December 19, 1980

Honorable Jennings Randolph
Chairman, Committee on Environment
and Public Works
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Thank you for your letter of October 23, 1980 expressing your continued interest in the Agency's definition of "ambient air." During the time since David Hawkins, my Assistant Administrator for Air, Noise, and Radiation, met with you last February, the definition has been extensively reviewed and debated.

After reviewing the issues and alternatives, I have determined that no change from the existing policy is necessary. We are retaining the policy that the exemption from ambient air is available only for the atmosphere over land owned or controlled by the source and to which public access is precluded by a fence or other physical barriers. EPA will continue to review individual situations on a case-by-case basis to ensure that the public is adequately protected and that there is no attempt by sources to circumvent the requirement of Section 123 of the Clean Air Act.

I hope that this has been responsive to your needs.

Sincerely yours,

/s/ Douglas M. Costle

Douglas M. Costle

Exhibit BB-19

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

OCT - 9 2007

Mr. Leon Sedefian
Air Pollution Meteorologist
New York State Department of Environmental Conservation
Division of Air Resources
625 Broadway
Albany, New York 12233-3254

Re: Ambient Air for the Offshore LNG Broadwater Project

Dear Mr. Sedefian,

This is in response to your March 29, 2007 letter requesting EPA's position on the definition of ambient air particularly with respect to the proposed Broadwater offshore LNG facility in the Long Island Sound. We have consulted with our Office of Air Quality Planning and Standards and they concur with our position. As you state in your letter, EPA defines an exemption from ambient air as "the atmosphere over land owned or controlled by the source and to which public access is precluded by a fence or physical barrier." The significance of this area is that it may be exempted from the modeled assessment of air quality impacts since it is not considered "ambient air" with respect to its own emissions.

As you know, EPA's definition of ambient air does not specifically address this type of situation (i.e., offshore LNG facilities) where the source does not own the area (i.e., there is no real "property" except for the physical structure itself) nor does it have a fence or physical barrier. In the case of Broadwater, the only area that is actually owned by the facility is the circular area formed by the pivoting Floating Storage Regasification Unit (FSRU), its docks and the associated offloading structures. In addition, Broadwater does not have a fence or physical barrier which it controls. However, as you indicated in your letter, the U.S. Coast Guard (USCG) intends to establish a safety and security zone around the proposed LNG facility, which will be monitored (radar detection system in combination with a radio warning system) and enforced by the USCG. This safety zone in effect acts like a fence by precluding public access. In the case of Broadwater, this safety and security zone is currently estimated to be a 1.1 km radius surrounding the FSRU. There is also a secondary safety and security zone surrounding the LNG carrier while it is in transit but Broadwater further clarified in a June 20, 2007 letter to us that they are not proposing to use this as an ambient air boundary. Broadwater is requesting to use the 1.1 km safety and security zone as its boundary to define ambient air.

In previous permitting decisions involving offshore LNG terminals and drilling operations, EPA Regional offices have used the USCG's safety zone as the boundary for defining ambient air. (In cases where the USCG has chosen not to establish a safety zone, sources have been required to model the immediate area around the proposed source without exempting any portion from ambient air.) In those previous decisions the facilities are located in international waters where international maritime law limits the safety zone to 500 meters plus the length of the vessel. However, since Broadwater's proposed facility will not be located in international waters, the Coast Guard was able to use stricter criteria for determining the safety and security zone, and is considering setting the safety zone for the proposed Broadwater facility at 1.1 km.

The "safety zone" approach represents a reasonable surrogate for a source's fence or physical barrier and thus could act as an ambient air boundary. Therefore, EPA has determined that it is appropriate for Broadwater to use the Coast Guard's proposed safety and security zone as a surrogate for defining an ambient air boundary around the proposed LNG facility in the Sound.

In addition, you requested clarification regarding the ambient assessment from emission sources inside the ambient air boundary which are not part of Broadwater and Broadwater's impact on them. Specifically, you proposed that emissions from the docked LNG carrier be assessed inside the ambient air boundary since the boundary only pertains to Broadwater itself. In addition, you requested whether air impacts from Broadwater's emissions should be assessed on them.

In order to address this question we would like to note that in a May 3, 2007 letter from EPA (Bill Harnett, Director, Air Quality Policy Division) to Broadwater, we indicated that the offloading emissions from the docked LNG carriers should be considered part of the stationary source to which they are connected. Therefore, these emissions must be modeled as part of the source with receptors placed starting at the ambient air boundary and outward. Regarding activities at the docked LNG carrier that are not directly associated with the stationary source, (e.g., the hoteling emissions), these emissions are secondary emissions that should be included in ambient air assessments starting at the ambient air (safety zone) boundary and outward. It is not necessary for Broadwater to model impacts inside the safety zone because that area is excluded from ambient air as discussed above.

If you have questions regarding this letter you may contact Annamaria Coulter of my staff at (212) 637-4016.

Sincerely,

Steven C. Riva, Chief
Permitting Section, EPA Region 2

Exhibit BB-48

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

MAR 2 3 2010

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS

FROM: Stephen D. Page, Director
Office of Air Quality Planning and Standards

TO: See Addressees

This memorandum addresses the need for recommendations regarding appropriate dispersion modeling procedures which can be used to demonstrate compliance with $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). The need for these recommendations arises from several recent regulatory actions and proposals which increase the likelihood that applicants for permits under the new source review (NSR) and prevention of significant deterioration (PSD) programs may be required to demonstrate compliance with $PM_{2.5}$ NAAQS rather than relying upon the PM_{10} surrogate policy established in 1997. These recommendations are intended to facilitate appropriate and consistent implementation of current guidance regarding $PM_{2.5}$ dispersion modeling contained in the *Guideline on Air Quality Models*, Appendix W to 50 CFR Part 51, while acknowledging that such guidance is somewhat limited in detail due to technical issues associated with $PM_{2.5}$ modeling.

This memorandum provides recommendations on two aspects of the modeling procedures for demonstrating compliance with the $PM_{2.5}$ NAAQS. First, this memorandum discusses some of the technical issues that must be addressed by any applicant or permitting authority that is seeking to rely on the PM_{10} surrogate policy. Second, this memorandum provides additional information on modeling procedures to demonstrate compliance with $PM_{2.5}$ NAAQS without relying upon the PM_{10} surrogate policy.

