that the goal of demonstrating that the source will not cause or contribute to violations of the NAAQS has been achieved and the less controversial the review process will be from the perspective of the reviewing authority. The June 29, 2010 memo also indicated that 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. Given the importance of this aspect of the analysis and the challenges that have arisen in application of the guidance to date, we feel compelled to offer additional guidance on this issue.

While the “first tier” assumption from the June 29, 2010 memo of using a uniform monitored background contributions based on the overall highest hourly background NO_2 concentration should be acceptable without further justification in most cases, we recognize that this approach could be overly conservative in many cases and may also be prone to reflecting source-oriented impacts from nearby sources, increasing the potential for double-counting of modeled and monitored contributions. Based on these considerations, we believe that a less conservative “first tier” for a uniform monitored background contribution based on the monitored design value from a representative monitor should be acceptable in most cases. The monitored NO_2 design value, i.e., the 98^{th}-percentile of the annual distribution of daily maximum 1-hour values averaged across the most recent three years of monitored data[7], should be used irrespective of the meteorological data period used in the dispersion modeling. This somewhat less conservative “first tier” for a uniform monitored background contribution retains the advantage of being relatively easy to implement.

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[6] The 1-hour NO_2 “modeled design value” refers to the highest (across all modeled receptors) of the 5-year average of the 98^{th}-percentile (8^{th}-highest) of the annual distribution of daily maximum 1-hour values based on NWS meteorological data, or the multiyear average of the 98^{th}-percentile of the annual distribution of daily maximum 1-hour values based on one or more complete years (up to 5 years) of site-specific meteorological data. The1-hour SO_2 “modeled design value” follows the same form except that the multiyear averages of the 99^{th}-percentile (4^{th}-highest) values are used.

[7] The monitored design value for the 1-hour SO_2 standard is based on the 99^{th}-percentile of the annual distribution of daily maximum 1-hour values averaged across the most recent three years of monitored data.

Depending on the circumstances of a particular application, use of a "first tier" assumption for a uniform monitored background contribution may represent a level of conservatism that would obviate the need to include any background sources in the modeled inventory if, for example, the number of nearby sources which could contribute to the cumulative impact is relatively few and the available ambient monitor would be expected to reflect their cumulative impacts reasonably well or conservatively in relation to the modeled design value based on the project emissions. At the other extreme, if the background source inventory included in the modeling is complete enough and background levels due to mobile sources and/or minor sources that are not explicitly modeled is expected to be small, an analysis based solely on modeled emissions and no monitored background might be considered adequate for purposes of the cumulative impact assessment.

One of the important factors to consider in relation to this issue is that the standard is based on the annual distribution of daily maximum 1-hour values, which implies that diurnal patterns of ambient impacts could play a significant role in determining the most appropriate method for combining modeled and monitored concentrations. For example, if the daily maximum 1-hour impacts associated with the project emissions generally occur under nighttime stable conditions whereas maximum monitored concentrations occur during daytime convective conditions, pairing modeled and monitored concentrations based on hour of day should provide a more appropriate and less conservative estimate of cumulative impacts than a method that ignores this diurnal pattern. This situation could occur for applications dominated by low-level sources and for elevated releases subject to plume impaction on nearby complex terrain. It is also important to consider the role of NO_x chemistry for applications using the Tier 3 options in AERMOD since diurnal patterns of background ozone concentrations may also factor into the diurnal patterns of modeled impacts. Given the potential contribution of background ozone levels to the temporal variability of modeled impacts, the seasonal variability of background monitored values could also be important. Incorporating a seasonal component to the variability of background monitored concentrations will also account for some of the variability in meteorological conditions that may contribute to high hourly impacts.

