INTEGRATING NETWORK MODELING AND AIR POLLUTION MODELING TO DETERMINE NO2 CONTRIBUTIONS FROM MOTOR VEHICLES

Paper Presented at the 1993 ASCE national conference

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ABSTRACT

Since 1970, traffic volumes have more than doubled in some areas near Burlington, VT. During the same period, NOx emissions from motor vehicles have been reduced by approximately 260%. Thus, emission rate improvements over the past 20 years have surpassed the growth in vehicle volumes; although, the rate of improvements in emissions are slowing.

Using travel demand network models integrated with air pollution emissions and dispersion models, the analyses in this paper sought to characterize daily NOx emissions from motor vehicles and forecast NO_2 ground level concentrations from motor vehicles in the year 2000.

It was found that, despite increasing vehicle-miles-traveled (VMT) and congestion, the average annual NO_2 concentrations due to motor vehicles will roughly halve by the year 2000. Furthermore, for small communities, emissions caused by vehicle congestion are shown to be a minor part of overall emissions. Therefore, air pollution models that do not take into account added delays due to congestion may still accurately portray mesoscale NO_2 concentrations.

INTRODUCTION

The 1970 federal Clean Air Act (42 U.S.C.A sections 7401-7642) set the maximum air pollution concentration that would be permitted in any one area. These "National Ambient Air Quality Standards" (NAAQS) were based on the minimum dose of a pollutant required to cause adverse health effects on the most sensitive portion of the population. Shortly after this legislation was enacted, the Sierra Club sued the U.S. Environmental Protection Agency (EPA) to enforce the intent of the law: "to protect and enhance the quality of the Nation's air resources...." The court held that this phrase in the statute was intended to mean that no significant deterioration of the existing air quality in a specific area was permitted, even if pollution of the ambient air was well below the NAAQS. This led to the formation of the Prevention of Significant Deterioration (PSD) rules and standards.

Any major source of NO_2 built or modified since February 8, 1988 or minor source built or modified since the baseline date of February 8, 1988(1) consumes air pollution increments. Along the same lines, any source that has been shut down since those dates, or has reduced emissions, would make available air pollution increments for another use. In the case of NO_2, the annual NAAQS is set at 100 $\mu g/m^3$, while the PSD increment is set at 25 $\mu g/m^3$. This means that ground-level concentrations may not exceed 100 $\mu g/m^3$, and can not increase more than 25 $\mu g/m^3$ above the concentration in the baseline year.

On June 12, 1990, the EPA's New Source Review Section issued draft guidance on modeling NO_2 PSD increments.[2] This guidance suggested that when modeling to permit new industrial sources, the increment consumed by minor sources, such as transportation sources, be taken into account:

> "Area and mobile sources are minor sources and thus, like minor point sources, any changes in actual NOx emissions occurring since the **minor** source baseline date can consume (or expand) increment."[3]

This means that a growth in traffic volumes without subsequent improvements in emissions would consume increment, and therefore may serve to indirectly limit industrial growth in a region. On the other hand, if vehicle emissions improve at a higher rate than traffic growth, then some increment may be made available, making way for new increment-consuming sources or, even better, cleaner air.

This paper will evaluate a procedure which estimates NOx increment consumption from mobile sources in small and medium sized communities using an integration of travel demand network modeling and Gaussian plume air pollution dispersion models.

BACKGROUND

THE STUDY AREA

The study area encompasses Chittenden County, Vermont, of which the largest city is Burlington. This is the largest county in Vermont, with a 1990 population of 131,761, and has been growing at a rate of 1.3% per year since 1980.[4]

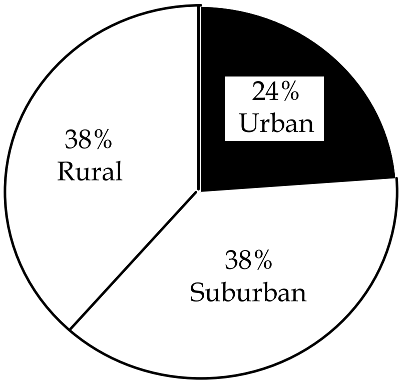
The county can be divided into urban, suburban, and rural portions, with the urban center experiencing the least growth and the suburban and the rural areas the most growth since 1980 (Table 1).

TABLE 1: Population growth in Chittenden County since 1980 in urban, suburban and rural areas [5]

Classification	1980	1990	Percent Change per year
Urban	54,710	58,585	0.69%
Suburban	35,864	41,987	1.59%
Rural	24,960	31,189	2.25%
Total	115,534	131,761	1.32%

Figure 1 shows further that the distribution of new residences also heavily favors rural and suburban locations. This trend in population growth reflects the "suburbanization" of American cities. As population centers become more congested, residential and commercial development has centered on major arterials leading into the cities, and other less-developed areas.

FIGURE 1: Distribution of new residences between 1980 and 1990 [6]