BACKGROUND

On July 18, 1997, EPA revised the NAAQS for particulate matter to add new annual and 24-hour standards for fine particles using $PM_{2.5}$ as the indicator. EPA revised the 24-hour NAAQS for $PM_{2.5}$ on September 21, 2006, reducing the standard from 65 $\mu g/m^3$ to 35 $\mu g/m^3$. EPA also retained the previous 1997 annual standard for $PM_{2.5}$ and the 24-hour standard for PM_{10}, while revoking the previous annual standard for PM_{10}. For attainment of the new 24-hour $PM_{2.5}$ NAAQS based on ambient monitoring, the average of the 98^{th} percentile 24-hour values over three years of monitoring must not exceed 35 $\mu g/m^3$. The annual $PM_{2.5}$ NAAQS is set at 15 $\mu g/m^3$ based on the average of the annual mean $PM_{2.5}$ concentrations over three years.

Citing significant technical difficulties with respect to $PM_{2.5}$ monitoring, emissions estimation, and modeling, EPA established a policy, known as the PM_{10} surrogate policy, on October 23, 1997. This policy allowed permit applicants to use compliance with the applicable PM_{10} requirements as a surrogate approach for meeting $PM_{2.5}$ NSR requirements until the technical difficulties were resolved. On May 16, 2008, EPA promulgated final rules governing the implementation of the NSR program for $PM_{2.5}$, which included a "grandfathering provision" allowing applicants for federal PSD permits covered by 40 CFR § 52.21, with complete permit applications submitted as of July 15, 2008, to continue relying on the PM_{10} surrogate policy. In response to a petition challenging the continued use of the PM_{10} surrogate policy for issuing PSD permits, on June 1, 2009, EPA issued a 3-month administrative stay of the grandfathering provision for $PM_{2.5}$ affecting federal PSD permits to give EPA time to propose repealing the challenged grandfathering provision. On September 16, 2009, the original 3-month stay was extended to June 22, 2010, to allow additional time for EPA to formally propose repeal of the grandfathering provision from the $PM_{2.5}$ NSR implementation rule for federal PSD permits issues under 40 CFR § 52.21. On February 11, 2010, EPA published its proposal to repeal the grandfathering provision in the *Federal Register* at 75 FR 6827. These actions cite the fact that the technical difficulties which necessitated the PM_{10} surrogate policy have been largely, although not entirely, resolved.

As part of the proposed rulemaking to repeal the grandfathering provision contained in the federal PSD program, EPA has also proposed to end the use of the PM_{10} surrogate policy for state PSD programs that EPA has approved as part of the state implementation plan (SIP) under 40 CFR § 51.166. Under the PSD programs for $PM_{2.5}$ currently in effect for SIP-approved states, states would be allowed to continue using the PM_{10} surrogate policy until May 2011, or until EPA approves the revised SIP for $PM_{2.5}$, whichever occurs first. While we continue to allow states to use the PM_{10} surrogate policy during their transition to the new $PM_{2.5}$ requirements, we have also made it clear that the policy needs to be implemented by taking into account court decisions that address the surrogacy concept. Accordingly, an applicant seeking a PSD permit under a SIP-approved PSD program may still rely upon the PM_{10} surrogate policy as long as (1) the appropriateness of the PM_{10}-based assessment for determining $PM_{2.5}$ compliance has been adequately demonstrated based on the specifics of the project; and (2) the applicant can show that a $PM_{2.5}$ analysis is not technically feasible. Absent such demonstrations, applicants would be required to submit a $PM_{2.5}$-based assessment to demonstrate compliance with the $PM_{2.5}$ standards, in addition to meeting the other requirements under the NSR/PSD programs.

PM_{10} SURROGACY DEMONSTRATIONS

Given the need for applicants that continue to rely on the PM_{10} surrogate policy to demonstrate the appropriateness of the policy based on the specifics of the project, we feel that it is appropriate and timely to address some of the technical issues associated with a surrogacy demonstration. EPA's August 12, 2009, Administrative Order in response to petitions regarding the Title V permit for Louisville Gas and Electric Company (LG&E), Trimble Generating Station, provides a brief summary of the case law history that bears on the PM_{10} surrogacy issue which suggests that an appropriateness demonstration "would need to address the differences between PM_{10} and $PM_{2.5}$."[1] The LG&E order cites two examples in this regard: 1) "emission controls used to capture coarse particles may be less effective in controlling $PM_{2.5}$"; and 2) "particles that make up $PM_{2.5}$ may be transported over long distances while coarse particles normally only travel short distances." These examples serve to highlight the two main aspects of PSD permitting for which the appropriateness of the surrogate policy should be demonstrated: 1) the Best Available Control Technology (BACT) emission control technology assessment; and 2) the ambient air quality impact assessment to demonstrate compliance with the applicable NAAQS.

While acknowledging "an evolving understanding of the technical and legal issues associated with the use of the PM_{10} Surrogate Policy," the LG&E order offers two steps as possible approaches for making an appropriateness demonstration, without suggesting that the "two steps are necessary or sufficient to demonstrate that PM_{10} is a reasonable surrogate for $PM_{2.5}$" and clearly stating that "these two steps are not intended to be the exclusive list of possible demonstrations" regarding surrogacy. The two steps offered in the LG&E order are primarily relevant to the appropriateness demonstration regarding emission controls under BACT, while the discussion here will be focused on the appropriateness demonstration in relation to ambient air impacts.

Given the range of application-specific factors that may need to be addressed for an appropriateness demonstration in relation to ambient air impacts, it is not practical to provide detailed guidance regarding how to conduct such demonstrations. However, the following list identifies some of the "differences between PM_{10} and $PM_{2.5}$" in relation to ambient air impacts that should be addressed in the development of a surrogacy demonstration:

1. While EPA revoked in 2006 the annual PM_{10} standard that was in effect when the surrogate policy, the surrogacy demonstration would still need to address the appropriateness of the PM_{10} surrogate policy in relation to the annual $PM_{2.5}$ standard, and would likely require a modeling analysis of annual PM_{10} impacts.
2. The current 24-hour NAAQS of 35 $\mu g/m^3$ is well below the previous level of 65 $\mu g/m^3$ that was in effect when the PM_{10} surrogate policy was established. The background monitored levels of $PM_{2.5}$ are, therefore, likely to account for a more significant fraction of the cumulative impacts from a modeling analysis relative to the current 24-hour $PM_{2.5}$ NAAQS than for PM_{10}.
3. Secondary formation of $PM_{2.5}$ from emissions of NO_x, SO_x and other compounds from sources across a large domain will often contribute significantly to the total ambient levels of $PM_{2.5}$, and may be the dominant source of ambient $PM_{2.5}$ in some cases. In contrast, secondarily formed particles are less likely to be significant portion of PM_{10}, which may result in significant differences in the spatial and temporal patterns of ambient impacts between $PM_{2.5}$ and PM_{10}.