Another situation where understanding the temporal variability of modeled vs. monitored concentrations could be important in determining the most appropriate method for combining modeled and monitored concentrations is where contributions from mobile source emissions contribute significantly to either the monitored background concentrations and/or the modeled concentrations. In these cases, diurnal variability of emissions associated with morning and afternoon rush hours could contribute to the temporal variability of ambient impacts in addition to meteorological factors associated with the dispersion and conversion of NO_x emissions. Since rush hours tend to be relatively fixed in terms of time of day and also occur near the transitions from nighttime stable to daytime convective conditions, and vice versa, incorporating a seasonal or monthly element to the temporal variability should account for the variable effect that dispersion conditions may have depending on whether rush hour occurs during stable or convective hours.

With these general considerations in mind, we now examine the following guidance in relation to the use of background monitored concentrations in a cumulative impact assessment, from Section 8.2.2 of Appendix W, which applies to applications for isolated sources and for the contribution of “other sources” consisting of “[t]hat portion of the background attributable to all other sources (e.g., natural sources, minor sources and distant major sources)” in a multi-source area:

> b. Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors not impacted by the source in question, should be averaged for each separate averaging time to determine the average background value. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact. One hour concentrations may be added and averaged to determine longer averaging periods.
>
> c. If there are no monitors located in the vicinity of the source, a ‘‘regional site’’ may be used to determine background. A ‘‘regional site’’ is one that is located away from the area of interest but is impacted by similar natural and distant man-made sources.

The key principle in this guidance in relation to short-term averaging periods is to determine background concentrations associated with “meteorological conditions accompanying the concentrations of concern.” The concentrations thus determined “should be averaged for each separate averaging time to determine the average background value.”

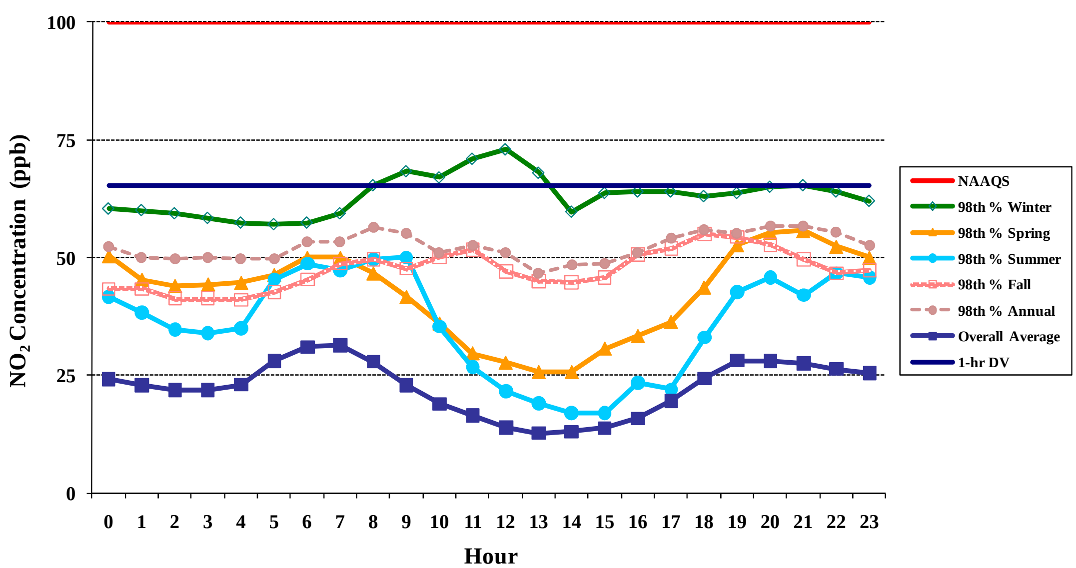
Based on this guidance, we believe that an appropriate methodology for incorporating background concentrations in the cumulative impact assessment for the 1-hour NO_2 standard would be to use multiyear averages of the 98th-percentile[8] of the available background concentrations by season and hour-of-day, excluding periods when the source in question is expected to impact the monitored concentration (which is only relevant for modified sources). For situations involving a significant mobile source component to the background monitored concentrations, inclusion of a day-of-week component to the temporal variability may also be appropriate. The rank associated with the 98th-percentile of daily maximum 1-hour values should be generally consistent with the number of “samples” within that distribution for each combination based on the temporal resolution but also account for the number of samples “ignored” in specifying the 98th-percentile based on the annual distribution. For example, Table 1 in Section 5 of Appendix S specifies the rank associated with the 98th-percentile value based on the annual number of days with valid data. Since the number of days per season will range from 90 to 92, Table 1 would indicate that the 2nd-highest value from the seasonal distribution should be used to represent the 98th-percentile. On the other hand use of the 2nd-highest value for each season would effectively “ignore” only 4 values for the year rather than the 7 values “ignored” from the annual distribution. Balancing these considerations we recommend that background values by season and hour-of-day used in this context should be based on the 3rd-highest value for each season and hour-of-day combination, whereas the 8th-highest value should be used if values vary by hour-of-day only. For more detailed temporal pairing, such as season by hour-of-

