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RESEARCH TRIANGLE PARK, NC 27711

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OFFICE OF  
AIR QUALITY PLANNING  
AND STANDARDS

MEMORANDUM

**SUBJECT:** NOx Network Review and Background

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**TO:** NO2 NAAQS Review Docket

This document is intended to address issues raised by the Clean Air Scientific Advisory Committee (CASAC) Oxides of Nitrogen (NOx) Review Panel about the current NOx network and what it is actually addressing or accomplishing in regard to public health. This document was produced by reviewing old CFR versions (prior to the October 2006 rule), the current CFR, interviewing EPA staff familiar with agency monitoring stretching back into the 1970s and 1980s, interviewing select state and local air agency staff, and analyzing available NOx network meta-data in AQS. For clarification, the NOx standard addresses oxides of nitrogen, but utilizes nitrogen dioxide (NO2) as the indicator. Therefore, within this document the terms NOx and NO2 are analogous, however any referenced data will be tied to NO2 data or NO2 related values.

From the inception of State and Local Ambient Monitoring Stations (SLAMS) in 1979 and their implementation in the early 1980's through the present (2008), the NO<sub>2</sub> network has remained relatively stable with regard to the number of monitoring sites (see memo by Watkins, 2008). As of October 2008, there were 409 NO<sub>x</sub> monitors within the U.S. actively reporting NO<sub>2</sub> data into AQS. The NO<sub>2</sub> network was originally deployed to support implementation of the NO<sub>2</sub> NAAQS established in 1971. Despite the establishment of an NO<sub>2</sub> standard, the first requirements for NO<sub>2</sub> monitoring did not appear until May of 1979. From the time the implementation of the 1979 monitoring rule was effectively complete in 1982, through 2008, the NO<sub>2</sub> network has averaged approximately 411 NO<sub>2</sub> monitors reporting data to AQS or its predecessors per calendar year. That 1979 monitoring rule established SLAMS (and the now defunct National Ambient Air Monitoring Stations [NAMS]) and required that NO<sub>2</sub> only be monitored using Federal Reference Methods (FRMs) or Federal Equivalent Methods (FEMs). The 1979 monitoring rule called for two NO<sub>2</sub> monitoring sites in urban areas of the country with populations greater than 1,000,000 people. The 1979 monitoring rule, 40 CFR Part 58, Appendix D, section 3.5 stated:

“Nitrogen Dioxide NAMS [National Ambient Monitoring Stations, now a defunct term] will be required in those areas of the country which have a population greater than 1,000,000. These areas will have two NO<sub>2</sub> NAMS. It is felt that stations in these major metropolitan areas would provide sufficient data for a national analysis of the data, and also because NO<sub>2</sub> problems occur in areas of greater than 1,000,000.

Within urban areas requiring [NO<sub>2</sub>] NAMS, two permanent monitors are sufficient. The first station (category (a), middle scale or neighborhood scale) would be to measure the photochemical production of NO<sub>2</sub> and would best be located in that part of the urban area where the emission density of NO<sub>x</sub> is the highest. The second station (category (b) urban scale), would be to measure the NO<sub>2</sub> produced from the reaction of NO with O<sub>3</sub> and should be downwind of the area peak NO<sub>x</sub> emission areas.”

