UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

February 22, 1992

MEMORANDUM

SUBJECT: Distribution of Report on Procedures to Estimate Nitrogen oxides (NO_X) Emission Increases from Mobile and Area Sources for Prevention of Significant Deterioration (PSD) Increment Analyses

FROM: Eric Noble
Operating Permits Policy Section (MD-15)

TO: New Source Review (NSR) Contacts

Attached is a copy of the final report on estimating NO_X emissions from mobile and area sources for PSD nitrogen dioxides increment analyses. Additional copies may be had by downloading from either the NSR bulletin board, which has been renamed the Permits Programs Bulletin Board System, or the Technology Transfer Network.

This report differs from the draft report distributed for review last fall. The primary change is the removal of lookup tables for determining worst case NO_X impacts of mobile and area sources. The tables made it appear that, for even small increases in No_x emissions, the estimated ambient NO_X impacts were so high that very few sources would be able to use then to avoid a full ambient air quality dispersion analysis. Others changes were made to incorporate comments and suggestions you made during the review process. I appreciate the time and effort you took to provide me with those comments.

As you may have noted from my new byline, I am no longer directly involved in the NSR program. I recently transferred into the Operating Permits Policy Section so, while this may be my final act as a representative of the NSR Section, it is probably not my last contact with you. In any event, I want to express my appreciation for all the support I've received (both internally and from the Regions), since I joined the NSR Section.

If you have any questions or comments on this report, you can give me a call at (919) 541-5362.

Attachment

United States Environmental Protection Agency
Air

Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

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EPA

PROCEDURES TO ESTIMATE NO_X EMISSION INCREASES FROM MOBILE AND AREA SOURCES FOR PSD NO_2 INCREMENT APPLICATIONS

Procedures to Estimate NO_X Emission Increases

from

Mobile and Area Sources

for

PSD NO_2 Increment Applications

by
Trinity Consultants, Inc.
Dallas, Texas 75243

EPA Contract No. 68-00-0123
Work Assignment No. K

EPA Work Assignment Manager: Eric Noble

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Research Triangle Park, NC 27711

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ABSTRACT

This report presents simple methods that may be used by reviewing agencies and permit applicants to estimate the increase in NO_X emissions from mobile and area sources for PSD NO_2 increment applications. This study is not intended to provide the complete methodology for estimating NO_2 increment impacts, but only to provide the basis for a screening analysis to estimate those impacts and to determine if a detailed analysis of NO_X emissions is required.

A three-step screening framework is presented, as follows:

Step 1 - define the study area;

Step 2 - estimate the emissions change in the study area; and

Step 3 - distribute the emissions change throughout the study area.

Techniques are presented that may be used to relatively easily estimate NO_x emissions increases from area and mobile sources. Based on these emissions increases, NO_2 impacts can be estimated using air quality screening models that provide worst-case impacts from line sources and area sources. These impacts can then be compared with significant impact levels to determine whether a more detailed analysis is required.

The methods presented in this report will not be appropriate in many situations. An analysis of the limitations of the methods is presented so that these situations may be identified.

CONTENTS

SECTION 1

INTRODUCTION

PURPOSE

The purpose of this study is to provide a procedure which reviewing agencies and permit applicants may use to estimate the NO_X emissions increases from mobile and area sources. These estimates can be used as the basis for screening analyses to estimate worst case NO_X emissions impacts. This study is not intended to provide a complete methodology for estimating NO_X emissions estimates, but rather to provide a necessary portion of the screening framework needed to estimate NO_X emissions impacts and to determine when detailed analyses of NO_X emissions and NO_2 increment impacts may be required.

BACKGROUND

In 1988, the U.S. Environmental Protection Agency (EPA) promulgated regulations to add NO_2 to the list of compounds subject to increments under the PSD program. The PSD increments for NO_2 are defined as 25 micrograms per cubic meter for class II areas and 2.5 micrograms per cubic meter for class I areas based on an annual average. The PSD increment limit applies to all major stationary sources and major modifications of NO_X constructed or permitted after February 8, 1988 and to all minor stationary sources of NO_X constructed after the minor source baseline date. (Note: NO_X emissions include a family of compounds of which NO is the primary component. Since NO reacts quickly in the atmosphere to form NO_2, emissions of NO_X are usually converted to NO_2 for measurement and reporting purposes, and are used when estimating ambient NO_2 concentrations).

The EPA's policy when estimating the NO_2 increment consumption is to include emissions which occur after the minor source baseline date from mobile sources and other minor point sources referred to in this aggregate as "area sources". Unfortunately, the emission rates for these types of sources, and the change in their emissions over time, are not easily measured or quantified. For mobile sources, year-to-year variations in vehicle volumes, vehicle speeds, driving patterns, inspection programs, emission controls, etc., greatly influence the magnitude and the spatial distribution of the emissions.

Since it is impossible to directly measure the emissions from all mobile sources in a given area, emission estimation and allocation techniques for these sources must be developed. Similar techniques are required to estimate the emissions from area sources.

Various techniques for calculating emissions changes and NO_2 impacts for these sources have been developed.[1,2] Unfortunately, these techniques require a great amount of analysis, including the development of a gridded emission inventory and a detailed dispersion modeling analysis, to provide accurate estimates of the NO_2 impacts from these types of sources. Therefore, the data base development procedures for more simplistic methods of determining NO_2 impacts are developed in this document.

SUMMARY

This study provides a screening framework by which NO_X emissions increases from mobile and area sources may be estimated, and the resulting NO_2 increment impacts calculated. The screening framework is presented as a three-step process:

1) define the 'study area' (area where emissions are being estimated),
2) estimate the emissions change within the "study area," and
3) distribute the emissions change throughout the 'study area."