[8] The 99th-percentile should be used for the 1-hour SO_2 standard.

day and day-of-week or month by hour-of-day, the 1st-highest values from the distribution for each temporal combination should be used.[9]

Figure 1 shows the background monitored concentrations by season and hour-of-day for the Salt Lake City, UT monitor for the period 2005-2007 based on these recommendations. The values labeled "Average Winter", "Average Spring", etc. are the 3-year averages of the 3rd-highest values by hour-of-day for each season; the values labeled "Average 98th %" (the dashed line) are the 3-year average of the 8th-highest values by hour-of-day only; and the values labeled "Overall Average" are the averages across all values by hour-of-day. These results illustrate the significant temporal variability captured by the multiyear averages of the 98th-percentile values by season and hour-of-day. Also note that values for the 98th-percentile by hour-of-day only show little variation by hour-of-day, while values by season and hour-of-day show significant diurnal variability for some seasons.

Figure 1. Monitored Background Concentrations for Salt Lake City, UT Monitor
2005-2007 One-Hour NO_2 Concentrations



It should also be noted here that the conventions regarding observation reporting time differ between ambient air quality monitoring, where the observation time is based on the hour-beginning convention (EPA, 2009; see Section 3.20), and meteorological monitoring where the observation is based on the hour-ending convention (EPA, 2000; see Section 7.1). Thus, ambient monitoring data reported for hour 00 should be paired with modeled/meteorological data for hour 01, etc. The recent update to the AERMOD model (dated 11059) provides an option (the BACKGRND keyword on the SO pathway) to include temporally-varying background concentrations within the cumulative impact assessment based on these temporal factors, similar

[9] For 1-hour SO_2 analyses, use the 2nd-highest value for each season and hour-of-day combination, or the 4th-highest value for hour-of-day only. Use the 1st-highest value for more detailed pairing, such as month by hour-of-day or season by hour-of-day and day-of-week.

to the options that have been available in previous versions of the model to vary source emissions using the EMISFACT keyword. We believe that this technique provides a reasonable and efficient method for ensuring that the monitored contribution to the cumulative impact assessment will be representative of the "meteorological conditions accompanying the concentrations of concern" since the monitored values will be temporally paired with modeled concentrations based on temporal factors that are associated with meteorological variability, but will also reflect worst-case meteorological conditions in a manner that is consistent with the probabilistic form of the 1-hour NO_2 standard. The use of multiyear-averaged monitored values for the meteorological conditions of concern is consistent with the language in Appendix W related to this issue, and also consistent with the intent of using monitored background concentrations, which is to reflect the contribution from natural or regional levels of pollution and the net contribution of minor emission sources which are not explicitly accounted for in the modeled inventory.