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[1] A discussion of the case law that bears on the PM_{10} surrogacy issue also appears in the February 11, 2010, proposed rule at 75 FR 6831-6832.

4. The probabilistic form of the $PM_{2.5}$ NAAQS, based on the multiyear average of the 98th percentile for the daily standard, differs from the expected exceedance form of the PM_{10} NAAQS, which allows the standard to be exceeded once per year on average using the high-sixth-high (H6H) value over 5 years. These differences affect the temporal and spatial characteristics of the ambient air impacts of PM_{10} and $PM_{2.5}$. Differences in the form of the NAAQS also complicate the process of combining modeled impacts with monitored background levels to estimate cumulative impacts under the NSR/PSD permitting programs, as well as the determination of whether modeled impacts from the facility will cause a significant contribution to any modeled violations of the NAAQS that may occur.

These factors complicate the viability of demonstrating the appropriateness of the PM_{10} surrogate policy to comply with the requirement for a $PM_{2.5}$ ambient air quality impact assessment. In light of these complications, applicants may elect to use $PM_{2.5}$ dispersion modeling to explicitly meet the requirement of an ambient air quality impact assessment under the PSD permitting program, provided that the technical difficulties with respect to $PM_{2.5}$ monitoring, emissions estimation, and modeling have been sufficiently resolved in relation to the specific application.

For surrogacy demonstrations, it is assumed that as an initial step the applicant will have conducted an appropriate dispersion modeling analysis which demonstrates compliance with the PM_{10} NAAQS, including an analysis of annual PM_{10} impacts to address item 1. A simple example illustrating when a PM_{10} modeling analysis might serve as a surrogate for $PM_{2.5}$ modeling would be if a clearly conservative assumption is made that all PM_{10} emissions are $PM_{2.5}$, and the modeled PM_{10} impacts are taken as a direct surrogate for $PM_{2.5}$ impacts and compared to the $PM_{2.5}$ NAAQS. If an adequate accounting for contributions from background $PM_{2.5}$ concentrations to the cumulative impact assessment can be made, and a reasonable demonstration that the modeled PM_{10} emission inventory adequately accounted for potential nearby sources of $PM_{2.5}$, then the appropriateness of surrogacy could be reasonably found in this example. An analysis of source-specific $PM_{2.5}$/ PM_{10} emission factor ratios may also support the assumption of a more realistic, yet still conservative approach for taking a ratio of modeled PM_{10} ambient impacts to provide conservative estimates of $PM_{2.5}$ impacts.

While additional modeling analyses, short of explicit $PM_{2.5}$ modeling, may also be used to the support the surrogacy demonstration in some cases, it is important to make a clear distinction between modeling analyses for purposes of surrogacy demonstrations and modeling analyses that are intended to explicitly demonstrate compliance with the $PM_{2.5}$ standards. The distinction between these two types of modeling analyses may not always be clear, but one important distinction is whether or not a $PM_{2.5}$ emission inventory has been developed as the basis for the modeling. The distinction between these types of modeling is important because modeling procedures that may be considered appropriate for one type of analysis may not be appropriate for the other. The following section elaborates further on this point.

$PM_{2.5}$ MODELING ANALYSES

The differences between PM_{10} and $PM_{2.5}$ described above in relation to surrogacy demonstrations, especially items 2 through 4, also have implications on how best to conduct an explicit $PM_{2.5}$ NAAQS compliance demonstration through dispersion modeling. Due to the potentially significant contribution from secondary formation of $PM_{2.5}$, and the more prominent role of monitored background concentrations of $PM_{2.5}$ in the cumulative analysis, certain aspects of standard modeling practices used for PM_{10} and other criteria pollutants may not be appropriate for $PM_{2.5}$. Our recommendations for addressing these issues in terms of explicit $PM_{2.5}$ modeling analyses are described in more detail below.

Given the issues listed above, and especially the important contribution from secondary formation of $PM_{2.5}$, which is not explicitly accounted for by the dispersion model, PSD modeling of $PM_{2.5}$ should currently be viewed as screening-level analyses, analogous to the screening nature of the guidance in Section 5.2.4 of Appendix W regarding dispersion modeling for NO_2 impacts given the importance of chemistry in the conversion of NO emissions to ambient NO_2. The screening recommendations presented below for demonstrating compliance with the $PM_{2.5}$ NAAQS through dispersion modeling have been developed with the factors listed above in mind. As with any modeling analysis conducted under Appendix W, alternative models and methods may be considered on a case-by-case basis, subject to approval by the Regional Office in accordance with the recommendations in Section 3.2 on "Use of Alternative Models."

The following sections describe the recommended modeling methods for the two main stages in a typical PSD ambient air quality analysis: 1) preliminary significant impact analysis; and 2) cumulative impact assessment. The rationale for the recommendations is also provided.

<u>Preliminary Significant Impact Analysis</u>

The initial step in air quality impact assessments under NSR/PSD is typically a significant impact level analysis to determine whether the proposed emissions increase from the proposed new or modified source (i.e., project emissions) would have a "significant" ambient impact. Thus, the first step of the ambient impact analysis is to determine whether those emissions would result in ambient air concentrations that exceed a de minimis level, referred to as the Significant Impact Level (SIL). If modeled impacts from the facility do not exceed the SIL, then the permitting authority may be able to conclude, based on this preliminary analysis, that the project would not cause or contribute to a violation of the NAAQS. Under these circumstances, EPA would not consider it necessary for the facility to conduct a more comprehensive cumulative impact assessment that would involve modeling the facility's total emissions along with emissions from other nearby background sources, and combining impacts from the modeled emission inventory with representative ambient monitored background concentrations to estimate the cumulative impact levels for comparison to the NAAQS. The SIL is also used to establish the significant impact area of the facility for purposes of determining the geographic range of the background source emission inventory that would be appropriate should a cumulative impact assessment be necessary.

EPA's 2007 proposed rule to establish PSD increments, SILs, and a Significant Monitoring Concentration (SMC) for $PM_{2.5}$ included three options for the $PM_{2.5}$ SILs for both the 24-hour and annual NAAQS. Until the $PM_{2.5}$ SILs are finalized, the proposed SILs may not be presumed to be appropriate de minimis impact levels. However, EPA does not preclude states from adopting interim de minimis impact levels for $PM_{2.5}$ to determine whether a cumulative impact analysis will be necessary, provided that states prepare an appropriate record to support the value used. Such de minimis levels do not necessarily have to match any of the SILs that have been proposed for $PM_{2.5}$, but the levels proposed by EPA and the record supporting EPA's proposed rule could be considered in the state's determination.