This three-step process is not appropriate in all situations. There are many situations where a "simple" solution to estimating NO_X emissions and NO_2 impacts is not possible.

A discussion of how to determine the study area is provided in Section 2 of this report. Recommended emission estimation techniques are summarized in Sections 3 and 4, for mobile sources and area sources, respectively. Section 5 describes the methodology to determine the appropriate allocation of the emissions changes and, finally, Section 6 discusses additional considerations that should be taken into account in the NO_2 impact estimation process.

SECTION 2

DEFINING THE STUDY AREA

The first step in estimating the NO_x emissions impact of mobile and area sources is to define the area over which these emissions will be estimated. This area is referred to as the "study area" in this report. The nature and extent of the sources in the study area will determine which emissions estimation technique will be most appropriate. In order to define this area, the impact area of the proposed PSD source (as defined by the PSD rules) must first be identified. Based on this impact area, the study area should encompass all mobile and area sources of NO_x that may contribute significantly to NO_x impacts within the impact area.

The determination of the specific sources that contribute "significantly" to NO_x impacts in the impact area must be determined by the reviewing authority and PSD applicant on a case-by-case basis. In most instances, the study area will consist of any urbanized area within or near the impact area, since only urbanized areas are likely to have large enough mobile and area source impacts to warrant assessment. For instance, if the impact area of the proposed source completely encompasses a small city with no surrounding developed areas, the limits of the city itself can usually be the study area boundaries. Similarly, if the impact area covers an undeveloped area but is adjacent to an isolated city, the city should be used as the study area.

Other situations are more complex. For instance, if the impact area of the proposed source is located entirely within a large city, what should the study area be? Should it be the area of the city within the impact area, or should it also include some (or all) areas of the city located beyond the impact area? In such cases, the specific limits of the study area should be decided by the reviewing authority, taking into account the distribution of new development within the city and the location of this development with respect to the impact area. Some of the impact estimation techniques discussed later in this report may be useful in making this determination.

SECTION 3

MOBILE SOURCE EMISSION ESTIMATION TECHNIQUES

OVERVIEW

This section provides a discussion and analysis of several techniques that can be used to estimate the increase in NO_X emissions from mobile sources in a specific study area over a given time period. It is intended that the emissions growth estimated by these techniques be used to estimate the maximum NO_2 increment impact due to the growth in these source types that has occurred in the study area since the baseline date.

The specific techniques analyzed are chosen based on ease of use, availability of required input data, and physical appropriateness. In most cases, the techniques are subject to certain physical assumptions that greatly limit their usefulness and may only work well for certain specific situations. A summary of these assumptions and limitations is presented for each technique.

The basic approach to estimating total $_{NOX}$ emissions from mobile sources for a given study area is to estimate the total vehicle miles traveled (VTM) within the study area and to multiply this value by the appropriate $_{NOX}$ emissions factor expressed in terms of grams per vehicle-mile. The emissions growth is then calculated as the difference in the mobile source emissions between the permit year and the baseline year. This methodology is summarized in the equation below.

$$)Q = (VMT_p \text{ x } EF_p) - (VMT_B \text{ x } EF_B)$$

where:

)Q	= change in emission rate (grams/year)
VMT_p	= total vehicle miles traveled in permit year
VMT_B	= total vehicle miles traveled in baseline year
EF_p	= NO, emission factor in permit year (grams/veh-mile)
EF_B	= NO, emission factor in baseline year (grams/veh-mile)

The appropriate $_{NOX}$ emission factors are easily obtained using the MOBILE-4.1 model as discussed in a later section. However, estimating the total VMT for the study area is a more difficult task. Therefore, several different techniques are presented that may be used depending on the characteristics and availability of data for the specific study area. These techniques are described below and summarized in Table 1. Examples of the use of these techniques are provided at the end of this section.

VMT ESTIMATION METHODS

Direct Vehicle Counts

The most accurate and representative method of estimating VMT for a given area is to directly count the number of vehicles that travel on each road in the study area and to multiply these values by the length of each road segment. Unfortunately, this technique is impossible for all but the smallest study area . While local traffic planning engineers routinely perform traffic surveys and maintain databases of vehicle volumes for many roads in their cities, it is unlikely that all of the vehicle miles are accounted for. Usually the measurements are made only along major highways and arterials. Traffic counts for local roads and parking areas are not usually available. In addition, representative vehicle counts are not always available for each year.

For small study areas such as new subdivisions or office parks, however, this method may be quite useful. Detailed traffic surveys are often required to be performed in advance of these projects and follow-up measurements are often made to validate the studies. If the study area only contains a few roads it may be quite easy to gather this vehicle data. The city engineer or traffic planning office may be contacted to obtain this data.

As discussed later in Section 5, it is often useful to estimate emissions from a single major road in a given study area in order to estimate the maximum NO_2 increment impact. In this case, the only technique that may be used is a direct vehicle count. Other VMT estimation techniques cannot be reliably used to estimate emissions along a single road link.

In summary, while direct vehicle counts are the best method for estimating total VMT in a given study area, the lack of a complete, readily available database limits the situations where it may be applied. This technique is impractical for large study areas, but may be used for very small study areas or for single road segments.

Area-Wide VMT Estimates

Each year, the Federal Highway Administration (FHWA) publishes the Highway Statistics publication which contains annual highway statistics for the previous year. It summarizes numerous traffic parameters for all 50 States and for all metropolitan areas greater than 200,000 in population. One of the parameters presented is an estimate of the total VMT in the State or metropolitan area for that particular year. These values are usually computed from local traffic counts or gasoline consumption data, or a mixture of both.