Since several applications have come to our attention proposing to combine monitored background and modeled concentrations on an hour-by-hour basis, using hourly monitored background data collected concurrently with the meteorological data period being processed by the model, we feel compelled to include a discussion of the potential merits and concerns regarding such an approach. On the surface this approach could be perceived as being a more "refined" method than what is recommended above, and therefore more appropriate. However, the implicit assumption underlying this approach is that the background monitored levels for each hour are spatially uniform and that the monitored values are fully representative of background levels at each receptor for each hour. Such an assumption clearly ignores the many factors that contribute to the temporal and spatial variability of ambient concentrations across a typical modeling domain on an hourly basis. Therefore we do not recommend such an approach except in rare cases of relatively isolated sources where the available monitor can be shown to be representative of the ambient concentration levels in the areas of maximum impact from the proposed new source. Another situation where such an approach may be justified is where the modeled emission inventory clearly represents the majority of emissions that could potentially contribute to the cumulative impact assessment and where inclusion of the monitored background concentration is intended to conservatively represent the potential contribution from minor sources and natural or regional background levels not reflected in the modeled inventory. In this case, the key aspect which may justify the hour-by-hour pairing of modeled and monitored values is a demonstration of the overall conservatism of the cumulative assessment based on the combination of modeled and monitored impacts. Except in rare cases of relatively isolated sources, a single ambient monitor, or even a few monitors, will not be adequately representative of hourly concentrations across the modeled domain to preclude the need to include emissions from nearby background sources in the modeled inventory.

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ATTACHMENT A

Summary of AERMOD Model Performance for 1-hour NO2 Concentrations

As noted in the June 29, 2010 memo, limited evaluations of the Plume Volume Molar Ratio Method (PVMRM) for estimating conversion of NO to NO_2 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_2 (Hanrahan, 1999; MACTEC, 2005). The original evaluations of PVMRM also focused on model performance for annual averages since the only NO_2 standard in effect at the time was annual. These evaluations have recently been updated to reflect the current AERMOD modeling system components and extended to examine model performance for hourly NO_2 concentrations and to include the Ozone Limiting Method (OLM). Preliminary results from these recent evaluations are presented below in the form of Q-Q plots of ranked hourly NO_2 concentrations for the two monitors included in the New Mexico Empire Abo field study and for the single monitor included in the Palaau, HI field study. Evaluation results are also summarized in the form of predicted vs. observed 1-hour Robust Highest Concentrations (RHC), a model evaluation metric that represents an exponential tail fit to the top 26 ranked values in the distribution of hourly concentrations. Note that the OLM results presented here incorporate an equilibrium NO_2/NO_x ratio of 0.90, consistent with the PVMRM option.

Figures A-1 and A-2 show results in the form of hourly Q-Q plots for the North monitor and the South monitor, respectively, from the New Mexico field study based on the Tier 1 option of full conversion of NO to NO_2, the OLM option applied on a source-by-source basis, the OLM option applied using OLMGROUP ALL (OLMGRP), as recommended in the June 29, 2010, NO_2 clarification memorandum, and the PVMRM option. The New Mexico results clearly show the conservatism associated with the Tier 1 assumption of full conversion and the OLM option on a source-by-source basis, with both options showing a significant bias to overpredict hourly NO_2 concentrations. The OLMGRP option exhibits the best performance for both New Mexico monitors, with nearly unbiased results for the North monitor and a slight bias to overpredict for the South monitor. The PVMRM option shows significantly better performance than full conversion or source-by-source OLM for both monitors, but not as good performance as the OLMGRP option.

Figure A-3 shows the hourly Q-Q plot for Palaau based on the same range of options shown in Figures A-1 and A-2. Similar to the New Mexico results, the Tier 1 option of full conversion and the OLM option applied on a source-by-source basis show a significant bias to overpredict hourly NO_2 concentrations at Palaau. The PVMRM option shows the best performance for this field study with very good agreement between predicted and observed concentrations. The use of the OLMGRP option clearly improves model performance as compared to application of the OLM option on a source-by-source basis, with the peak predicted concentrations within a factor of 2 higher than observed. These Q-Q plot comparisons are consistent with the comparisons of RHCs summarized in Table A-1, where the average (geometric mean) ratios of Predicted/Observed RHCs for PVMRM and OLMGRP are about 1.5 and 1.2, respectively, and the average RHC ratios for OLMGRP and FULL conversion are much higher at 4.5 and 5.0.