The modeling methods used in this initial significant impact assessment phase of the $PM_{2.5}$ analysis, based on either a state's interim de minimis levels or EPA-finalized SILs, are similar to the methods used for other pollutants, including the use of maximum allowable emissions. However, due to the probabilistic form of the NAAQS, we recommend that the highest average of the modeled annual averages across 5 years for National Weather Service (NWS) meteorological data or the highest modeled annual average for one year of site-specific meteorological data be compared to the annual screening level (SIL). Similarly, the highest average of the maximum 24-hour averages across 5 years for NWS meteorological data or the highest modeled 24-hour average for one year of site-specific meteorological data should be compared to the 24-hour screening level (SIL).

Using the average of the highest values across the years modeled preserves one aspect of the form of the NAAQS, while using the average of the <u>first</u> highest 24-hour averages rather than the 98^{th} percentile (8^{th} highest) values from the distribution is consistent with the screening-level nature of the analysis. In addition, since the $PM_{2.5}$ NAAQS is based on air quality levels averaged over time, it is appropriate to use an average modeled impact for comparison to the SIL since that will more accurately characterize the modeled contribution from the facility in relation to the NAAQS than use of the highest modeled impacts from individual years. At the present time, the dispersion modeling recommendations presented here are based on modeling only the primary or direct $PM_{2.5}$ emissions from the facility.

<u>Cumulative Impact Assessment</u>

Unless modeled ambient air concentrations of $PM_{2.5}$ from the project emissions are shown to fall below the state's de minimis level or EPA's promulgated SIL (when finalized), then a cumulative impact assessment would be necessary to account for the combined impact of facility emissions, emissions from other nearby sources, and representative background levels of $PM_{2.5}$ within the modeling domain. The cumulative impacts are then compared to the NAAQS to determine whether the facility emissions will cause or contribute to a violation of the NAAQS. Several aspects of the cumulative impact assessment for $PM_{2.5}$ will be comparable to assessments conducted for other criteria pollutants, while other aspects will differ due to the issues identified above.

Modeling Inventory

The current guidance on modeling emission inventories contained in Section 8.1 of Appendix W will generally be applicable for the $PM_{2.5}$ modeling inventory, recognizing that these recommendations only address modeling of primary $PM_{2.5}$ emissions. The guidance in Appendix W addresses the appropriate emission level to be modeled, which in most cases is the maximum allowable emission rate under the proposed permit. Nearby sources that are expected to cause a significant concentration gradient in the vicinity of the facility should generally be included in the modeled inventory. Since modeling of $PM_{2.5}$ emissions has not been a routine requirement to date, the availability of an adequate $PM_{2.5}$ emission inventory for background sources may not exist in all cases. Recommendations for developing $PM_{2.5}$ emission inventories for use in PSD applications will be addressed separately, but existing PM_{10} inventories may provide a useful starting point for this effort.

Monitored Background

The determination of representative background monitored concentrations of $PM_{2.5}$ to include in the $PM_{2.5}$ cumulative impact assessment will entail different considerations from those for other criteria pollutants. An important aspect of the monitored background concentration for $PM_{2.5}$ is that the monitored data should account for the contribution of secondary $PM_{2.5}$ formation representative of the modeling domain. As with other criteria pollutants, consideration should also be given to the potential for some double-counting of the impacts from modeled emissions that may be reflected in the background monitoring, but this should generally be of less importance for $PM_{2.5}$ than the representativeness of the monitor for secondary contributions. Also, due to the important role of secondary $PM_{2.5}$, background monitored concentrations of $PM_{2.5}$ are likely to be more homogeneous across the modeling domain in most cases, compared to other pollutants. We plan to address separately more detailed guidance on the determination of representative background concentrations for $PM_{2.5}$.

Comparison to NAAQS

Combining the modeled and monitored concentrations of $PM_{2.5}$ for comparison to the $PM_{2.5}$ NAAQS also entails considerations that differ from those for other criteria pollutants, due to the issues identified above. Given the importance of secondary contributions for $PM_{2.5}$ and the typically high background levels relative to the NAAQS for $PM_{2.5}$, greater emphasis is placed on the monitored background contribution relative to the modeled inventory. Also, given the probabilistic form of the $PM_{2.5}$ NAAQS, careful consideration must be given to how the monitored and modeled concentrations are combined to estimate the cumulative impact levels.

The representative monitored $PM_{2.5}$ design value, rather than the overall maximum monitored background concentration, should be used as a component of the cumulative analysis. The $PM_{2.5}$ design value for the annual averaging period is based on the 3-year average of the annual average $PM_{2.5}$ concentrations; for the 24-hour averaging period, the design value is based on the 3-year average of the 98^{th} percentile 24-hour average $PM_{2.5}$ concentrations for the daily standard. Details regarding the determination of the 98^{th} percentile monitored 24-hour value based on the number of days sampled during the year are provided in the ambient monitoring regulations, Appendix N to 40 CFR Part 50.

The modeled annual concentrations of (primary) $PM_{2.5}$ to be added to the monitored annual design value should be computed using the same procedure used for the initial significant impact analysis based on the highest average of the modeled annual averages across 5 years for NWS meteorological data or the highest modeled annual average for one year of site-specific meteorological data. The resulting cumulative annual concentration would then be compared to the annual $PM_{2.5}$ NAAQS of 15 $\mu g/m^3$.

For the 24-hour NAAQS analysis, the modeled concentrations to be added to the monitored 24-hour design value should be computed using the same procedure used for the preliminary analysis based on the highest average of the maximum modeled 24-hour averages across 5 years for NWS meteorological data or the maximum modeled 24-hour average for one year of site-specific meteorological data. As noted above, use of the average modeled concentration across the appropriate time period more accurately characterizes the modeled contribution from the facility in relation to the NAAQS than use of the highest modeled impact from individual years, while using the average of the first highest 24-hour averages rather than the 98^{th} percentile (8^{th} highest) values is consistent with the screening nature of $PM_{2.5}$ dispersion modeling. Furthermore, combining the 98^{th} percentile monitored with the 98^{th} percentile modeled concentrations for a cumulative impact assessment could result in a value that is below the 98^{th} percentile of the combined cumulative distribution and would, therefore, not be protective of the NAAQS.