GROWTH IN TRAFFIC VOLUMES

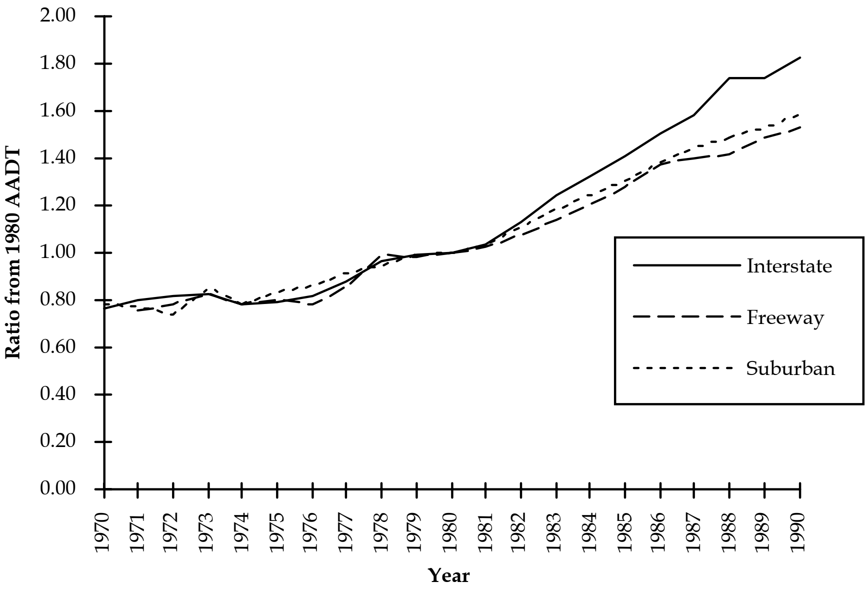
As a direct result of population growth and the dispersion of economic activity, traffic volumes have also been growing. While the interstate system has absorbed most of the additional traffic, major suburban arterials are also exhibiting high traffic growth rates. As shown in Figure 2, suburban arterials have shown a 58% growth since 1980 and a 100% growth since 1970. This translates into a growth rate of 3.6% per year since 1970 or 4.7% per year since 1980.

As the population data also suggest, much of the growth in the study area roads has taken place in the suburbs, where the proper infrastructure is often not in place to handle large traffic volume increases. Therefore, as suburbanization increases, congestion along suburban arterials also increases.

AIR POLLUTION

Due to implementation of the Clean Air Act of 1970 and later amendments, emissions of NOx, carbon monoxide (CO), and hydrocarbons (HC) from the vehicle fleet (i.e., the composite emissions from all vehicles on the road in proportion to their VMT) have been rapidly decreasing. As shown with the EPA's MOBILE 4.1 computer program,[7] fleet emissions of NOx have decreased by 61%, while CO emissions have decreased by 69%, and HC emissions have decreased by 71% since 1978 (Figure 3). However, legislated vehicle emission standards for NOx and CO have not substantially changed since 1981. Therefore, as the vehicle fleet ages and cars older than 1981 model years leave the fleet, emissions improvements may no longer offset the projected rise in VMT in a specific region. This is shown in Figure 3, where MOBILE 4.1 predicts national fleet emissions leveling out starting in 1995, and continuing through 2000.

FIGURE 2: Growth in traffic volumes at continuous counters in Chittenden County since 1970 [8]



One would expect these emissions improvements to be reflected in ambient air monitoring data collected in the region. NO_2 data in Chittenden County has been collected only since 1986; however, since that time, no clear trend in ambient concentrations has been established (Figure 4). This is similar to NO_2 monitoring on a national scale. The EPA reports that "nationally, composite annual average NO_2 levels decreased from 1980 to 1983, and remained essentially constant since 1984."[9] A similar trend is experienced when metropolitan statistical areas (MSA) of less than 250,000 are isolated; in this case, an overall decline of approximately 7% has been observed since 1980, although the overall trend is fairly flat.[10]

There are two possible reasons for the generally flat trend. First, although fleet emissions have decreased by approximately 58% since 1980, traffic volumes have grown by 58% during that time. Improvements we have seen in vehicle emissions have been cancelled out by increases in vehicle use.

FIGURE 3: Vehicle fleet emission trends[11]

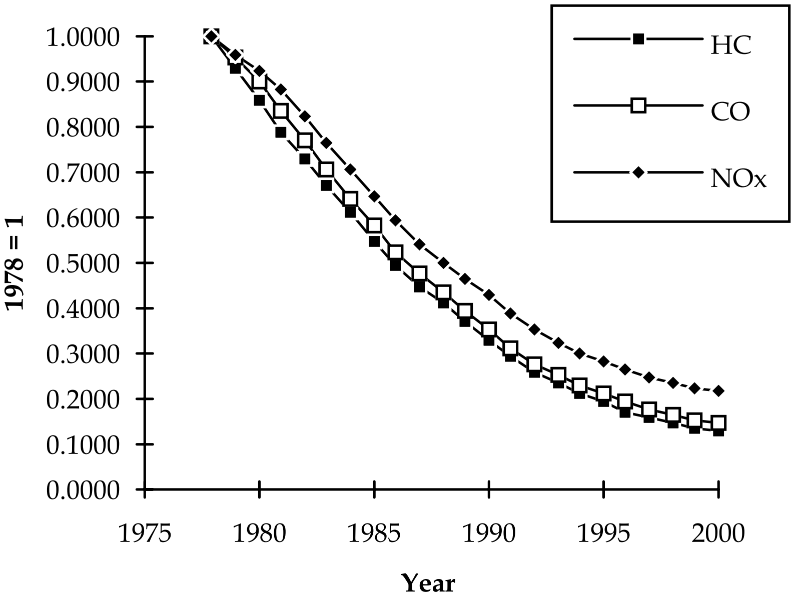


FIGURE 4: Annual average NO_2 concentrations in Burlington

Secondly, at a national level, NOx emissions from motor vehicles are 40% of the total emissions from all sources.[12] This is a decline from 50% since 1980. However, growth in other sectors, especially fuel combustion since 1980, has also somewhat offset the improvements in motor vehicle NOx emissions.

COMPUTER MODELING

Given the high growth rates in the study region, the declining emission rates for motor vehicles, and proposed EPA rules on increment consumption modeling, it has become necessary to develop a consistent set of techniques that can be used to estimate NOx concentrations both for the baseline year and for future years. Computer modeling is an ideal application for increment determination, so long as a consistent set of input parameters is used and assumptions included in the modeling can be well justified. The following section will formulate a computer modeling technique, apply it to a particular example, and discuss the assumptions and results.