If the study area for which an emission estimate is needed closely corresponds to one of the metropolitan area summarized, the FHWA data is the quickest and easiest data source for an estimate of total VMT in the study area. This VMT estimate may then be directly multiplied by the appropriate emission factor to arrive at a total $_{NOX}$ emissions estimate.

The advantages of this method are that the data are readily available for all large metropolitan areas and that these data should be fairly reliable. However, for maximum data correlation, the study area boundaries should closely match those of the metropolitan area itself. If the study area is much smaller or larger than the metropolitan area, an assumption must be made as to how to distribute the VMT data within the given metropolitan area or state. This method is also limited by the fact that the VMT data are available only for large metropolitan areas. Thus, the area-wide VMT estimate technique cannot be used for cities with populations of less than 200,000.

<u>Fuel Consumption Data</u>

Theoretically, fuel consumption data (gasoline and diesel) can be used to develop a VMT estimate that should be very close to what would be obtained from direct vehicle counts. This method simply multiplies the fuel consumed in the study area by an average vehicle fuel efficiency expressed in miles per gallon, as shown in the equation below.

$$VMT = G \times MPG$$

where:
- VMT = total vehicle miles traveled per year
- G = total fuel consumption (gallons/year)
- MPG = average fuel efficiency (miles/gallon).

In many cases, a fuel consumption approach may be more accurate than the VMT estimates contained in the FHWA Highway Statistics publication since it Implicitly accounts for all VMT, including miles traveled in parking areas and on minor roadways that may be overlooked in the FHWA data. However, the major assumption that must be satisfied for this technique to be appropriate is that the fuel purchased in the study area must be entirely consumed within the study area.

Fuel sales data for a given year are usually available on a county or municipality basis from the state tax collectors office. In addition, annual summaries of fuel use for each State are available in the FHWA Highway Statistics publication. If the boundaries of the study area closely correspond to the county or municipality boundaries, then an estimate of total fuel consumption in the study area can be derived from state fuel sales data. As the size of the study area decreases, however, it is more difficult to obtain accurate fuel sales data. In addition, the assumption that all fuel purchased in a given area is consumed in that area becomes inappropriate as the size of the area decreases. Therefore, this method is most appropriate for large cities or counties with easily obtainable fuel sales data.

Once a fuel consumption estimate is made for the study area, an estimate of the average vehicle fuel efficiency must be obtained in order to calculate VMT. This is the most difficult aspect of this technique since the fleet-average fuel efficiency is dependent on many factors such as the vehicle mix, average vehicle age, average vehicle speed, and climate. It is unlikely that local data concerning the fleet-average fuel efficiency will be readily available. Therefore, Table 2 contains a summary of fleet-average fuel efficiencies for the years 1988 through 2007 that have been developed based on data contained in the MOBILE-4.1 model. These estimates are based on national average vehicle mixes and mileage accumulations, and do not take into account local variations in climate. However, they may be used to get a quick estimate of the fleet-average fuel efficiency for any given year.

In summary, a fuel consumption approach is favored in area where fuel sales data are readily available and satisfy the assumption that fuel purchases in the study area are equivalent to fuel consumption in the study area. This assumption is not appropriate for small study areas, and this technique should not be directly applied in such areas.

Per Capita Estimates

In many cases, none of the approaches described above may be used due to certain limitations or lack of data. In such cases, state-wide values of VMT from the FHWA manual or VMT estimates derived from state-wide gasoline sales may be used to develop a per capita estimate of VMT. The per capita value may then be multiplied by the population of the study area to estimate the total VMT in the study area as shown in the equation below,

$$VMT_T = VMT_A \times P$$

where: VMT_T = total vehicle miles traveled
VMT_A = average vehicle miles traveled per person
P = population of study area.

There are two major flaws to this method. The first is that it assumes that vehicle usage rates are the same throughout the entire state. This is probably not the case in states that have both large urban and rural populations with greatly differing driving habits. The second flaw is that this method assumes that vehicle mileage can actually be distributed correctly on a per capita basis. For large study areas, a per capita distribution is probably appropriate since most of the miles driven by a person living in the study area will likely be driven within the study area itself. Any miles driven outside the study area by that person are probably balanced by miles driven in the study area by those who do not live there. But for small study areas, it is unlikely that a person who lives in the study area will drive all of their miles in the that area, and there is no guarantee that the miles driven elsewhere by that person will be balanced by others driving within the study area. This is especially true in "commuter cities" where a large number of miles will be driven well outside of the area in which the person lives.

Despite these flaws, a per capita approach is useful for large study areas where fuel sales or FHWA VMT data are not available. In addition, it is the only approach available for certain smaller study areas within large metropolitan areas where complete vehicle counts are not available.

Summary of VMT Estimation Methods

Table 1 summarizes the advantages, disadvantages, and limitations of the four VMT estimation methods described above. Based on these factors, Table 3 contains a summary of the recommended methods for different types of study areas.

EMISSION FACTORS

After the total VMT within the study area is estimated, the total $_{NOX}$ emissions from mobiles sources are calculated by multiplying the total VMT times a NO_X emission factor expressed in grams per vehicle-mile. The primary source of mobile emission factors is the MOBILE-4.1 emission factor model. For a given evaluation year, this model calculates fleet-average emission factors for NO_X, carbon monoxide, and hydrocarbons. The model takes into account actual vehicle mixes, mileage accruals, vehicle registrations, climatology, and the affect of inspection/maintenance (I/M) and anti-tampering programs.