The recommendations provided above constitute a First Tier modeling analysis for $PM_{2.5}$ compliance demonstrations. For applications where impacts from primary $PM_{2.5}$ emissions are not temporally correlated with background $PM_{2.5}$ levels, combining the modeled and monitored contributions as described above may be overly conservative. In these cases, a Second Tier modeling analysis may be considered that would involve combining the monitored and modeled $PM_{2.5}$ concentrations on a seasonal or quarterly basis, and re-sorting the total impacts across the year to determine the cumulative design value. We plan to provide separately additional details regarding this Second Tier, including a discussion of circumstances where this approach may be appropriate.

Determining Significant Contributions to Modeled Violations

If the cumulative impact assessment following these screening recommendations results in modeled violations of the $PM_{2.5}$ NAAQS, then the applicant will need to determine whether the facility emissions are causing a significant contribution to those modeled violations. A "significant contribution" determination is based on a comparison of the modeled impacts from the project emissions associated with the modeled violation to the appropriate SIL. The significant contribution determination should be made following the same procedures used during the initial significant impact analysis, based on a comparison of the average of the modeled concentrations at the receptor location showing the violation, across 5 years for NWS meteorological data and the highest modeled concentration for one year of site-specific meteorological data. For a violation of the annual NAAQS, the average of the annual values at the affected receptor(s) is compared to the SIL, while the average of the highest 24-hour average concentrations at the affected receptor(s) should be used for the 24-hour NAAQS. Use of the average modeled concentration is appropriate in this context since it is consistent with the actual contribution of the facility to the cumulative impacts at the receptor(s) showing violations and accounts for the fact that modeled violations of the 24-hour NAAQS represent average impacts across the modeling period.

Synopsis

Significant Impact Analysis: Compare the average of the highest modeled individual year's annual averages and the average of the first highest individual year's 24-hour average concentrations from project emissions to their respective screening levels, which may be based on the state's de minimis levels or EPA-finalized SILs. If modeled impacts exceed the screening levels, a cumulative impact assessment would need to be performed.

Cumulative Impact Assessment: Develop an emission inventory of background sources to be included in the modeling analysis using traditional guidance. That would include using the significant impact area established in the initial significant impact analysis, plus a 50-km annular ring to determine the geographic extent of the background emission inventory. From data obtained within this combined area, compare the average of the highest modeled individual year's annual averages and the average of the first highest individual year's 24-hour averages, plus representative background monitored concentrations, to their respective NAAQS. Monitored background concentrations are based on the 3-year average of the annual $PM_{2.5}$ concentrations, and the 3-year average of the 98^{th} percentile 24-hour averages. To determine whether the proposed project's emissions cause a significant contribution to any modeled violations of the NAAQS, the proposed project's impacts at the affected receptor(s) are determined based on the average of the highest modeled individual years' annual averages and average of the first highest individual years' 24-hour averages from the proposed project's emissions, and are compared to the state's de minimis levels or EPA-finalized SILs.

Additional Caveats

A few additional caveats should be considered while implementing these recommendations:

1. The current preferred dispersion model for near-field $PM_{2.5}$ modeling, AERMOD, does not account for secondary formation of $PM_{2.5}$. Therefore, any secondary contribution of the facility's or other modeled source's emissions is not explicitly accounted for. While representative background monitoring data for $PM_{2.5}$ should adequately account for secondary contribution from background sources in most cases, if the facility emits significant quantities of $PM_{2.5}$ precursors, some assessment of their potential contribution to cumulative impacts as secondary $PM_{2.5}$ may be necessary. In determining whether such contributions may be important, keep in mind that peak impacts due to facility primary and secondary $PM_{2.5}$ are not likely to be well-correlated in space or time, and these relationships may vary for different precursors. We plan to issue separately additional guidance regarding this issue.

2. While dry and/or wet deposition may be important processes when estimating ambient concentrations of particulate matter (PM) in general, these factors are expected to be minor for $PM_{2.5}$ due to the small particle size. In addition, there may be additional uncertainty associated with deposition modeling for $PM_{2.5}$ due to the variable makeup of the constituent elements for $PM_{2.5}$ and the fact that deposition properties may vary depending on the constituent elements of $PM_{2.5}$. Therefore, use of deposition algorithms to account for depletion in estimating ambient $PM_{2.5}$ concentrations should be done with caution and only when clear documentation and justification of the deposition parameters is provided.

3. While EPA has proposed PSD increments for $PM_{2.5}$, the increments have not been finalized yet. Until the increments are finalized, no increment analysis is required for $PM_{2.5}$. However, it should be noted that some of the recommendations presented here in relation to NAAQS modeling analyses may need to be modified for $PM_{2.5}$ increment analyses due to the differences between the forms of the NAAQS and increments. We plan to provide further clarification of these differences separately, once the increments are finalized.

This memorandum presents EPA's views on these issues concerning modeling procedures for demonstrating compliance with the $PM_{2.5}$ NAAQS. The statements in this memorandum do not bind State and local governments and the public as a matter of law. If you have any questions concerning this memorandum, please contact Tyler Fox, Leader, Air Quality Modeling Group at (919) 541-5562.

Addressees:

Bill Harnett, C504-01
Richard Wayland, C304-02
Scott Mathias, C504-01
Tyler Fox, C439-01
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EPA Regional Modeling Contacts

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

JUN 2 8 2010

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard

FROM: Tyler Fox, Leader
Air Quality Modeling Group, C439-01

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) 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_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). This memorandum clarifies 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.

SUMMARY OF CURRENT GUIDANCE

While the new 1-hour NAAQS is defined relative to ambient concentrations of NO_2, the majority of nitrogen oxides (NOx) emissions for stationary and mobile sources are in the form of nitric oxide (NO) rather than NO_2. Appendix W notes that the impact of an individual source on ambient NO_2 depends, in part, "on the chemical environment into which the source's plume is to be emitted" (see Section 5.1.j). Given the role of NOx chemistry in determining ambient impact levels of NO_2 based on modeled NOx emissions, Section 5.2.4 of Appendix W recommends the following three-tiered screening approach for NO_2 modeling for annual averages:

- Tier 1 - assume full conversion of NO to NO_2 based on application of an appropriate refined modeling technique under Section 4.2.2 of Appendix W to estimate ambient NOx concentrations;

- Tier 2 - multiply Tier 1 result by empirically-derived NO_2/NOx 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_2/NOx 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_2, based on NOx 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_2 NAAQS

In general, the Appendix W recommendations regarding the annual NO_2 standard are also applicable to the new 1-hour NO_2 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_2 standard without any additional justification;
- Tier 2 may also apply to the 1-hour NO_2 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_2 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_2/NOx ratios based on ambient monitoring data will generally be more difficult to justify for the 1-hour NO_2 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_2 in the presence of ozone, based on the following basic chemical mechanism, known as titration, although there are important differences between these methods:

$$NO + O_3 \rightarrow NO_2 + O_2 \qquad \text{(Eq. 1)}$$

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_2 (Hanrahan, 1999b; MACTEC, 2005). EPA is currently updating and extending these evaluations to examine model performance for predicting hourly NO_2 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_2 concentrations may be impacted by application of this three-tiered screening approach, and includes comparisons for both annual average and maximum 1-hour NO_2 concentrations.