GENERAL PROCEDURE

To determine average daily NOx concentrations for both the current year and future years, a four-step process was carried out:

1) A survey was conducted on Chittenden County residents to determine daily trip-making behavior.
2) A network model was designed and calibrated for the baseline year, 1989. Model runs for future years were made using regional land-use forecasts.
3) Resultant link (road) operating speeds and idling time were converted into NOx emissions using MOBILE 4.1 emission factors.
4) An area source model, EPA's CDM 2.0,[13] and emission rates from Step 3 were used to calculate ground level NOx concentrations.

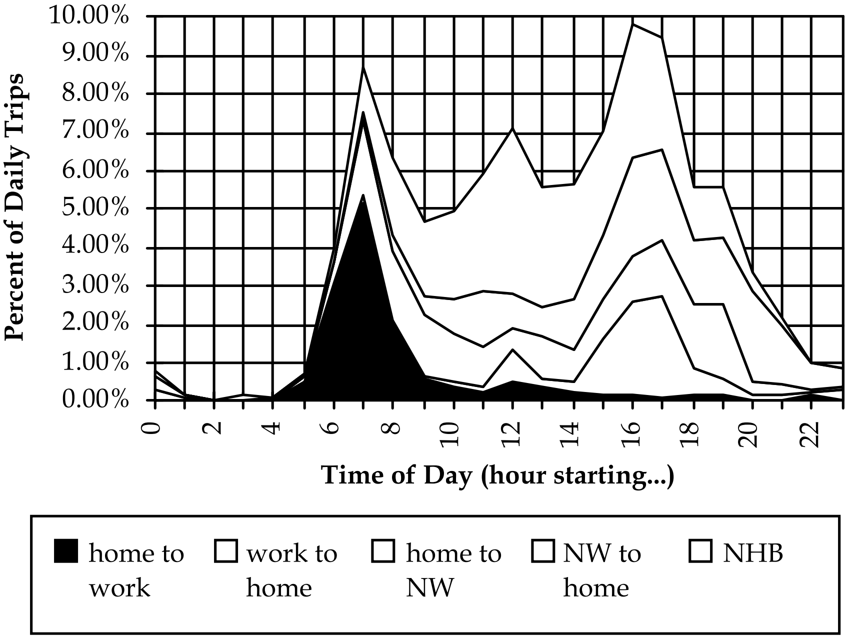
THE SURVEY

In 1989, a comprehensive travel diary survey was conducted of 1,200 households in Chittenden County[14] by the Chittenden County Regional Planning Commission (CCRPC) and *Resource Systems Group, Inc.*

The response rate to the survey was 38%, accounting for approximately 3,500 daily vehicle trips. Of these, 25% were home-based work trips, 41% were home-based non-work (NW) trips, and the remaining 34% were non-home based trips (NHB).

As expected, a daily distribution of trips showing three peaks – morning, noon, and evening – was derived from the survey data (Figure 5). The morning peak was characterized by its short duration and relatively large percentage of home-to-work trips. The noon-time peak was less pronounced and comprised mainly non-home-based trips. The evening peak was spread over two to three hours, and is characterized by a somewhat even distribution of home-based work, home-based non-work, and non-home-based trips.

FIGURE 5: Distribution of daily vehicle trips by trip type

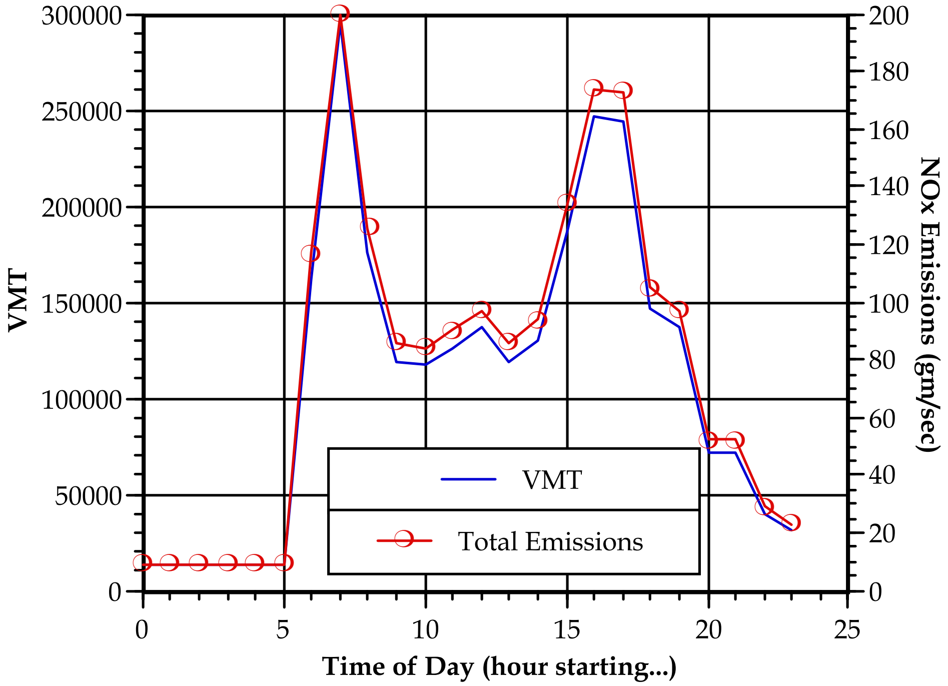


THE NETWORK MODEL

Based on the survey data detailed above and land use data supplied by the CCRPC, a network model was calibrated to the road system of Chittenden County. The model consists of 954 links accounting for 1,174 lane-miles. The network was created using the TMODEL2[15] modeling package. It was calibrated to within 1.4% of the total counted network volume during the 1989 design hour[16], with a correlation coefficient of 0.90 and an average link error of 28%.[17]

The model was calibrated to reflect design hour conditions and not the average hour. Since NO_2 standards are based on the average annual concentration, the model was altered to reflect the annual average hour. This was accomplished by running the model for each of the 24 hours of the day[18] and determining the average hour in terms of VMT and NOx emissions. The results of this modeling are shown in Figure 6, where VMT and NOx emissions are observed to follow each other very closely. Using this graph, the “average” or “typical” hour was determined to start at 10:00 AM.

