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Technical Report

Motor Vehicle NOx Inventories

By

Amy Brochu and Dale Rothman

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Standards Development and Support Branch
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NOTICE

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Background

In support of the Notice of Proposed Rulemaking (NPRM) on Light-duty Truck/Heavy-duty Engine NOx and Particulate Standards, published on October 15, 1984, (49 FR 40258) air quality projections were made using a model based on the "rollback" theory. This rollback model uses the change in emissions inventory between two given years to predict the accompanying change in air quality. The future emissions used in this model are estimated by applying travel growth rates and emission factor ratios to a base-year emissions inventory.[1]

Since the mid-1970's, EPA's NOx projections have been made using a baseline NOx inventory taken from the National Emissions Data System (NEDS), compiled by the Office of Air Quality and Planning Standards (OAQPS).[2] The motor vehicle portion of this base-year NEDS inventory is developed using estimates of annual vehicle miles travelled (VMT) within individual counties across the U.S.

Because NEDS does not include estimates of diesel particulate emissions, the NPRM particulate modelling used a different approach. This approach differs from NEDS in that no county or city-specific figures are determined; instead, emissions are modelled on a nationwide urban basis, using annual VMT estimates from Energy and Environmental Analysis, Inc.(EEA).[3]

In an effort to confirm the NOx and particulate modelling contained in the NPRM, the motor vehicle portion of the base-year (1981) NEDS NOx inventory was compared to an analogous NOx inventory developed using the nationwide urban approach. This comparison revealed that the two approaches differed significantly in their predicted breakdown of nationwide urban VMT by vehicle class, particularly with respect to the heavy-duty diesel vehicle (HDDV) fraction of travel. As shown in later sections, NEDS attributes a VMT fraction to HDDVs that is over twice that calculated with the nationwide method. Because the HDDV class has the largest projected VMT growth and has the largest per mile emission factor, this two-fold difference has a significant impact on future NOx inventory projections.

The inconsistency between the NEDS and nationwide approaches led to a search for local VMT data for the 11 cities being modelled for NOx emissions (listed in Table 1). Local and state agencies were contacted, and total 1981 VMT figures were obtained for all 11 cities; and, most importantly, breakdowns of local VMT by vehicle class were obtained for a majority of the cities.

Table 1

Eleven Urban Areas Currently Being Modelled for NOx*

Low Altitude

Boston, MA
Chicago, IL
Nashville, TN
New York City, NY
Newark, NJ
Philadelphia, PA
Seattle, WA
Tucson, AZ
Washington, D.C.

High Altitude

Denver, CO
Reno, NV

* These 11 cities were within 20 percent of the NOx NAAQS of 0.053 PPM in 1981.

This report briefly describes these three approaches to NOx inventory development (NEDS, nationwide, and localized) and presents comparisons of the findings under each with respect to both baseline and future NOx inventories. Detailed descriptions of the NEDS and nationwide methodologies appear in the Appendix, along with the various sources of input data used in each approach. In addition, the Appendix outlines the methods used by each individual city to determine local VMT characteristics, and presents the results for each locality.

NEDS Approach

As mentioned earlier, the NEDS emissions inventory is constructed on a county-specific basis; therefore, its primary task is to estimate VMT by county for each vehicle class. This is generally accomplished in three major steps: 1) nationwide VMT figures from the Federal Highway Administration (FHwA) are split between the four pertinent vehicle classes, 2) class-specific nationwide VMTs are apportioned to each state, then 3) statewide VMTs (by class) are distributed to individual counties. (Detailed equations outlining the precise NEDS methodology appear in the Appendix.)

The first major step begins with FHwA's nationwide VMT figures.[4] Passenger car, or light-duty vehicle (LDV), VMT is reported as a separate category by FHwA; therefore further manipulation is not necessary. However, the remaining portion of FHwA's nationwide VMT total (trucks plus buses) must be divided between the light-duty truck (LDT), heavy-duty gasoline (HDGV) and HDDV classes for use in emissions modelling. To do this, a VMT breakdown (by the three truck classes) is first calculated using model-year sales and scrappage rates from MVMA[5], and mileage-accumulation rates from EPA's MOBILE computer program[6]. This breakdown is then applied to the FHwA figure for total truck/bus VMT to yield nationwide annual VMT for each of the three pertinent truck types.

The second step involves the distribution of the class-specific nationwide VMT figures (calculated above) between individual states based on FHwA's state fuel consumption totals.[4] Nationwide HDDV VMT is apportioned using relative state diesel fuel consumption figures; VMTs for the remaining classes (LDV, LDT, and HDGV) are basically divided between states based on total gasoline consumption.