In the 1970s, the NO<sub>x</sub> NAAQS and related monitoring requirements were driven by health effects, however EPA also viewed NO<sub>x</sub> monitoring as a supporting measurement for understanding photochemical activity. There was a hydrocarbon (HC) standard, in the 1970s, which was intended to help support the related oxidants/ozone standard. During the early 1980's, EPA eliminated HC as a NAAQS, recognizing that HC would be addressed as a key precursor in implementing the ozone standard. Throughout the 1980's and early 1990's, EPA's ozone abatement strategies focused on reductions of hydrocarbons. A series of scientific findings on the importance of biogenic hydrocarbons lead to the 1991 National Academy of Sciences (NAS) recommendations (Rethinking the Ozone Problem in Urban and Regional Pollution) that urged EPA include NO<sub>x</sub> reductions in ozone air quality programs. The NAS Report also encouraged the agency to measure hydrocarbons to help develop strategies and track consequent progress in reducing ozone. The 1990 CAAA required EPA to develop rules requiring each serious and above ozone nonattainment area to operate an ozone precursor monitoring program; this program was subsequently named the Photochemical Assessment Monitoring Stations (PAMS) network, and was deployed in the early 1990's. The regulation called for two PAMS sites in each PAMS area. The PAMS network emphasizes the measurement of hydrocarbons, and compliments that emphasis with the inclusion of nitrogen oxides measurements at a certain type of PAMS sites. Of the two required PAMS sites in a given area, one of them had to be a so-called “Type 2” site, which monitors NO<sub>2</sub>, but only during PAMS/Ozone season for the given area. Type 2 sites are located to measure the maximum ozone precursor emissions impact of a given area, similar to the “category a” sites detailed in the CFR language (noted above) which preceded the 2006 monitoring rule. These Type 2 PAMS sites are typically located in or just downwind of a central business district and operate on the most intensive of PAMS monitoring schedules. Type 1, Type 3, and Type 4 PAMS sites are not required to measure NO<sub>2</sub>.

With regard to monitoring for the Prevention of Significant Deterioration (PSD), new NO<sub>x</sub> monitoring may be required prior to granting a PSD permit to proposed new sources or modifications to existing sources. PSD monitoring has specific QA criterion

to follow, which is spelled out in 40 CFR Part 58, Appendix A, however the siting and monitoring guidance is not in CFR, but in EPA document number 450/4-87-007, Ambient Monitoring Guidance for Prevention of Significant Deterioration. That document spelled out that PSD monitoring is usually carried out for 1 year. The monitoring is to represent 3 different types of source-oriented receptors for a specific source. The three areas that are to be addressed by PSD monitoring are:

- 1) Maximum concentration increase from the proposed source or modified source
- 2) Location of maximum air pollutant concentration from existing sources
- 3) Location of maximum impact area where maximum pollutant concentration would hypothetically occur based on combined effects of existing sources and the proposed new source or modified source.

PSD data are not especially differentiated from other data in AQS by meta-data categories like project class or monitoring objective. They likely are labeled as SPM sites, but could have other labels. Notably, EPA is aware that some states may run NOx sites with PSD requirements in mind, whether to maintain a fairly current evaluation of NOx concentrations in a given area, or even as a pre-construction measure and incentive to build for future new sources in a given area.

Except for the existing PAMS and PSD requirements, the 40 CFR Part 58 Appendix D monitoring language referenced above was removed from CFR in the October 2006 monitoring rule. Removal was driven by the fact that there is not an NO2 nonattainment problem, with respect to non-attainment areas anywhere in the US, under the current standards. Staff interviewed during the creation of this document, and review of data indicate that the U.S. has had 3 areas that ever were non-attainment for NO2, in the LA, Chicago, and Denver areas. The lack of non-attainment areas and the fact that the country was well below the NOx standard, led to the 2006 monitoring rule revision, where EPA chose to rewrite 40 CFR Part 58, Appendix D, section 4.3 to state that:

“There are no minimum requirements for the number of NO2 monitoring sites. Continued operation of existing SLAMS [State and Local Ambient Monitoring Station] NO2 sites using FRM [Federal Reference Method] or FEM [Federal Equivalent Method] is required until discontinuation is approved by the EPA Regional Administrator. Where SLAMS NO2 monitoring is ongoing, at least one NO2 site in the area must be located to measure the maximum concentration of NO2.”