FIGURE 6: VMT and NOx emission trends over the course of the day, using network modeling



As shown above in Figure 6, VMT and NOx emission trends during the day follow a similar course. This is the case despite the heavy congestion during the AM and PM peak hours. In order to track such congestion during the course of the day, a “congestion index” was formulated to apply to the loaded link file:

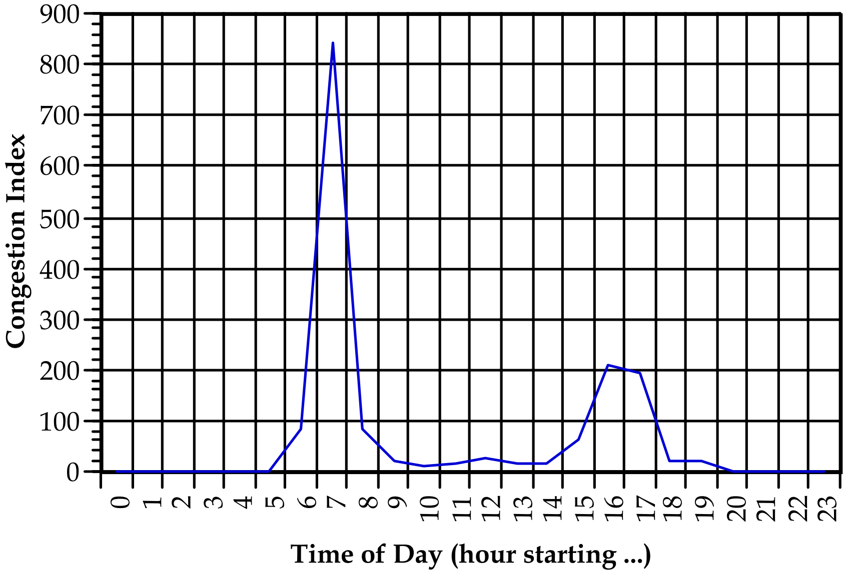
$$\text{Congestion index} = \sum\left(\frac{Vol_L \infty Dist_L}{Spd_L} - \frac{Vol_L \infty Dist_L}{FFSpd_L}\right)$$

where:

Vol_L = the loaded vehicle volume on link L;
$Dist_L$ = the length of link L;
Spd_L = the actual operating speed on link L; and,
$FFSpd_L$ = the posted speed limit on link L.

The results of congestion index tracking are shown in Figure 7. It is interesting to note that the congestion index is significantly higher during the morning peak hour than during the evening peak hour despite the fact that more vehicles are on the road during the evening peak hour (Figure 5). NOx and VMT emissions are also greater in the morning peak hour (Figure 6), but exhibit more of an evening peak than does congestion.

FIGURE 7: Daily trends in congestion



Modeling was also performed for a year 2000 scenario. Land use forecasts were provided by the CCRPC. These forecasts represent an increase of 1.4% per year in residential development and 5.1% per year in commercial and retail development.

Year 2000 model runs were performed assuming no additional roadway infrastructure. The runs showed an increase of 21% in daily VMT (1.0%/year) and 85% in the daily congestion index (5.8%/year).

THE INTEGRATION MODEL

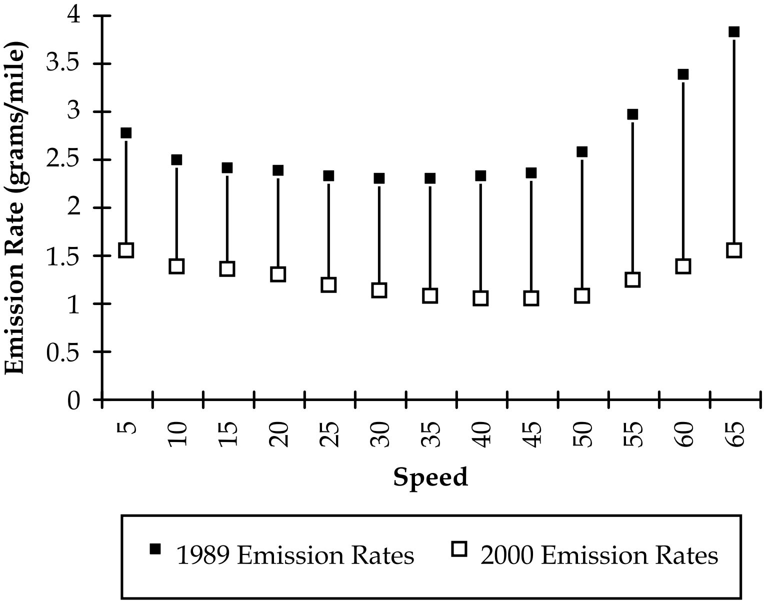
In order to convert the network modeling results to a form appropriate for an air pollution dispersion model, an integration model was developed. This model took link outputs, in terms of actual running speeds, travel times, and idling delays, and converted these to NOx emissions using output from the EPA's mobile-source emissions model, MOBILE 4.1. As a result, each link is associated with running NOx emissions, and two sets of idling emissions – one for each end.

The emission rates from MOBILE 4.1 were calculated using the following program parameters:

1) 100% hot stabilized (i.e., warmed-up) emissions on the Interstate highways and other freeways;
2) 20.6% cold start, 27% hot start on all other roads;
3) National vehicle fleet aging distribution;
4) Local vehicle mix distribution based on a suburban arterial classification count; and,
5) Annual average Burlington temperature of 52.7°F.