Since these Tier 3 options in AERMOD are intended to estimate the conversion of ambient NO to NO_2, it is also useful to compare the modeled vs. observed NO_2/NO_x ratios since offsetting errors in dispersion vs. conversion could mask poor model performance. Table A-2 summarizes the observed vs. predicted NO_2/NO_x ratios for the three monitors included in these Palaau and New Mexico field studies. These results are generally consistent with the hourly Q-Q plots of NO_2 concentrations, and clearly indicate that the OLM option on a source-by-source basis significantly overestimates the conversion of NO to NO_2. However, results for the New Mexico South monitor are interesting in that the PVMRM option shows much better agreement with observed NO_2/NO_x ratios than the OLMGRP option, whereas the OLMGRP option indicates better performance than PVMRM in terms of hourly NO_2 concentrations.

These preliminary model evaluation results of hourly NO_2 predictions for Palaau and New Mexico show generally good performance for the PVMRM and OLMGROUP ALL options in AERMOD; however, it should be emphasized that these results are very limited in terms of the number of monitors. Although the scope of the field study data is limited, this level of model performance on a paired-in-space basis is impressive, especially for the PVMRM option at Palaau and for the OLMGROUP ALL option for the North monitor at New Mexico. We believe that these additional model evaluation results lend further credence to the use of these Tier 3 options in AERMOD for estimating hourly NO_2 concentrations and to the recommendation to use the OLMGROUP ALL option whenever OLM is applied.

Figure A-1. AERMOD Model Evaluation - New Mexico North Monitor - Hourly NO2 Q-Q Plot