It is recommended that individual MOBILE-4.1 model runs be performed for the baseline year and permit year that take into account local climatological characteristics, vehicle registrations and accruals, and anti-tampering and I/M programs. However, if certain input parameters for the MOBILE-4.1 model are not available, default NO, emission factors may be substituted. Table 4 contains the $_{NOX}$, emission factors calculated by the MOBILE-4.1 model based on the national default vehicle mix, vehicle registrations and mileage accruals. These factors also assume no local I/M or anti-tampering programs, a low-altitude location, and an average temperature of 50 degrees Fahrenheit.

An average vehicle speed in the study area must be estimated for both the baseline and permit years in order to select the correct emission factors. This value may be difficult to obtain or estimate accurately for most areas. However, note that the NO_X emission factors are almost identical for vehicle speeds between 25 and 45 miles per hour. Since the average vehicle speed almost certainly falls in this range for most urban study areas, a precise estimate of the average vehicle speed may not be necessary.

EXAMPLE CALCULATIONS

Four example calculations are provided below that highlight each of the VMT estimation techniques described earlier. Each example assumes that the NO_X minor source baseline date for the study area is 1989 and that the permit year is 1993. The same hypothetical city is used for all examples, and each example is constructed to highlight the most appropriate application of the method being described. It is assumed that the city has experienced explosive growth during this four-year period, with the population growing 3.5 percent per year from 400,000 to 460,000 people.

Example #1 - Area-Wide VMT Method

Assume that the border of the study area being examined coincides with the city limits of the hypothetical city and that the population of the city is greater than 200,000. In this case, the area-wide VMT estimates contained in the FHWA Highway statistics publication are the most readily available source of VMT data. Further assume that the rate of VMT growth in 1993 equaled population growth rate for 1993.

Referring to the FHWA manual for 1989 and 1992 (hypothetically), it is determined that the annual VMT is the following:

Baseline year VMT (1989) = 2,920 million miles.
Permit year VMT (1993) = 1.035(3,565) = 3,690 million miles.

Next, total emissions for each year are calculated using MOBILE-4. 1. It is assumed that the average vehicle speed in the study area is approximately 30 miles per hour, with default values being used for the remaining vehicle fleet characteristics. Referring to the default MOBILE-4.1 NO_X emission factors contained in Table 4, the appropriate $_{NOX}$ emission factors are:

1989 Emission Factor = 3.322 grams per vehicle mile.
1993 Emission Factor = 2.470 grams per vehicle mile.

Using this data, the total NO_X emissions change for the study area is calculated below:

$$)Q = (3,690 \text{ X } 10^6 \text{veh-miles/yr x } 2.470 \text{ grams/veh-miles})-(2,920 \text{ x } 10^6 \text{ x } 3.322 \text{ grams/veh-miles})$$

$$= 9.114 \text{ X } 10^6 \text{grams/yr} - 9,700 \text{ X } 10^6 \text{grams/yr}$$

$$= 10,046 \text{tons/yr} - 10,692 \text{tons/yr} = -646 \text{tons/yr}$$

As calculated above, the annual emission rate for the study area decreases by 646 tons per year between the baseline date and the permit year.

Example #2 - Fuel Consumption Method

An alternate method of estimating VMT and emissions change for the situation described in Example #1 is to use fuel consumption data. Assume that state gasoline sales data indicate that the fuel consumption in the city is the following:

1989 Fuel Consumption = 154.2 million gallons
1992 Fuel Consumption = 177.6 million gallons.

Fuel consumption data are not available for 1993, so the applicant and the reviewing agency reach an agreement to estimate the increase from 1992 to 1993 using the same rate of change as occurred between 1991 and 1992 (11.7 million gallons). Thus,

1993 Fuel Consumption = 177.6 + 11.7 = 189.5 million gallons.

To estimate total VMT in the city for each year, the fleet-average fuel efficiency must be obtained. Referring to the EPA-derived default data on fuel efficiency in Table 2 yields the following:

1989 Fuel Efficiency = 19.13 miles per gallon
1993 Fuel Efficiency = 19.58 miles per gallon.

Using these data, the total VMT in the study area are calculated below for each year:

VMT_{1989} = 154.2 x 10^6gallons x 19.13miles/gallon = 2,950 x 10^6miles

VMT_{1993} = 189.5 X 10^6gallons x 19.58miles/gallon = 3,710 x 10^6miles

Finally, the total $_{NOX}$ emissions change for the study area is calculated using the NOX emission factors from Example #1:

)Q = (3,710 X 10^6veh-miles/yr x 2.470grams/veh-miles) - (2,950 x 10^6veh-miles X 3.322grams/veh-miles)

= 9,164 X 10^6grams/yr - 9,800 X 10^6grams/yr

= 10,101 tons/yr - 10,802 tons/yr = 701 tons/yr

As calculated by this method, the annual average emission rate for the study area decreases by 701 tons per year between the baseline date and the permit year.

Example #3 - Per Capita Method

An analysis of the growth patterns indicate that most of the population growth between 1989 and 1993 occurred in the northern part of the city. Therefore, it is determined to restrict the study area to just this part of the city. Since the FHWA VMT data are not available for only part of the city, the method in Example #1 is no longer appropriate. In addition, fuel consumption data is not available for this pan of the city. This fact coupled with the necessary condition that all fuel purchased in this part of the city must be consumed in this area, also rules out the method used in Example #2.