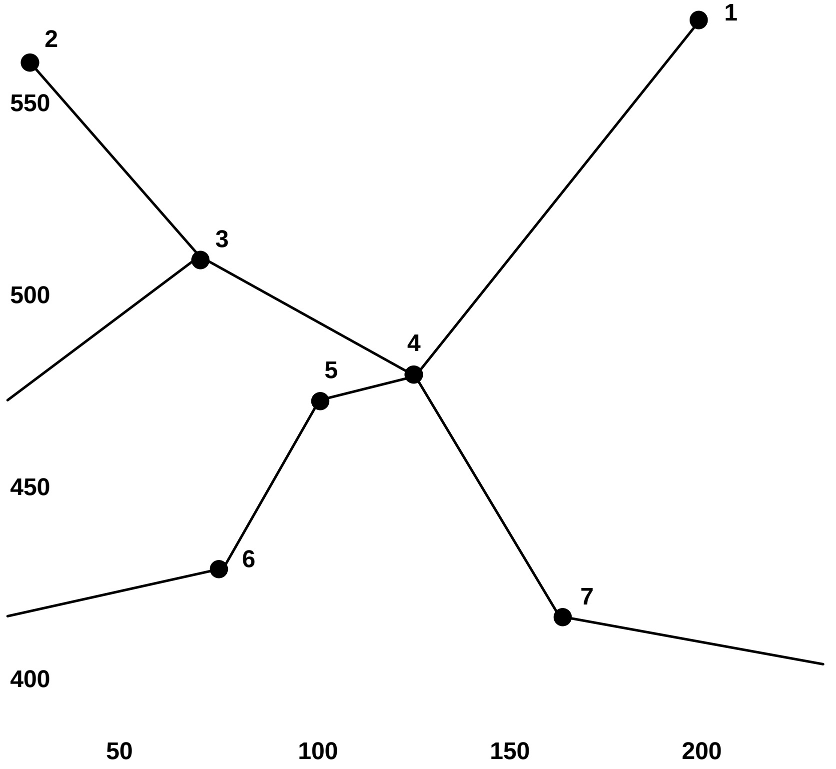
The emission rates that resulted were distributed in a "U" shaped curve when plotted against speed (Figure 8). As speed increases up to 30 mph, NOx emissions decrease. After 35 mph, emissions increase exponentially. However, when compared to the 1989 emission ∞ speed curve, the 2000 curve does not rise as steeply with higher speeds. Indeed the largest improvement in emission rates between 1989 and 2000 is in the 60 and 65 mph categories.

FIGURE 8: Emission rate by speed in 1989 and 2000



After each link was assigned running and idle emission levels, the County was divided into gridded squares, with the side of each grid measuring 1.0 mile. The total emissions for each grid were then calculated, based on the

FIGURE 9: Sample calculations of gridded emissions from a loaded network



Scale - 50 units = 1 mile

In this example, all links represent one-way roads, A->B.

The 30 mph NOx emission rate is 1.93 g/mile and the 45 mph NOx emission rate is 2.01 g/mile. The idle emission rate is 6.34 g/hour.

Link A->B	Avg speed	Volume	Distance	Running NOx	Stopped delay	Idle NOx
1/4	30 mph	250 vph	2.3 miles	0.31 g/s	25 sec	0.0031
2/3	45	150	1.5	0.13	0	0
3/4	45	150	1.4	0.11	10	0.0007
4/5	30	250	0.6	0.08	0	0
4/7	45	250	1.6	0.22	0	0
5/6	30	150	1.0	0.08	0	0

Running NOx = NOx emission rate for speed ∞ volume ∞ distance / 3600 s/h
Idle NOx = NOx idle emission rate ∞ volume ∞ stopped delay / (3600 s/h)^2

Tot. emissions for grid 100/450 = Running NOx (100% of link 4/5 + 30% of link 5/6 +
70% of link 3/4 + 10% of link 1/4 + 35% of link 4/7
+ Idle NOx (link 3/4 at node 4 + link 1/4 at node 4)

overlapping portions of links in the network. Figure 9 shows a theoretical link network overlaid on a grid similar to that used in this analysis.

In the above example, each link represents a road segment in our network. The link is characterized by a distance, speed limit, actual travel speed, and traffic volume; the latter two are determined by the simulation model results. At each end of the link are nodes, which may represent intersections and thus may also have associated stopped delays.

To determine NOx emissions for the link, the volume of vehicles on the link is multiplied by the link length and the appropriate NOx emission rate for the speed class. Furthermore, idling emissions for each node are assigned based on the volume of vehicles multiplied by the stopped delay and idling emission rates.

After link emissions were calculated, they were assigned to a grid square in proportion to the link in that grid square. For example, in Figure 9, 40% of link 4/7 would be assigned to grid 100/450, 10% would be assigned to grid 150/450, and 50% would be assigned to grid 150/400. Furthermore, idling emissions from node 7 would be assigned to grid 150/400.

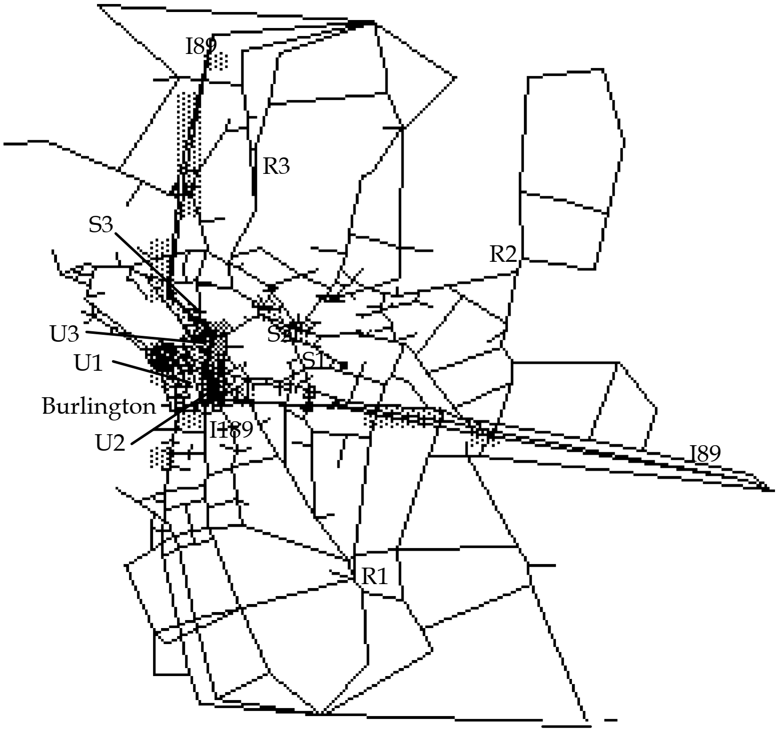
Figure 10 shows the actual Chittenden County link network that was used in the modeling. The shaded areas show the grid squares with higher total NOx emissions. As is shown, the highest emissions tend to occur around the interstates, and to some degree in the Burlington street network. The darkest area, that is the grids with the highest emissions, is seen on Interstate 89 between I-189 and the Burlington exit. This section carries a heavy volume of traffic, traveling at high speeds. As Figure 8 has shown, vehicles traveling at higher speeds can have an overall emission rate up to 66% higher than those at lower speeds.