As noted earlier, the size of the NOx network has been fairly stable through time, including 2007 and 2008, even though the 2006 monitoring rule removed the specific NOx monitoring requirements, other than the PAMS and PSD requirements, and allowed state and local agencies to request EPA approval to remove existing NOx monitors. When asked why they continue to monitor for NOx, state and local agencies indicate that they are driven by other interests. Most state and locals pointed out NOx data as support for ozone modeling and forecasting as was earlier suggested; however, other reasons also came up, including general modeling support, PM precursor tracking, public perception,

and most notably, since there was an NO<sub>2</sub> NAAQS, state and locals felt that they had a responsibility to continue to understand what was happening specifically with NO<sub>2</sub> in their jurisdiction, regardless of a requirement to monitor. The reasons given by the state and locals indicate that the NO<sub>x</sub> network likely will not contract a great deal in the near future; barring severe changes in resource availability. Further, any adjustment from the current NO<sub>x</sub> NAAQS will certainly present the opportunity to adjust the size or to consider refocusing the network design. It is also appropriate to note that EPA's recent shift to promoting the multi-pollutant paradigm has led to the requirement of multi-pollutant National Core (NCORE) monitoring network. NCORE is intended to compliment the existing SLAMS networks, while furthering the move to multi-pollutant monitoring wherever feasible, recognizing that state and locals strive for balance between federally required monitoring and local interests and needs. The NCORE sites, a subcomponent of the SLAMS network, require NO<sub>y</sub> measurements, which technically includes NO<sub>2</sub>, but does not specifically provide a NO<sub>2</sub> value.

To address the questions about what the current NO<sub>x</sub> network is addressing or characterizing, and in light of the relatively recent removal of a specific NO<sub>x</sub> monitoring requirement, EPA reviewed some of the NO<sub>x</sub> network meta-data. This review is only intended to broadly describe how the network addresses the varied monitoring objectives and how the network is situated with regard to measurement scale of individual monitors. The data reviewed are those available from AQS in October 2008, for monitors reporting data in 2008. The meta-data fields are usually created by state and locals whenever a monitor or site is opened, moved, or has a certain characteristic re-characterized. Often, EPA Regions consult with states and locals on some of these meta-data characteristics, but it is the responsibility of the state or local to classify their own sites. With that, it should be noted that EPA must caveat this review due to the fact the AQS meta-data may have missing or 'old' meta-data field entries, as states and locals do not have a routine or enforced process by which they must update or correct meta-data fields.

#### Monitor Objective

The monitor objective meta-data field describes what the data from the monitor are intended to characterize. The focus of the data presented is to show the nature of the network in terms of its attempt to generally characterize health effects, photochemical activity, transport, or welfare effects. As of October 2008, there were 489 records of NO<sub>x</sub> monitor objective values. It should be noted that any particular monitor can have multiple monitor objectives, and of those 489 records, 74 monitors had two monitor objectives and 3 monitors had three monitor objectives, which corresponds to the known 409 NO<sub>x</sub> sites reporting data in 2008. Table 1 shows the monitor objective distribution across all NO<sub>x</sub> from the available AQS data. There are 11 categories of monitor objective for a NO<sub>x</sub> monitor within AQS. The "other" category is for sites likely addressing a state or local need outside of the routine objectives, and the "unknown" category represents missing meta-data. The remaining categories stem directly from categorizations of site types within CFR. In 40 CFR Part 58 Appendix D, there are six examples of NO<sub>x</sub> site types:

1. Sites located to determine the highest concentration expected to occur in the area covered by the network (Highest Concentration).
2. Sites located to measure typical concentrations in areas of high population (Population Exposure).
3. Sites located to determine the impact of significant sources or source categories on air quality (Source Oriented).
4. Sites located to determine general background concentration levels (General Background).
5. Sites located to determine the extent of regional pollutant transport among populated areas; and in support of secondary standards (Regional Transport).
6. Sites located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts (Welfare Related Impacts).