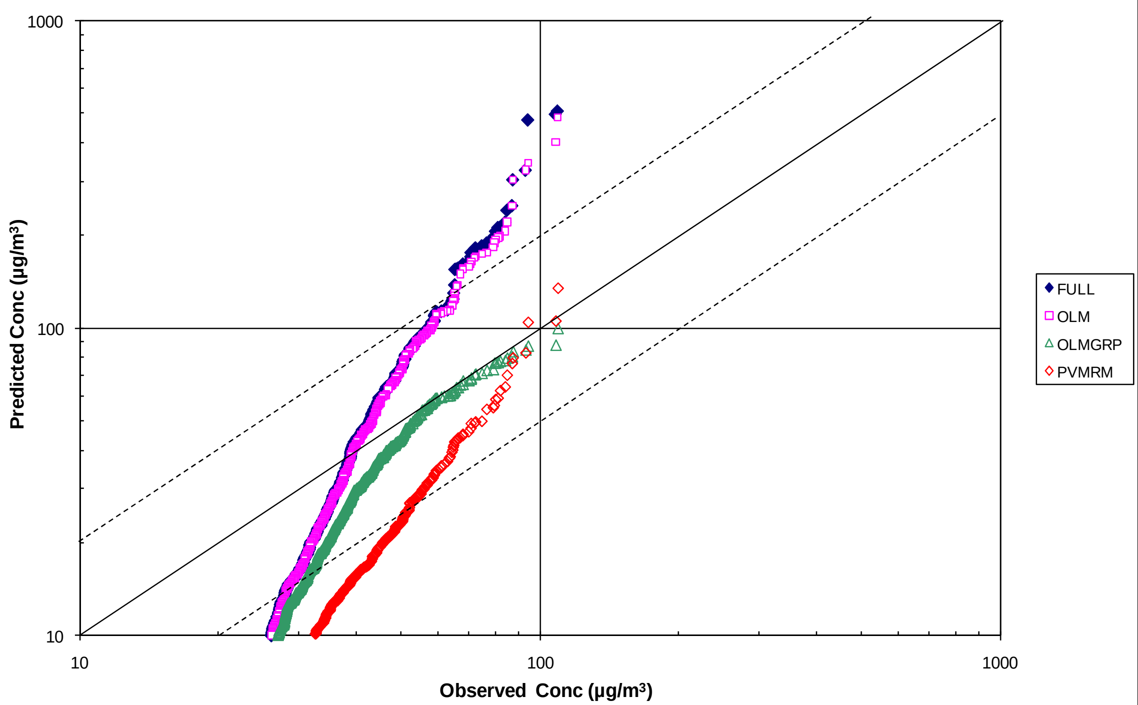
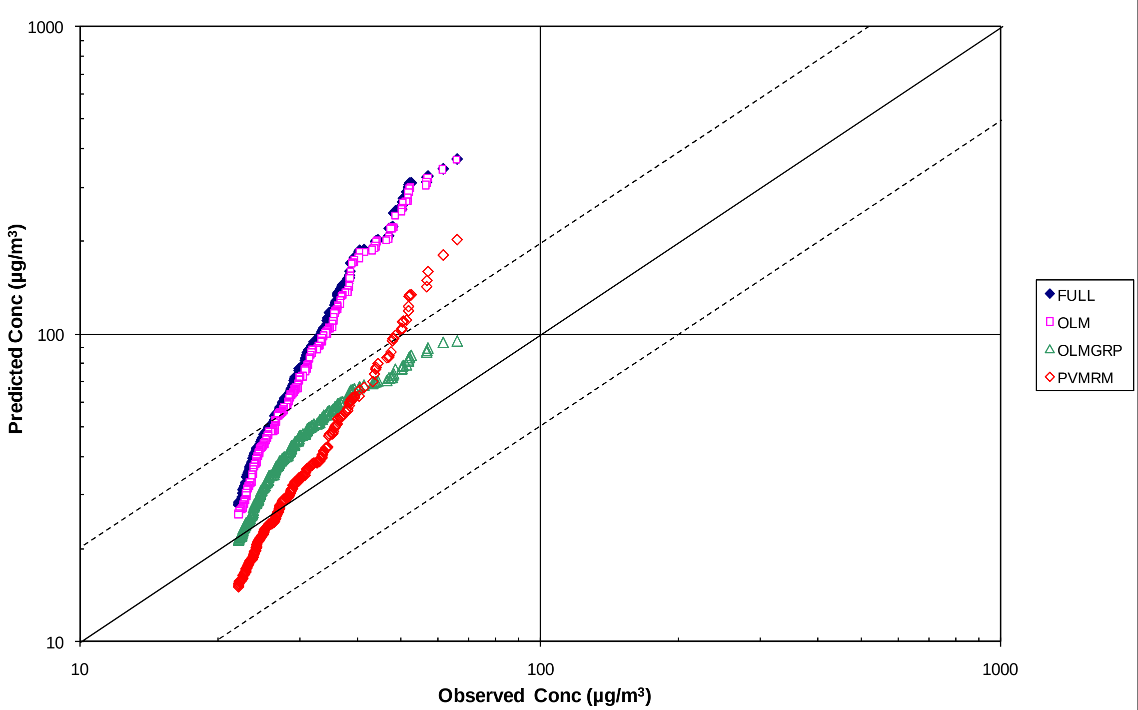


Figure A-2. AERMOD Model Evaluation - New Mexico South Monitor - Hourly NO2 Q-Q Plot