It is decided to use a per capita allocation of the city-wide VMT estimate used in Example #1. The population of the new study area is assumed to be the following:

1989 Population = 30,000 people (7.5 % of city-wide total)
1993 Population = 70,000 people (15.2 % of city-wide total)

Multiplying the total VMT in the city found in the FHWA manual by the fractional number of people in the new study area yields the following estimates of VMT:

1989 VMT = 0.075(2,920) = 228 million miles
1993 VMT = 0.152(3,690) = 561 million miles.

Finally, the total $_{NOX}$ emissions growth for the study area is calculated using the $_{NOX}$ emission factors from Example #1:

)Q = (561 X 10^6veh-miles/yr x 2.470grams/veh-miles) - (228 x 10^6veh-miles/yr X 3.322grams/veh-miles)

= 1,386 X 10^6grams/yr - 757 X 10^6grams/yr

= 1,528tons/yr - 834tons/yr = 694tons/yr

As calculated by this method, the annual average emission rate for the smaller study area increases by 694 tons per year between the baseline date and the permit year.

Example #4-Direct Traffic Count

It is observed that the explosive growth in northern part of the city has greatly increased the traffic volume on the three mile stretch of freeway that links this part of the city with the central business district. Therefore, it is desired to estimate the emissions growth along this link. The only appropriate method to estimate this emissions growth is to use direct traffic counts.

According to data obtained from the city engineer's office, the following traffic characteristics have been measured for this stretch of freeway:

1989 Average Traffic Volume = 80,000 vehicles per day
1993 Average Traffic Volume = 130,000 vehicles per day
1989 Average Vehicle Speed = 55 miles per hour
1993 Average Vehicle Speed = 50 miles per hour.

The annual VMT for this road segment is calculated by multiplying the yearly traffic volume times the road length. This procedure yields the following VMT estimates for each year:

1989 VMT 87.6 million miles
1993 VMT 142.4 million miles.

Referring to the default MOBILE-4.1 $_{NOX}$ emission factors contained in Table 4 yields the following emission factors for each year:

1989 Emission Factor = 4.373 grams per vehicle-mile
1993 Emission Factor = 2.721 grams per vehicle-mile.

Finally, the total $_{NOX}$ emission change attributable to the freeway link is calculated below:

)Q = (142.4 X 10^6veh-miles/year x 2.721grams/veh-miles) - (87.6 x 10^6veh-miles/year x 4.373grams/veh-miles

= 387 X 10^6grams/year - 383 X 10^6grams/year

= 427 tons/year - 422 tons/year = 5 tons/year

As calculated by this method, the annual average emission rate for the road segment increases by 5 tons per year between the baseline date and the permit year.

SECTION 4

ESTIMATING EMISSIONS FROM AREA SOURCES

For the purposes of this study, area sources are defined as all emission-causing activities that are not included in point source emission inventories or included in the mobile source emissions estimate. For NO_x, most area source emissions are contributed by residential, commercial, and industrial fuel combustion sources. Other area sources of NO_x include solid waste disposal and emissions from aircraft, railroad, and ship traffic.

In most locations, area sources contribute only a fraction of the total NO_x emissions. The contribution from mobile sources alone far outweighs that of area sources. Therefore, a detailed accounting of the increase in area source NO_x emissions for use in analyzing NO_2 increment consumption is not necessary, and a relatively simple technique for estimating the growth in area source emissions is presented.

The U.S. EPA publishes an annual National Emissions Report that summarizes emissions estimates for the five criteria pollutants.[4] Summary data are presented for the nation as a whole, for individual states, and for Air Quality Control Regions (AQCR's) within States. For NO_x, the emissions estimates are made for individual source categories such as those described above. These emission estimates are based on local fuel consumption data, utility hook-up information, local climatology, and other information.

It is recommended that the emissions estimates in the National Emissions Report be used on a per capita basis to estimate area source emission increases. A "per capita" assumption for the nature of these emissions is appropriate since the growth in emissions for each area source category can be directly linked to population growth. However, the specific method of applying these numbers to an emissions growth estimate will vary depending on the size of the study area. Therefore, two recommended methodologies for large and small study areas are summarized below.

LARGE STUDY AREAS

The National Emissions Report divides area source emissions into the following categories:

Residential Fuel Combustion
Industrial Fuel Combustion
Commercial/Institutional Fuel Combustion
Residential Solid Waste Disposal

Industrial Solid Waste Disposal
Commercial/Institutional Solid Waste Disposal
Aircraft
Vessels
Miscellaneous

The recommended procedure is to identify the AQCR in which the study area is located and obtain the emission estimates for each of the categories listed above for both the permit year and the baseline year. If the study area boundaries coincide with the AQCR boundaries, then the change in NO_x emissions is simply the total NO_x emissions for each of the categories listed above in the permit year minus the total emissions in the baseline year. An example of this method is provided at the end of this section.

If the study area is smaller than the AQCR, however, the emissions must be distributed on a per capita basis. For each source category, the total NO_x emissions are divided by the population of the AQCR to estimate emissions in tons per year per person in the AQCR, and then multiplied by the number of persons in the study area to estimate the emissions in the study area alone. Then the change in NO_x emissions is simply the total NO_x emissions for the each of the categories listed above in the permit year minus the total emissions in the baseline yew.

A per capita assumption for these emission categories is probably appropriate for a large study area since the emission generating activities summarized in these categories all relate directly to population. In addition, it is assumed that these different types of activities (industrial, commercial, residential, etc.) are all present and uniformly distributed throughout the study area. If these assumptions are not true, then a straight per capita approach will not work (see small study area approach below.)

In many state emission inventories. the emissions contained in the industrial source categories of the National Emissions Report may already be summarized in the point source database. If is the case, the emissions contained in these categories should not be included in the area source estimates. If there is some doubt as to whether or not they are included in the point source database, they should be included in the area source estimate as a worst-case assumption.