Key model inputs for both the OLM and PVMRM options are the in-stack ratios of NO_2/NOx emissions and background ozone concentrations. While the representativeness of these key inputs is important in the context of the annual NO_2 standard, they will generally take on even greater importance for the new 1-hour NO_2 standard, as explained in more detail below. Recognizing the potential importance of the in-stack NO_2/NOx ratio for hourly NO_2 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_2/NOx 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_2 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 NOx 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 NOx 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_2/NOx 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_2 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_2 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 l 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_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. Furthermore, since modeled results for NO_2 are averaged across the number of years modeled for comparison to the new 1-hour NO_2 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_2 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 $PM_{2.5}$ NAAQS" (EPA, 2010b), combining the 98^{th} percentile monitored value with the 98^{th} percentile modeled concentrations for a cumulative impact assessment could result in a value that is below the 98^{th} percentile of the combined cumulative distribution and would, therefore, not be protective of the NAAQS. However, unlike the recommendations presented for $PM_{2.5}$, the modeled contribution to the cumulative ambient impact assessment for the 1-hour NO_2 standard should follow the form of the standard based on the 98^{th} 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_2 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_2 standard would also apply in the context of the new 1-hour NO_2 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_2 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_2 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_2 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 NOx emission inventories used to support modeling for compliance with the annual NO_2 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_2 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_2 standard. Due to the importance of in-stack NO_2/NOx 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_2/NOx 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 NOx emission inventories for the new 1-hour NO_2 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 NOx 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_2 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_2 standard.

Tier-specific Technical Issues

This section discusses technical issues related to application of each tier in the three-tiered screening approach for NO_2 modeling recommended in Section 5.2.4 Appendix W. A basic understanding of NOx 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_2 will provide the most conservative treatment of NOx chemistry in assessing ambient impacts, there are no technical issues associated with treatment of NOx chemistry for this tier. However, the general issues related to emission inventories for the 1-hour NO_2 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_2 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_2 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 NOx 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_2 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 NOx concentrations. By contrast, for elevated sources in relatively flat terrain, the peak hourly NOx 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_2/NOx 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_2/NOx 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_2/NOx ratio based on monitoring data for the new 1-hour NO_2 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_2 (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_2 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_2 than photosynthesis, and as such is likely to be appropriate for characterizing peak 1-hour NO_2 impacts in many cases.

Both OLM and PVMRM rely on the same key inputs of in-stack NO_2/NOx 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_2 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_2 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_2 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_2 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_2/NOx 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_2 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 NOx impacts occur close to the source under stable/light wind conditions, the plume volume will be relatively small and the ambient NO_2 impact for such cases will be largely determined by the in-stack NO_2/NOx ratio, especially for sources with relatively close fenceline or ambient air boundaries. This example also highlights the fact that the relative importance of the in-stack NO_2/NOx ratios may be greater for some applications than others, depending on the source characteristics and other factors. Assumptions regarding in-stack NO_2/NOx 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_2 compliance demonstrations.

Another difference between OLM and PVMRM that is worth noting here is the treatment of the titration mechanism for multiple sources of NOx. 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_2; 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_2 concentrations in most cases since the ambient NO_2 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 NOx concentration at each receptor for that hour. Sources which contribute significantly to the ambient NOx concentration at the receptor will compete for available ozone in proportion to their contribution, while sources that do not contribute significantly to the ambient NOx 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_2 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_2 concentrations from the application of AERMOD for the Atlanta NO_2 risk and exposure assessment (EPA, 2008), and recent re-evaluations of hourly NO_2 impacts from the two field studies (New Mexico and Palaau) that were used in the evaluation of PVMRM (MACTEC, 2005). These model-to-monitor comparisons of hourly NO_2 concentrations show reasonably good performance using the "OLMGROUP ALL" option within AERMOD, with no indication of any bias to underestimate hourly NO_2 concentrations with OLMGROUP ALL. Furthermore, model-to-monitor comparisons based on OLM without the OLMGROUP option do exhibit a bias to overestimate hourly NO_2 concentrations. We will provide further details regarding these recent hourly NO_2 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_2 assessments generally applies to the new 1-hour NO_2 standard.
2. While generally applicable, application of the 3-tiered screening approach for assessments of the new 1-hour NO_2 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_2/NOx 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_2 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 l year of site specific data.

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ATTACHMENT A

Background on Hourly NOx Emissions for Permit Modeling for the 1-hour NO_2 NAAQS

Introduction

The purpose of this attachment is to address questions about availability of hourly NOx emissions for permit modeling under the new NO_2 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_2 permit modeling and computation of hourly emissions appropriate for assessing the new 1-hour NO_2 standard. Although the NAAQS is defined in terms of ambient NO_2 concentrations, source emission estimates for modeling are based on NOx.

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_2 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_2 NAAQS relative to emissions used for the annual standard.

Model Emission Inventory for NO_2 Modeling

For the existing annual NO_2 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_2 NAAQS. However, appropriate estimates of emissions from background sources for the 1-hour NO_2 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_2 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_2 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_2 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 EIQ. 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. NOx/10^6 SCF natural gas combusted. The hourly emission rate is derived by converting the emission factor expressed in terms of lbs. NOx/10^6 SCF to lbs. NOx/MMBtu. The conversion is done by dividing the 100 lbs. NOx/10^6 SCF by 1,020 to convert the AP-42 factor to lbs. NOx/MMBtu. The new emission factor is now 0.098 lbs. NOx/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_{hourly} = 0.098 lbs/MMBtu x 30MMBtu/hr = 2.94 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_2 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 NOx emissions reported to the NEI is computed by:

E_{annual} = (AP-42 emission factor) x (total annual fuel combusted)

E_{annual} = (100 lbs/10^6 SCF) x (100 10^6 SCF/yr) = 10,000 lbs. NOx/yr or 5 tons NOx/yr

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

MAR 0 1 2011

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

FROM: Tyler Fox, Leader
Air Quality Modeling Group, C439-01

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 98^{th}-percentile of the annual distribution of daily maximum 1-hour values not exceeding 100 ppb. The 8^{th}-highest of the daily maximum 1-hour values across a year is an unbiased surrogate for the 98^{th}-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.