The remaining four categories available are a result of updating the AQS database. In the more recent upgrade to AQS, the data handlers inserted the available site types for Photochemical Assessment Monitoring Stations (PAMS) network. These PAMS site types are spelled out in 40 CFR Part 58 Appendix D:

1. Type 1 sites are established to characterize upwind background and transported ozone and its precursor concentrations entering the area and will identify those areas which are subjected to transport (Upwind Background).
2. Type 2 sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact and are suited for the monitoring of urban air toxic pollutants (Max. Precursor Impact).
3. Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions (Max. Ozone Concentration).
4. Type 4 sites are established to characterize the downwind transported ozone and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas (Extreme Downwind).

<b>NOx Monitor Objective</b>	<b>Number of Monitor Objective Records</b>	<b>Percent Distribution</b>
Population Exposure	177	36.20
Highest Concentration	58	11.86
General Background	51	10.43
Max. Precursor Impact (PAMS Type 2 Site)	21	4.29
Source Oriented	19	3.89
Upwind Background	18	3.68

(PAMS Type 1 Site)		
Regional Transport	12	2.45
Other	9	1.84
Max. Ozone Concentration (PAMS Type 3 Site)	8	1.64
Extreme Downwind (PAMS Type 4 Site)	3	0.61
Welfare Related Impacts	1	0.20
Unknown	112	22.90
<b>Totals:</b>	<b>489</b>	<b>100%</b>

**Table 1. NOx Network Distribution of Monitor Objectives.** Table 1 lists all monitor objective records in AQS for monitors reporting data in 2008 as of October 2008, and is intended to show characterization of the NOx network in terms of the distribution of those monitors addressing a given monitor objective.

#### Measurement Scales

The spatial (measurement) scales are laid out in 40 CFR Part 58, Appendix D, Section 1 "Monitoring Objectives and Spatial Scales." This part of the regulation spells out what data from a monitor can represent in terms of air volumes associated with area dimensions:

- Microscale - 0 to 100 meters
- Middle Scale - 100 to 500 meters
- Neighborhood Scale - 500 meters to 4 kilometers
- Urban Scale - 4 to 50 kilometers
- Regional Scale - 50 kilometers up to 1000km

There are meta-data records for the NOx network to indicate what the measurement scale of a particular monitor represents. There are 386 NOx monitor records in AQS with available measurement scale information. The difference in numbers between the 489 monitor objective records and the 386 measurement scale records may be attributed to missing data. It is also important to recall that a monitor can only have one measurement scale, as opposed to the possibility of a single monitor having multiple monitor objectives. Table 2 shows the measurement scale distribution across all NOx sites from the available data in AQS of monitors reporting data in 2008.

Measurement Scale	Number of Measurement Scale Records	Percent Distribution
Microscale	3	0.78
Middle Scale	23	5.96
Neighborhood	212	54.92
Urban Scale	119	30.83
Regional Scale	29	7.51
<b>Totals:</b>	<b>386</b>	<b>100%</b>

**Table 2. NOx Network Distribution across Measurement Scales.** Table 2 lists all measurement scale records in AQS and is intended to show characterization of the NOx network in terms of the distribution of those NOx monitors characterizing a given geographic area.

### Review Summary

Upon review of the known 409 monitors reporting data to AQS in 2008, and the distribution of the available data from the categories of monitor objective and measurement scale, we see the NOx network is primarily targeting public health and effectively addressing photochemical process monitoring objectives. We should note that nearly half of the monitor objective records are more directly targeting health effects through the population exposure (36.2%) and highest concentration (11.8%) categories alone. The other categories serve to inform public health concerns, but also address photochemistry issues where NOx serves as a precursor to ozone. Further, it appears that approximately 10% of the NOx network is in place due to the PAMS network. In reality, a large majority of sites likely could serve both public health and photochemistry related objectives due to their increased proximity to or representation of more urban areas, except possibly those categories such as upwind background, extreme downwind, regional transport, and possibly maximum ozone concentration. These four categories only represent approximately 7% of the NOx network, and have a higher likelihood of being more rurally sited, largely regional in scale, than the other monitor objective categories.