SMALL STUDY AREAS

As indicated above, when the study area is much smaller than the AQCR, a per capita method of estimating area source emissions faces some problems. For instance, assume that the study area is largely residential and does not contain any commercial or industrial areas, but the estimate for the entire AQCR lists emissions for these categories. Distributing commercial and industrial emissions in the study area on a per capita basis would be incorrect since it would include emissions sources that do not exist in the study area.

Conversely, if the study area is largely industrial and contains no residences, a per capita approach would estimate zero area source emissions in this area, which would clearly be incorrect.

To address these potential problems in small study area , it is recommended that the emissions estimate for each area source category be analyzed individually before being added to the total emissions estimate. For instance, residential emission sources should only be included in the total estimate if there are actually residences present in the study area. in this case, residential emissions would be estimated on a per capita basis. Similarly, commercial and industrial emissions should only be included if these activities are actually present in the study area. In this case, the emissions should probably be apportioned based on estimates of the daytime (working) population of the study area. This will avoid the problem of zero emissions estimates in non-residential areas. Lastly, marine and aircraft emissions should only be included if such facilities are actually located in the study area. An example of this methodology is provided at the end of this section.

In some cases, the study area may be so small (such as individual city blocks or new industrial parks) that using the data gathered on an AQCR basis is totally inappropriate. In this case, there is no simple method of estimating emissions change. A detailed emission inventory should be created to estimate all area source emissions. This type of inventory may be developed by quantifying utility hook-ups, individual fuel consumption records for each property, etc.

EXAMPLES

Two examples of the methodologies described above are provided. Each example uses the same hypothetical city analyzed in the examples at the end of Section 3.

Example #1 - Large Study Area

Assume that the study area boundaries coincide with the boundaries of the AQCR in which the study area is located. To estimate the emissions increase, the National Emissions Reports for 1989 and 1993 (hypothetically) are obtained and emissions estimates are summarized below.

Source Category	1989 Emissions (tons/year)	1993 Emissions (tons/year)
Residential Fuel Combustion	400	435
Industrial Fuel Combustion	610	640
Commercial/Institutional Fuel Combustion	340	370
Residential Solid Waste Disposal	210	230
Industrial Solid Waste Disposal	10	10
Commercial/Institutional Waste Disposal	0	0
Aircraft	320	370
Vessels	210	225
Miscellaneous	230	245
Total	2,330	2,525

From these data, it is calculated that the annual average emission rate for the study area increased by 195 tons per year between the baseline date and the permit year.

Example #2 - Small Study Area

As mentioned in Example #3 in Section 3. most of the growth since 1989 has occurred in the northern section of the study area. This part of the study area contains no airport or marine facilities. In addition, there are no industrial sources. Therefore, these source categories are not included in the emissions estimate. However, there is a uniform mix of residential and commercial/institutional sources.

Assumptions	1989	1993
Population of Study Area (AQCR)	400,000	460,000
Population of Northern Section of Study Area	30,000	70,000
Percent of Population in Northern Section	0.075	0.152

Distributing the emissions listed above on a per capita basis, and assuming a population growth in the entire AQCR from 400,000 to 460,000 people and from 30,000 to 70,000 people in the northern section of the study area yields the emissions estimates summarized below. The numbers on the table below were derived by multiplying the percentage of the AQCR population in the northern section of the study area times the annual emissions listed on the previous table for each source type, as illustrated by the following sample calculations:

1989 Residential fuel combustion = 0.075(400) = 30 tons/year
1993 Residential fuel combustion = 0.152(435) = 66 tons/year

Source Category	1989 Emissions (tons/year)	1993 Emissions (tons/year)
Residential Fuel Combustion	30	66
Industrial Fuel Combustion	0	0
Commercial/Institutional Fuel Combustion	25	56
Residential Solid Waste Disposal	16	35
Industrial Solid Waste Disposal	0	0
Commercial/Institutional Waste Disposal	0	0
Aircraft	0	0
Vessels	0	0
Miscellaneous	17	37
Total	88	194

From these data, it is calculated that the annual average emission rate for the northern section of the study area increases by 106 tons per year between the baseline date and the permit year.

SECTION 5

DISTRIBUTING EMISSIONS CHANGE

Once the magnitude of the emissions change has been estimated, it is then necessary to make an assumption regarding the distribution of the emissions change within the study area so that ambient impacts may be correctly estimated. This is perhaps the most crucial step in the process of estimating NO_2 increment impacts since an incorrect assumption regarding the distribution of the emissions change may lead to a significantly different estimate of the increment impact.

In general, the most effective way of distributing mobile source and area source emissions across a wide area is to divide the study area into grid squares and allocate the emissions into each individual grid square. Various methodologies have been developed to allocate mobile and area source emissions to individual grid squares. However, these methodologies require a careful analysis of land use, population distributions, and traffic distributions, and can be quite labor-intensive. Therefore, one of the purposes of this study is to identify when a gridded analysis of the emissions change is not necessary so that a relatively simple approach to estimating the NO_2 increment impact can be developed for these situations.

When addressing the need for a gridded emissions inventory, it is useful to examine mobile source and area source emissions separately. Therefore, a methodology for determining the need for a gridded emissions inventory is presented for each source type.

MOBILE SOURCE EMISSIONS

Allocating the change in mobile source emissions over a given study area is the most challenging and least precise aspect of the entire NO_2 impact estimation process. This is because mobile source emissions cannot be easily measured or described on a spatially averaged basis. The emissions themselves are concentrated along narrow line sources whose intensity changes year-to-year as traffic patterns, vehicle usage, emission factors, meteorology, and population change. Since the emissions are concentrated in line sources and small, intense area sources (such as parking areas), apportioning the emissions into large area sources and spatially averaging the emissions across the area source is not an appropriate assumption in many cases. Such an approach can not account for the impact of an emissions "hotspot" (such as a major freeway) that may be located within the area source, and greatly underestimate the actual NO_2 increment consumption at or near the hotspot.