Application of Interim SIL to Cumulative Impact Assessment

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 98^{th}-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 98^{th}-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 8^{th}-highest (98^{th}-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 2^{nd}, 3^{rd}, 4^{th}-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 4^{th}-highest, or 99^{th}-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 98^{th}-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.

Significant Concentration Gradient Criterion

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.”

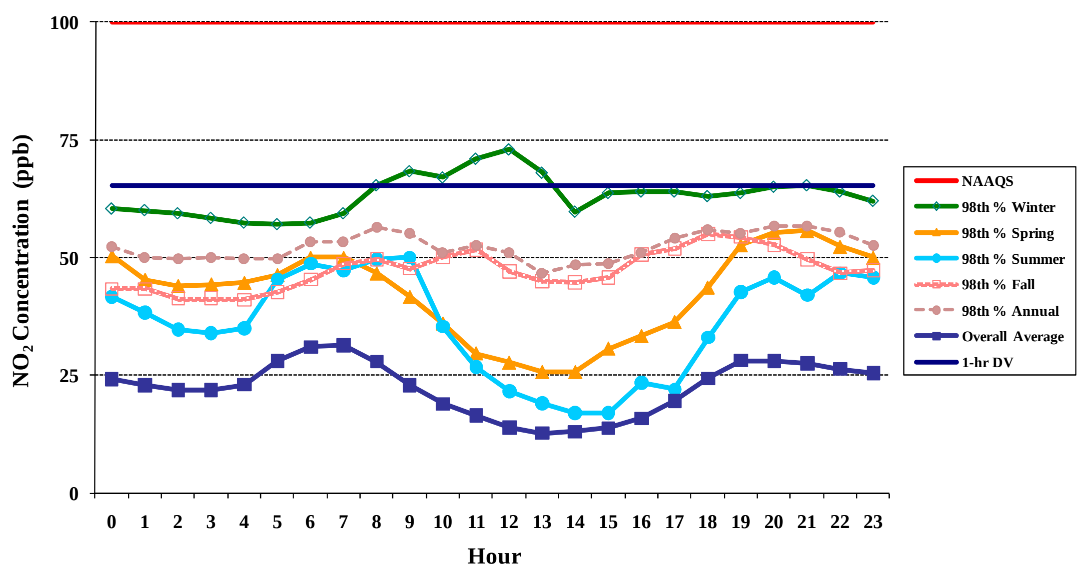
Based on this guidance, we believe that an appropriate methodology for incorporating background concentrations in the cumulative impact assessment for the 1-hour NO_2 standard would be to use multiyear averages of the 98th-percentile[8] of the available background concentrations by season and hour-of-day, 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.

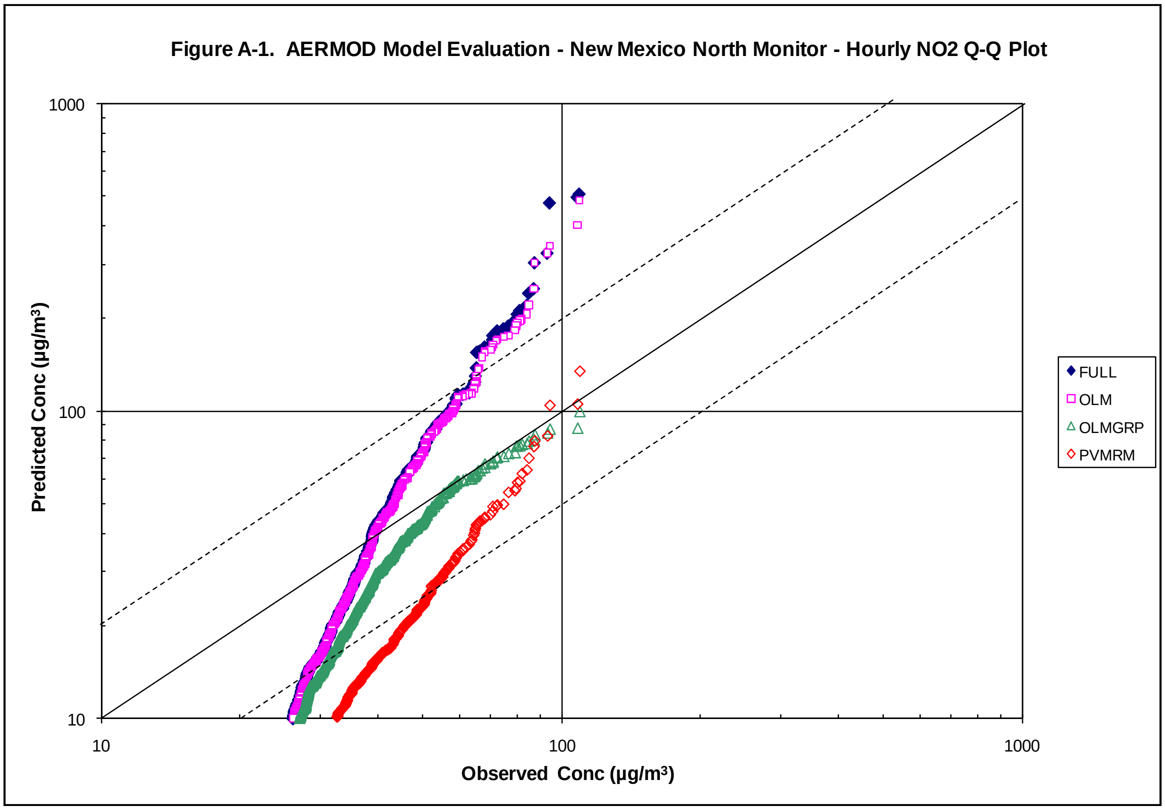
Figure A-1. AERMOD Model Evaluation - New Mexico North Monitor - Hourly NO2 Q-Q Plot
1000
100
10
10
100
1000
Predicted Conc (µg/m³)
Observed Conc (µg/m³)
FULL
OLM
OLMGRP
PVMRM