Finally, these statewide VMT totals for each of the four vehicle classes are broken down by county. This is done separately for each class, using each county's fraction of state vehicle registrations (from R. L. Polk).[7]

Several of the assumptions used in the NEDS procedure lead to some possible weaknesses in the percentage breakdown of county-specific VMT (and thus emissions) by vehicle class. Probably the strongest weakness is the use of HDDV registrations by county as a surrogate for HDDV travel in that particular county. Because the majority of HDDV travel can be characterized as long-range, there is no certain relationship between registrations and usage. For example, HDDVs appear to be usually registered in urban areas, while their actual travel consists mainly of trips between these urban areas. On the other hand, the use of county registrations to apportion county VMT for the remaining classes (LDV, LDT, and HDGV) is probably a reasonable approach, since these vehicles are primarily used in local and short-range applications. Thus, as will be seen later, the overall impact of the use of county registrations as a surrogate for county VMT appears to be an overestimation of the HDDV fraction of VMT in urban areas.*

As mentioned earlier, details of the NEDS methodology (including equations) are provided in the Appendix, along with a list of the sources used in the NEDS program. Also, because NEDS is based upon FHwA's figures for nationwide VMT and state fuel consumption, a description of FHwA's Highway Performance Monitoring System (HPMS) and details on the construction of FHwA's Table VM-1 (in Highway Statistics[4]) are provided in the Appendix, as well.

Nationwide Approach

Unlike NEDS, the approach taken in the NPRM diesel particulate analysis[8] examines the nation as a whole and applies the results equally to all urban areas; no county-specific distributions of VMT are derived. Annual nationwide urban emissions for any given year are estimated simply by multiplying calculated nationwide urban VMT figures by the appropriate emission factors.

The nationwide approach is based upon the annual VMT figures estimated by the Energy and Environmental Analysis (EEA) fuel consumption model.[3] The VMT figures are already divided between the appropriate vehicle classes; however, separation into gasoline and diesel portions, and conversion to urban VMT, is necessary before the urban emission inventories

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* This problem with overestimation of the HDDV fraction of VMT appears only at the county level; on a statewide or nationwide basis, the HDDV fraction would be expected to be much more accurate.

can be calculated. (Details of the methodologies and sources used in these calculations are provided in the Appendix, along with a brief description of EEA's estimation of total nationwide VMT figures.)

The method used to separate EEA's nationwide LDV and LDT VMTs into gasoline and diesel fractions involves much of the fleet characterization data developed for MOBILE3.[9] The diesel VMT portion is estimated using a 20-model-year summation of the registration fraction distribution (by age), mileage accumulation rates for diesel vehicles (by age), and diesel sales fractions (by model year). This diesel summation is then divided by the total of the diesel and analogous gas summations to yield the diesel fraction of total VMT for each class.

Finally, because the emphasis is on emissions in urbanized areas, it is necessary to convert these nationwide VMT figures into urban miles. This is accomplished using FHwA's estimates of the urban fractions of LDV and LDT VMT (0.59 and 0.49*, respectively). Because the fractions are assumed to be constant over all model years, they can simply be multiplied by the nationwide VMT totals to yield urban VMT for each class.

The approach used to calculate the gasoline and diesel fractions of heavy-duty truck VMT is just slightly different from the LDV/LDT method; instead of using model-year diesel sales fractions, EEA's total calendar-year registrations of HDDVs and HDGVs are substituted. As before, MOBILE3 mileage accumulation rates and distributions of calendar-year registrations (by age) are used in the gasoline and diesel summations. However, unlike those for light-duty, urban fractions of heavy-duty VMT change slightly by model year, due to the ongoing conversion of gasoline applications (local and short-range) into diesel usage -- a result of dieselization.[10] Because the urban fraction is not constant, it is necessary to include this term inside the 20-year summations. These urban fractions of VMT, derived for the MOBILE3 conversion factor analysis[10] and based on figures from the 1977 Truck Inventory and Use Survey (TIUS)[11], are lower for HDDVs because of their orientation toward long-range travel. Overall, the urban fractions for HDDVs are roughly one-third of those for the gasoline trucks (1981 fleet composites of 0.23 versus 0.68 for HDDVs and HDGVs, respectively).[10] The calculation of gas and diesel urban VMT is carried out separately for each of the heavy-duty weight divisions (Classes 2B, 3-5, 6, and 7-8) and then summed.

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* From 1982 Highway Statistics, Table VM-1, FHwA; passenger car figures used for LDVs, and single-unit trucks used to represent LDTs.[4]

The limitation associated with this nationwide method is that inventories are not developed on a county-specific basis, but rather for the urban portion of the nation as a whole. However, because the inaccuracies of county-specific distribution are avoided, the nationwide urban estimates should be fairly accurate. As shown in later sections, information developed with this approach can be translated to the local level; the nationwide average urban VMT breakdown can be applied to a locally-generated total VMT figure to yield local VMT by class and, eventually, emissions. Of course, in using this approach any distinctions in traffic characteristics from one city to another are lost, since the same nationwide urban VMT breakdown is used for all urban areas.