The integration model then created an input file for use in the CDM 2.0 dispersion model, described in the following section.

The integration model was also used in modeling NOx emissions for every hour of an average day. Part of these results have already been discussed in the *NETWORK MODEL* section of this paper, (see specifically Figure 6). In addition to calculations of county-wide NOx emissions, two other county-wide parameters were determined: 1) the percentage of total emissions due to idling; and 2) the percentage of emissions due to congestion. These two parameters are similar in that the total congestion emissions include idling emissions. However, congestion emissions also include changes in emissions due to the slowing of vehicles on congested roadways. Therefore:

Congestion emissions = Idling emissions
\+ Emissions on loaded (congested) links
\- Emissions on same links at freeflow speeds.

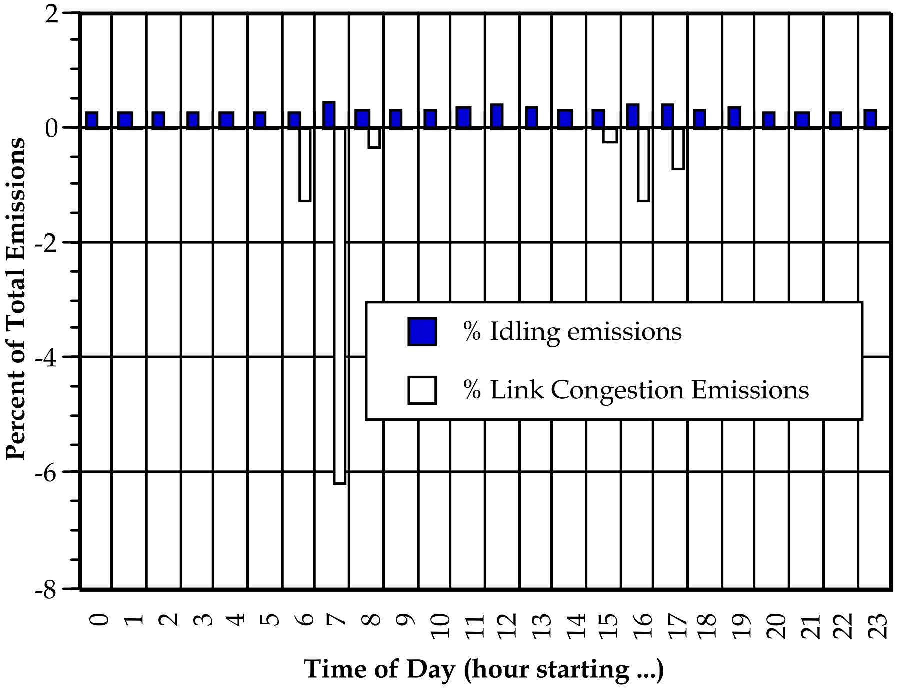
FIGURE 10: Chittenden County link network showing areas of high NOx concentrations



NOTE: Light gray is 25% to 50% of highest area-wide NOx emissions. Dark gray is 50% to 100% if highest area-wide NOx emissions R, S, and U refer to receptor locations used in the CDM 2.0 modeling, as described in the next section.

Figure 11 shows the percentage of total emissions from the entire network that is caused by idling vehicles and vehicles slowing down due to congestion. During periods of high congestion, idling emissions increase somewhat but the slowing of vehicles actually decreases total NOx emissions. Congestion is shown reducing NOx emissions by as much as 6% during the morning peak hour. During the “average” hour beginning at 10 AM, congestion plays little role in emissions.

FIGURE 11: 1989 emissions from idling vehicles and from vehicles slowed due to congestion over the course of an average day



THE AIR POLLUTION DISPERSION MODEL

The EPA's CDM2, or the Climatological Dispersion Model, is a Gaussian plume dispersion model, that forecasts ground level concentrations based on area and point source emissions. Area source emissions include the grid squares, which were defined above, while point source emissions tend to include industrial sources. Industrial sources were not included in this modeling effort.

Since CDM2 can predict ground level concentrations from multiple area and point sources, it is ideal for calculating increment consumption. This is done by modeling both the design year of a project, and the baseline year (1989 in Vermont), and subtracting the two results. If ground level concentrations are higher in the design year, then increment is consumed. Likewise, if ambient concentrations improve, increment is expanded.

Nine receptors were chosen for increment modeling in this case study; three in urban areas (the ANR NOx monitor near Bank Street in downtown Burlington, Dorset & Williston in South Burlington, and downtown Winooski), three in suburban areas (Taft Corners in Williston, CCRPC offices in Essex, and the I-89 Exit 16 area in Colchester), and three in rural areas (village centers of Milton, Jericho, and Hinesburg). Figure 10 shows the locations of each receptor.

The model was run assuming daytime emissions were 55% over the average daily emission rate, and night time emissions were similarly 55% below the average daily emission rate. These percentages were based on the daily emission trend data shown in Figure 6.