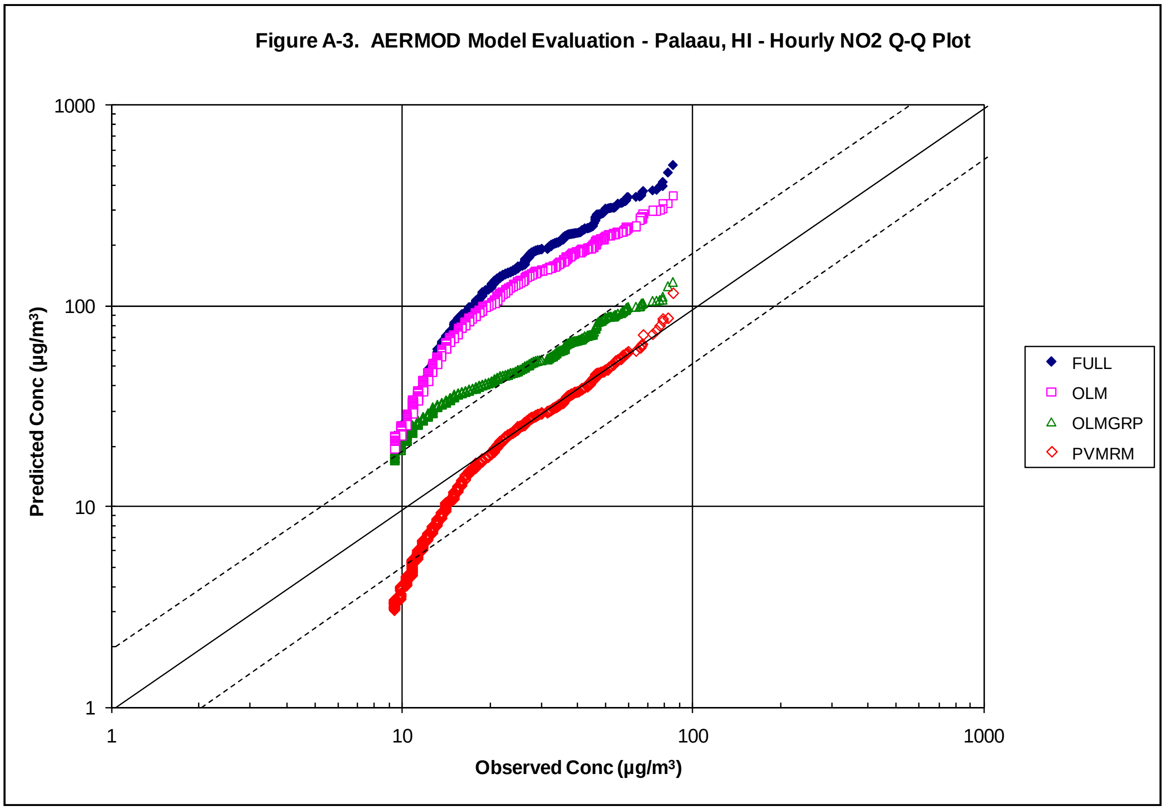


Table A-1. 1-hour NO_2 Robust Highest Concentrations ($\mu g/m^3$)

	Observed	PVMRM	OLMGRP	OLM	FULL
New Mexico Abo North Monitor RHC	117.87	116.26	108.38	444.87	449.24
New Mexico Abo South Monitor RHC	70.10	218.98	104.81	440.96	454.68
Hawaii Palaau Monitor RHC	95.42	101.57	113.18	368.57	480.38
Geometric Mean Pred/Obs RHC	---	1.486	1.177	4.510	4.993

Table A-2. Average Unpaired NO_2/NO_x Ratios for Monitored Values of NO_x > 20 ppb

	Monitored NO_2/NO_x	PVMRM NO_2/NO_x	OLMGRP NO_2/NO_x	OLM NO_2/NO_x
New Mexico Abo North Monitor (n=772)	0.455	0.377	0.669	0.976
New Mexico Abo South Monitor (n=262)	0.363	0.437	0.491	0.950
Hawaii Palaau Monitor (n=672)	0.138	0.163	0.376	0.854
Geometric Mean Pred/Obs Ratios	---	1.056	1.756	3.263