Due to these factors, the application of any "simple" approach to allocating mobile source emissions changes will be greatly limited. It is probable that in many cases a more detailed distribution of the emissions into small grid squares and line sources, and a subsequently more difficult modeling procedure, will be necessary. Nevertheless, a framework for determining whether a more detailed emissions inventory is required is provided below. This framework consists of a two-step set of questions concerning the nature of the emissions in the study area and the study area's location with respect to the impact area of the PSD source being evaluated. A flowchart of this decision framework is shown in Figure 1.

Question #1 Do the study area and the impact area of the proposed source overlap?

Yes. If the study area and impact area overlap, a detailed inventory allocation may be required. Proceed to Question #2.

No. If the study area is located entirely outside of the impact area of the PSD source, then a detailed distribution of the estimated emissions change is not required. An example of this situation is when the proposed PSD source is located in a rural area outside of a nearby city. In this case, the emission change may be spatially averaged across the study area, and the impact of this emissions change can be estimated using the procedures described in Section 6.

The reason that a precise distribution of the emissions change is not necessary is that as the distance from the source (a city in this example) increases, the impact of all of the individual line and area sources within this source begin to approximate that of a single, large area source.

Question #2 Has there been a noticeable change in emissions along any individual road link within the portion of the study area that overlaps the impact area?

Yes. If there has been a noticeable change in emissions along an individual road link located within the impact area of the proposed source, it is possible that there is a NO_2 increment "hotspot" that would be missed by spatially averaging the emissions across the entire study area. In this case, some degree of gridding of the mobile source emissions is required, and consideration should be given to modeling some of the road links as individual line sources.

Determining whether an emission change along a road link is "noticeable" is left up to the reviewing agency and the permit applicant. The easiest way to screen for "noticeable changes" is to identify the individual road link within the study area that has experienced the greatest traffic increase over the period being examined and to estimate the emissions change over this link using the methodology presented in Section 3. If this procedure indicates an emission increase along this link, then the impact of this increase can be estimated using the procedures outlined in Section 6 for line sources. If the impact is determined to be noticeable," then the reviewing agency and permit applicant may decide that a more detailed inventory is required.

No. If no individual road links within the study area have shown a noticeable change in emissions, it is then appropriate to spatially average the emissions change across the entire area. In this case, it is likely that the study area actually has experienced a net decrease in NO_x emissions due to the steady decrease in NO_x emissions factors for mobile sources. Since no "hotspots" of increment consumption exist either, spatial averaging is an appropriate "worst-case" assumption.

If only a small portion of the study area overlaps with the impact area of the proposed source, it is possible that there are noticeable emissions increases along road links located in other portions of the study area, but not within the impact area itself. Unless these road links are located immediately adjacent to the impact area, it is still appropriate to spatially average the emissions change across the entire study area. In this case, spatial-averaging will tend to overestimate the impact that is occurring within the portion of the study area that overlaps the impact area.

AREA SOURCE EMISSIONS

Distributing area source emissions changes throughout the study area is somewhat simpler than distributing mobile source emissions since the source locations and intensities do not change as drastically from year-to-year. Most of the growth in area source emissions can be attributed to new development within existing areas or expansion of urban development to previously undeveloped areas. In addition, as mentioned in Section 4, most of the area source emissions categories can be directly linked with population, providing, a readily available surrogate for distributing the emissions change.

However, simply assuming a spatially-averaged emission rate change over the entire study area is not always correct. It is possible that there are "hotspots" of development within the study area, similar to those discussed for mobile sources, that must be evaluated. Therefore, a similar framework to that provided for mobile source emissions changes is presented for area sources to help determine whether a gridded analysis of the emissions change is required. A flowchart of this decision framework is shown in Figure 1.

Question #1- Do the study area and the impact area of the proposed source overlap?

Yes. If the study area and impact area overlap, a detailed inventory may be required. Proceed to Question #2.

No. As with mobile source emissions, if the study area is located entirely outside of the impact area of the PSD source, then a detailed distribution of the estimated emissions change is not required. In this case, the emission change may be spatially averaged across the study area, and the impact of this emissions change can be estimated using the procedures described in Section 6.

Question #2 Has there been a noticeable variation in the growth pattern of residential, commercial/institutional or industrial facilities within the study area?

Yes. If the estimate of the area source emissions change over the study area indicates an increase in the emissions from any of the source categories listed, it is possible that a spatially-averaged distribution of this emissions change is not appropriate. For instance, if a new residential subdivision was constructed within a large study area but no other new residential sources were constructed anywhere else, spatially-averaging this emission increase would miss a potential NO_2 increment "hotspot".

Determining whether the variation in the growth of new development is important is left up to the reviewing agency and the permit applicant. One method to determine if the growth variation is important is to identify the sub-area of the study area that has experienced the most growth for one of the source categories listed, and to estimate the emissions change over this sub-area using the methodology presented in Section 4. Then the impact of this increase can be estimated using the procedures outlined in Section 6 for area sources. If the impact is determined to be "noticeable," then the reviewing agency and permit applicant may decide that a more detailed (gridded) inventory is required.

No. If there has been no variation in the growth of the sources in the categories listed in Section 1, a spatial average of the emissions change (if any) is appropriate. In addition, if variances in the growth rates are identified but are determined to be "insignificant" using the procedures listed above, then a spatial average may be used.

SECTION 6

ADDITIONAL CONSIDERATIONS

The validity of the methodology presented in this report is based on a major assumption, that all of the data required to estimate emissions in the permit year are immediately available. Unfortunately, this assumption is not true in all cases, and special consideration must be given to the effects that this assumption may have on the estimated impacts.