The CDM results showed decreases in ground-level NOx concentrations of up to 48% in the year 2000 in urban areas (Table 2). The three suburban receptors showed the widest spread, exhibiting a 22% to 49% decrease in NOx concentrations. The rural receptors showed concentration declines between 43% and 50%.

TABLE 2: Changes in ground level concentrations

Receptor	1989 conc. ($\mu g/m^3$)	2000 conc. ($\mu g/m^3$)	Percent difference
Urban 1	5.3	2.8	-47%
Urban 2	9.8	5.3	-46%
Urban 3	5.6	2.9	-48%
Urban Average	6.9	3.7	-47%
Suburban 1	2.3	1.8	-22%
Suburban 2	3.6	2.1	-42%
Suburban 3	5.5	2.8	-49%
Suburban Average	3.8	2.2	-41%
Rural 1	1.2	0.6	-50%
Rural 1	0.7	0.4	-43%
Rural 3	0.7	0.4	-43%
Rural Average	0.9	0.5	-46%
County Average	3.9	2.1	-45%

The average annual NO_2 concentration found at the Burlington monitoring station (receptor urban-1) was 35.6 $\mu g/m^3$. Since NO_2 from motor vehicles should comprise approximately 40% of the total emissions from all sources, one would expect the modeled concentrations to be somewhere near 14 $\mu g/m^3$. It should be noted, however, that the monitoring site is immediately adjacent to Winooski Avenue, and therefore would pick up higher concentrations of NO_2 than would the modeling of emissions averaged over 1-mile grid squares.

DISCUSSION

There are four major findings in this study that merit further discussion:

1) VMT, congestion, and NOx emissions are greater in the morning than in the evening, despite the greater number of vehicles on the road in the evening.
2) Idling emissions account for a very small part of total NOx emissions, even in the average peak hours.
3) Moderate increases in congestion are shown to improve ambient NOx concentrations.
4) NOx due to motor vehicles will decrease by approximately 45% between 1989 and 2000, despite increases in traffic volume.

24-HOUR MODELING RESULTS

The 24-hour network modeling effort was performed in order to calculated the hour of the day which represented "average" traffic conditions. In the course of this modeling, it was discovered that despite the fact that the total number of trips during the morning peak hour is approximately 10% less than the evening peak hour, total VMT, congestion, and NOx emissions is higher in the morning peak hour.

This behavior is likely due to the composition of trip types during both periods. During the morning peak hour, 84% of the trips are home-based-work. These trips tend to be longer, single purpose trips, highly concentrated between 7:00 AM and 8:00 AM. The evening peak hour is characterized by an even distribution of home-based-work, home-based-nonwork, and non-home-based trips. The latter two types of trips tend to be shorter, multi-purposed trips. The evening peak is spread over several hours owing to the fact that a work to home trip takes longer if one or more shopping or other non-home trip is made in between.

Therefore, while the AM peak *hour* may have a higher VMT, if the entire evening peak period is taken into account, the evening peak *period* VMT would exceed the AM peak *period.*

For example, if a 20 mile home-to-work trip takes place in the AM peak hour, the same work-to-home trip in the evening peak period may be punctuated by trips to a supermarket, repair shop, or school. Thus, the number of trips increases, the average trip length decreases, and the total work-to-home time increases. This leads to a longer evening peak period, with a shorter VMT per hour.

Since VMT is greater in the morning peak hour, NOx emissions and congestion are also greater. However, the congestion index is four times higher in the morning peak hour than the evening peak hour, while NOx emissions are only 13% higher. This is likely due to the fact that congestion increases exponentially with higher traffic volumes. While the morning peak has lower traffic volumes than the evening peak hour, the morning traffic tends to be more concentrated in residential and commercial areas with a high degree of directionality due to the limited trip purpose.

The concept of an exponentially increasing congestion with traffic volume is also supported by a comparison between 1989 and 2000 network modeling results. While the 2000 VMT is 21% higher than 1989, congestion is increased by 85%. Furthermore, the morning peak hour congestion index in 2000 is still four times that in the evening peak hour.

IDLING EMISSIONS

As part of the new guidance on NO_2 increment, and other draft guidance related to the Clean Air Act Amendments of 1990, states will be required to track VMT growth in, at least, non-attainment areas for ozone and CO. Furthermore, VMT tracking may also be required for NO_2 attainment areas. In order to meet the requirements of these new regulations, many states have begun to implement tracking programs,[19] and create computer programs to integrate tracking and air pollution modeling. One of the main drawbacks to this method, however, has been that these models do not tend to take into account stopped delays, and therefore idling emissions. Since we have already determined that congestion significantly increases in the eleven years between 1989 and 2000, the question that remains is whether congestion can significantly contribute to NOx emissions.

Based on the 24-hour model and integration model results, it was shown that idling emissions only account for 0.32% of total network emissions in 1989. The figure increases by 22% in 2000, but is still only 0.39% of the total area-wide NOx emissions.

For this type of county, with a concentrated urban area and vast suburban and rural component, stopped delays do not significantly add to the overall mesoscale emission rate. Therefore, state NOx models which do not factor in idling emissions may be appropriate for use in counties similar to Chittenden County or those with more sparse development distributions.

RUNNING CONGESTION EMISSIONS

Running congestions emissions are that segment of emissions caused by vehicles slowing down in congested areas. During the "average" 10 AM hour, there is very little congestion, and therefore very low running congestion emissions. However, during the morning peak hour, these emissions have been shown to *decrease* total emissions by up to 6.2% in 1989, and 3.2% in 2000.

This decrease in emissions is likely due to the slowing of vehicles, to a certain extent. As shown in Figure 8, NOx emissions decrease with speed to approximately 35 mph. The average uncongested speed on the network is 40 mph, which is reduced to 35 mph during the 1989 morning peak hour, and 33 mph during the 2000 morning peak hour.