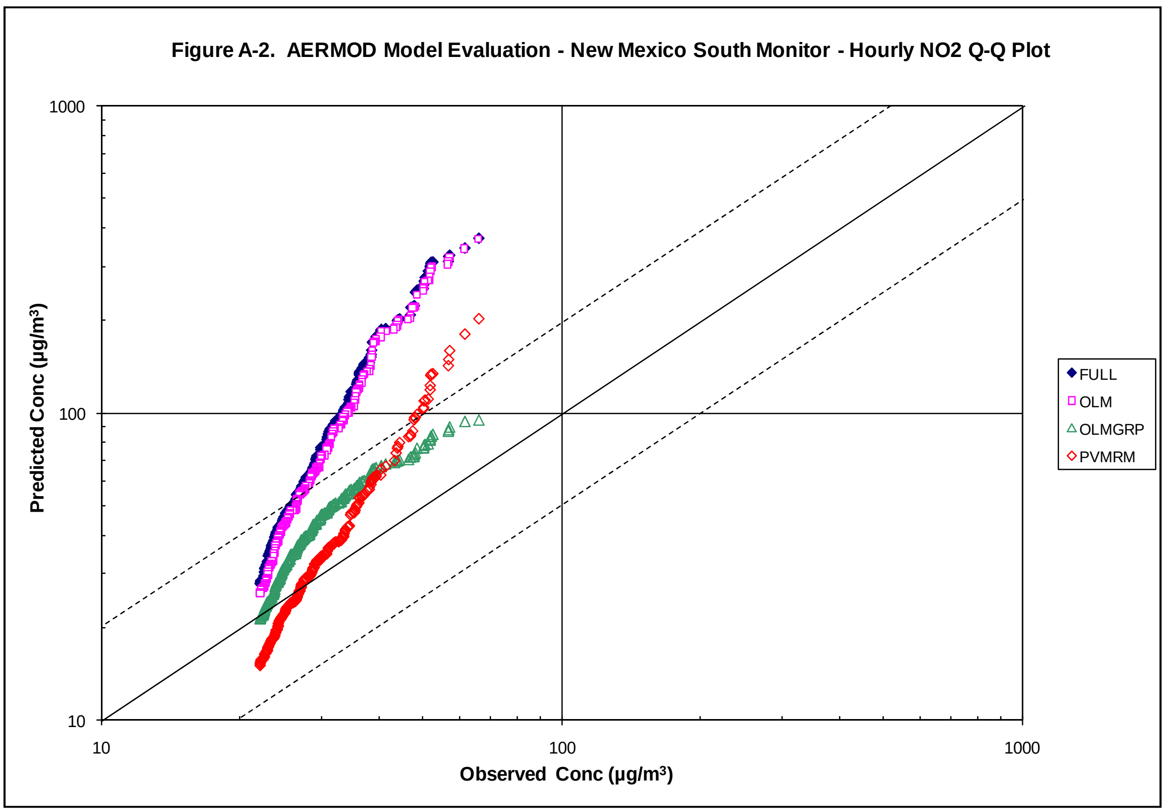
Figure A-2. AERMOD Model Evaluation - New Mexico South Monitor - Hourly NO2 Q-Q Plot
1000
100
10
10
100
1000
Predicted Conc (µg/m³)
Observed Conc (µg/m³)
FULL
OLM
OLMGRP
PVMRM

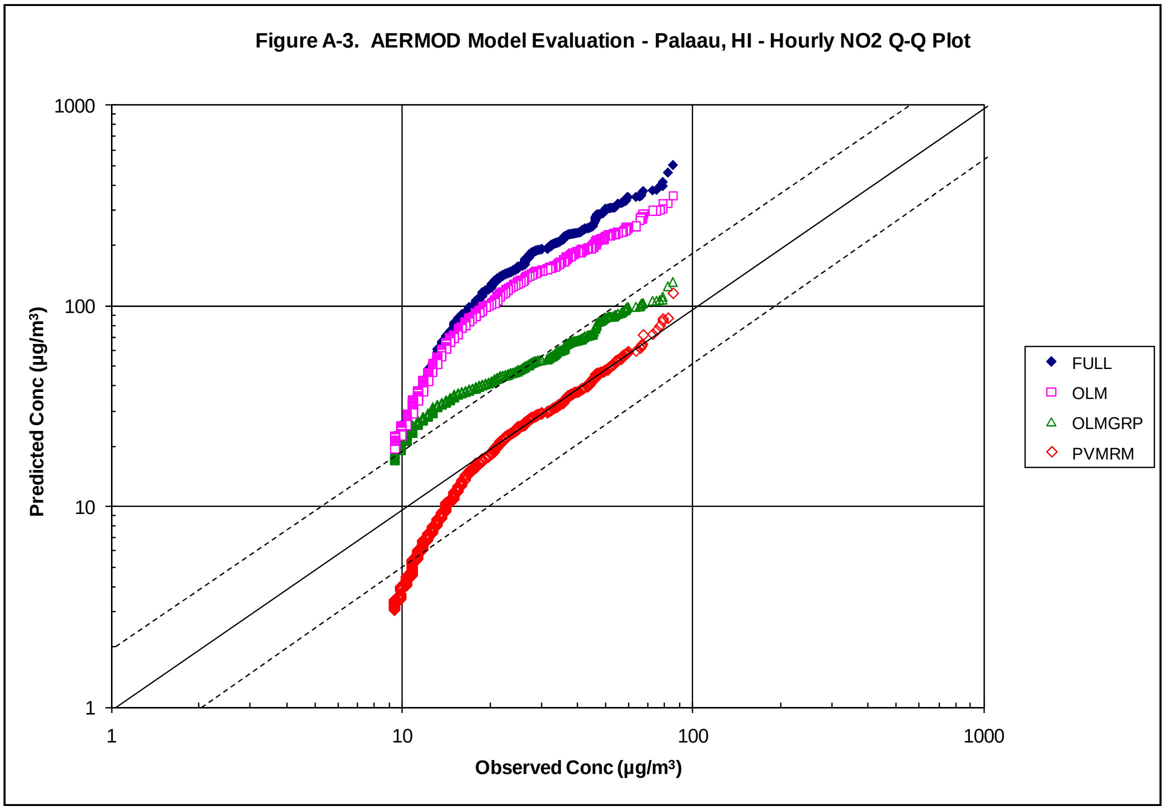

Table A-1. 1-hour NO_2 Robust Highest Concentrations (µg/m^3)

	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