DATA AVAILABILITY

To estimate the net NO_x emissions increase requires data concerning both the baseline year and the permit year. Since, in most cases, the permit year is the current year, many of the data sources cited in this report will not yet be available. For instance, the FHWA annual Highway Statistics publication is usually not available until eight months after the end of the year being summarized. In this situation, the reviewing authority and the PSD applicant must agree on a method of extrapolating the data from the most recent yew available. It is anticipated that this will not pose a great problem for most areas. Only for areas with explosive growth in a particular area of the city or in the emissions of a particular source category will an extrapolation greatly miscalculate the conditions in the permit year.

SECTION 7

SUMMARY

This report has detailed methods that may be used to estimate NO_x emissions increases and NO_2 increment impacts from mobile and area sources. These methods may be used in many situations to determine whether detailed emissions inventories are required to estimate NO_2 increment consumption.

It is likely that the methods presented in this report may not be appropriate in many situations. For instance, the methods presented for estimating NO_x emissions increases from mobile sources cannot be used when there are significant variances across the study area in the rate of emissions growth. This situation, however, frequently occurs in rapidly developing cities, where the growth is often concentrated in certain sectors of the city. In this situation, the only appropriate method for analyzing the NO_x emissions growth and NO_2 increment impacts is to develop a gridded emissions inventory and perform a detailed dispersion modeling analysis.

However, the methods presented in this report will be useful in developing the data base for estimating NO_2 increment impacts for smaller cities and in areas that are not experiencing rapid growth. They are also quite appropriate for use in analyzing the impacts of emissions from nearby or distant cities at the location of the proposed PSD source.

TABLE 1. SUMMARY OF VMT ESTIMATION TECHNIQUES

Technique	Advantages	Disadvantages
Direct Vehicle	Most accurate method	Impossible to obtain data for large areas
Area-wide VMT estimates	Data is easily obtained in large areas	Data not available for metropolitan areas with populations less than 200,000 May not include all miles traveled on minor roads
Fuel Consumption Data	Data is easily obtained in large areas Includes all miles traveled on minor roads	Assumes all fuel purchased in study area is consumed in the study area
Per Capita Estimates	Good for small study areas	Assumes similar vehicle usage in all areas Assumes all miles traveled in a given study area are only from people who live in the study area

TABLE 2. FLEET AVERAGE FUEL EFFICIENCY

Year	Fuel Efficiency (mpg)	Year	Fuel Efficiency (Mpg)
2007	19.32	1997	19.52
2006	19.35	1996	19.54
2005	19.37	1995	19.56
2004	19.39	1994	19.58
2003	19.42	1993	19.58
2002	19.45	1992	19.53
2001	19.45	1991	19.46
2000	19.52	1990	19.32
1999	19.57	1989	19.13
1998	19.56	1988	18.87

TABLE 3. RECOMMENDED VMT ESTIMATION TECHNIQUES

Study Area	Recommended Techniques
Large city with population ≥ 200,000	Area-Wide VMT Estimates Fuel Consumption Data
Large county with population ≤ 200,000	Fuel Consumption Data
Small city with population ≤ 200,000	Per Capita Estimate
Portion of city which is experiencing explosive growth	Per Capita Estimate
Individual road segment	Direct Vehicle Count
City block or small subdivision	Direct Vehicle Count

TABLE 4. MOBILE-4.1 EMISSION FACTORS FOR NO_X
(GRAMS/VEHICLE MILE)

	Vehicle Speed (miles/hour)								
Year	15	20	25	30	35	40	45	50	55
1999	3.876	3.692	3.540	3.474	3.472	3.527	3.649	3.996	4.607
1989	3.761	3.568	3.400	3.322	3.310	3.357	3.472	3.789	4.373
1990	3.596	3.399	3.221	3.133	3.112	3.152	3.257	3.552	4.094
1991	3.353	3.164	2.990	2.994	2.954	2.982	2.972	3.234	3.723
1992	3.107	2.930	2.746	2.648	2.612	2.631	2.707	2.941	3.382
1993	2.918	2.751	2.569	2.470	2.430	2.443	2.510	2.721	3.126
1994	2.758	2.598	2.416	2.315	2.273	2.281	2.339	2.533	2.907
1995	2.571	2.422	2.244	2.144	2.100	2.102	2.151	2.326	2.667
1996	2.425	2.296	2.111	2.011	1.965	1.964	2.006	2.166	2.482
1997	2.334	2.192	2.012	1.908	1.957	1.852	1.890	2.039	2.334
1998	2.245	2.109	1.929	1.823	1.770	1.761	1.793	1.931	2.208
1999	2.171	2.038	1.859	1.754	1.701	1.691	1.721	1.851	2.115
2000	2.127	1.995	1.816	1.711	1.657	1.646	1.674	1.800	2.056
2001	2.084	1.954	1.775	1.668	1.613	1.600	1.627	1.748	1.995
2002	2.055	1.925	1.746	1.640	1.585	1.571	1.597	1.716	1.957
2003	2.028	1.899	1.720	1.614	1.558	1.544	1.569	1.685	1.922
2004	2.012	1.883	1.704	1.597	1.540	1.525	1.549	1.664	1.897
2005	2.005	1.876	1.096	1.589	1.533	1.518	1.542	1.656	1.898
2006	1.966	1.940	1.662	1.556	1.501	1.495	1.508	1.619	1.845
2007	1.953	1.828	1.651	1.545	1.490	1.474	1.497	1.606	1.831

Figure 1. Decision framework for determining appropriate modeling approach for mobile sources