With increasing congestion, however, speeds will drop below 35 mph. As shown on Figure 8, emissions also increase as speeds drop below 30-35 mph. This trend is even more exaggerated with the 2000 vehicle fleet. This trend would explain why the running congestion emissions decreased by almost 50% between 1989 and 2000. In that period, congestion has doubled, average vehicle speeds have decreased below 35 mph , and as a result running emissions still decrease total NOx concentrations, but to a lesser extent. It is likely that with increased congestion on the network, running congestion emissions will start to increase the total mesoscale NOx contribution to air pollution.

These emissions are only significant when modeling a short-term peak-hour averaging period. Therefore models should not have to take running congestion emissions into account in forecasting annual average NOx increment. This may not be the case for larger communities where congestion may contribute significantly to the total daily NOx emissions.

YEAR 2000 INCREMENT EXPANSION

For urban, suburban, and rural receptors, microscale area-source modeling revealed decreases in NOx concentrations due to motor vehicles in the year 2000 on the order of 45%. If, as EPA has claimed, that mobile sources account for 40% of total NO_2 emissions, the “cleansing” of the vehicle fleet may finally have an impact on overall ambient NO_2 concentrations.

Whereas ground level emission changes did not significantly appear over the last ten years despite significantly lower emissions, the next ten years may see some actual reductions. The decline in traffic growth rates is the primary factor behind these decreasing emissions. Traffic growth rate is expected to significantly decline through 2000. Based on the land-use modeling performed, the 4.3%/year traffic growth rate of the 1980’s is expected to decline to 1%/year during the 1990’s, assuming no change in the trip generation characteristics of the average household.

Were fleet emissions to remain static over the next 10 years, ambient concentrations would, of course, increase. Therefore, it is likely that, if NOx emission standards from motor vehicles remain as they are, ambient NO_2 concentrations will start to rise again as the vehicle fleet ages. This may start to occur somewhere between 2005 and 2010, based on MOBILE 4.1 fleet emission rate trends.

SUMMARY AND CONCLUSIONS

While significant traffic growth has hit the Burlington area over the last 20 years, heavy congestion remains limited to the two peak periods of the days. The morning peak is characterized by higher VMT, higher congestion, higher NOx emissions, even through there are fewer vehicles on the road than during the evening peak hour.

On an annual basis, congestion emissions of NOx do not play a major role in the overall contribution to air pollution. Therefore, models being developed to determine increment consumption based simply on average annual daily traffic or VMT that do not take congestion and idling emissions into account, may be appropriate for small communities with urban, suburban, and rural components, such as Chittenden County.

Increases in congestion, in some respects may also decrease total NOx emissions by reducing overall travel speeds. However this behavior is only significant during the peak hours of the day.

Overall, traffic growth rates are expected to significantly decline over the next 10 years. This, in part, contributes to the modeled declines in NOx emission from motor vehicles on the order of 45% between 1989 and 2000. However, given that fleet emissions may begin to level out by 2005 to 2010, monitored NO_2 levels may eventually begin another upward climb.

ACKNOWLEDGEMENTS

The network model used in this study was developed under contract from the Chittenden County Regional Planning Commission and Metropolitan Planning Organization. The author also wishes to acknowledge the very helpful assistance of John Perreault and Paul Wishinski of the Vermont Agency of Natural Resources, and the staff of Resource Systems Group.

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[1] The baseline date is set as the date that the first major source applying for a permit after 2/8/88 is determined complete. In Vermont, the baseline date is September 14, 1989. ("State of Vermont Air Quality Implementation Plan: Proposed", Agency of Natural Resources, August, 1990)

[2] Noble, Eric, "Technical Guidance on Emission Inventory and Modeling for the NO_2 PSD Increments (Draft)," New Source Review Section, Noncriteria Pollutants Programs Branch, U.S. E.P.A. June 12, 1990.

[3] Noble, page 12.

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[4] "1980 Census of Population and Housing" (corrected data), and "1990 Census of Population and Housing, Thank you America" (uncorrected), U.S. Department of Commerce.

[5] IBID.

[6] IBID.

[7] "MOBILE 4.1" U.S. EPA Motor Vehicle Emission Laboratory, Office of Mobile Sources, Ann Arbor Michigan.

[8] Source: "Automatic Traffic Recorder Grouping Study and Regression Analysis Based on 1990 Traffic Data" Vermont Agency of Transportation, April 1991. Uses counters D2 and D40 (suburban), D1 and D99 (freeway), and D91 and D92 (interstate).

[9] "National Air Quality and Emissions Trends Report, 1989" Environmental Protection Agency, EPA-450/4-91-003, February, 1991. Page 3-20.

[10] IBID, page 3-21, figure 3-27.

[11] Based on 30 mph, hot stabilized, 50°F

[12] IBID, page 3-22, figure 3-28.

[13] "CDM 2.0 (Climatological Dispersion Model) User's Guide" US EPA, Meteorology and Assessment Division, PB86-136546, November, 1985.

[14] "Development of the Chittenden County Regional Travel Demand Model: Project Report" prepared for the Chittenden County Regional Planning Commission and the Chittenden County Metropolitan Planning Organization, Resource Systems Group, Inc., August 24, 1989.

[15] 'TMODEL2" TMODEL Corporation, Vashon, Washington.

[16] The design-hour is the 30th highest hour of the year.

[17] "Chittenden County Transportation Demand Subarea Modeling" prepared for the Chittenden County Regional Planning Commission and the Chittenden County Metropolitan Planning Organization, Resource Systems Group, Inc., September 6, 1991.

[18] Actually, the time between midnight and 5:59 AM were averaged and modeled as one hour.

[19] "VMT for Air Quality Purposes" Fleet, C.R. and DeCorla-Souza, P., FHWA, preprint for publication in the Proceedings to the ASCE Transportation and Air Quality National Conference, July, 1991.