Table 2 presents a comparison of the 1981 (base-year) VMT breakdowns by vehicle class computed using the NEDS and the nationwide approaches; the findings add support for the proposed weakness associated with the NEDS approach. The most significant discrepancy between the two analyses appears in the urban VMT breakdown, where NEDS estimates a HDDV fraction more than twice that found with the nationwide method (5.8 compared to 2.0 percent). Because HDDVs are expected to experience the largest VMT growth, and have the highest per-vehicle NOx emission rates, the impact of this two-fold difference in VMT on the HDDV contribution to future NOx emissions is significant.

It is this inconsistency in the projected HDDV fraction of urban VMT (and emissions) that necessitated the search for more information. Because the VMT breakdown developed with the nationwide approach represents an average for all urban areas across the nation, and not for specific cities, local VMT information from each of the 11 areas being modelled for NOx was sought.* The following section provides a discussion of the various methods used by localities to determine total VMT and its breakdown by vehicle class.

Localized Approach

As mentioned earlier, 12 local areas (the 11 NOx cities plus Detroit) were contacted in an attempt to obtain local estimates of total VMT and its breakdown by vehicle class. The primary sources for most of this local data were state departments of transportation, local councils of government,and regional transportation and planning commissions. Estimates of total VMT were obtained for all 12 of the local areas; however,

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* Also, because of its geographical proximity to the Ann Arbor EPA office, Detroit's VMT data were also gathered (although Detroit is not currently modelled for NOx).

Table 2

NEDS vs. Nationwide Approach: Base-year (1981) U.S. VMT

NEDS Approach

Vehicle Type	Total U.S. VMT Billions (%)	Urban Fraction	Urban VMT Billions (%)
LDV	1103.1 (72.0)	0.63	695.0 (74.5)
LDT	293.6 (19.2)	0.53	155.6 (16.7)
HDGV	49.6 (3.2)	0.58	28.8 (3.1)
HDDV	86.5 (5.6)	0.62	53.6 (5.8)
Total	1532.8 (100.0)	--	933.0 (100.0)

Nationwide Approach

Vehicle Type	Total U.S. VMT Billions (%)	Urban Fraction	Urban VMT Billions (%)
LDV	1166.1 (76.4)	0.59	688.0 (80.8)
LDT	242.5 (15.9)	0.49	118.8 (13.8)
HDGV	43.5 (2.9)	0.68	29.6 (3.4)
HDDV	73.3 (4.8)	0.23	16.9 (2.0)
Total	1525.4 (100.0)	--	853.3 (100.0)

VMT breakdowns were available for only 8 of the 12 cities.* The total VMT estimates, being much easier to determine than actual breakdowns by class, have a higher degree of confidence associated with them. To date, the analysis has focused on the eight urban areas with VMT breakdown estimates. A brief description of the methods used to estimate both total VMT and its breakdown by vehicle class is given below, followed by an analysis of the methods' strengths and weaknesses. A detailed description of each area's methodology is contained in the Appendix.

For the eight localities that were explored in detail, two basic approaches were used to estimate total local VMT-- 1) network models coupled with traffic counts, and 2) traffic counts alone. With the exception of Tucson, every city uses a network modelling system (which is described below).

Local traffic counts are obtained using automatic counters on selected roads throughout the study area. The number of counting sites varies between localities, but is generally substantial. Nashville (Davidson County), for example, has 381 traffic count stations,[12] and there are 5,000-8,000 sites throughout New York State.[13] The data are generally sampled and summed by functional classification of roadway (e.g. interstate, arterial). Often, local roads are estimated as they represent only a small proportion of travel.

The network modelling systems utilized by the local areas all operate along the same general principles. The area being modelled is subdivided into zones, and the transportation network consists of the links connecting these zones. Using population and employment data by zone, trip origins and destinations are estimated, and trips are routed through the network, either via mass transit (i.e., by train or bus) or personal vehicle. Truck trips must be generated separately as they are not generally related to population and employment. After determining the number of trips and trip lengths, total VMT can then be calculated. Traffic counts are, in turn, used to either normalize total VMT in the model (in which case the estimates of total VMT are actually independent from the network model), or to calibrate parts of the modelling system which then determines total VMT (in which case the model has some effect on the total VMT estimate).

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* Chicago, New York, Tucson, Reno, Seattle, Nashville, Detroit, and Philadelphia.

Unlike the fairly standard methods used to estimate total VMT, the determination of VMT breakdown by vehicle class is much less uniform across the eight local areas that provided such data. To estimate VMT breakdown, visual counts, vehicle registration data, mileage accumulation estimates, and survey data were used in varying degrees by each local area. The important aspects of each area's procedures include: 1) the number and nature of the visual counts, 2) the types of vehicles classified (and how they relate to the four vehicle classes desired here), and 3) the determination of gas/diesel splits.

For those localities that use visual counts to determine VMT breakdown (Nashville, New York, Philadelphia, Detroit, Reno, Tucson, and Chicago), the number and "statistical quality" of the sites vary greatly. For example, Nashville's counting program consists of nine total sites on five different classes of roadway; these sites were randomly chosen several years ago and have since remained the same. The sites are monitored once a year, at no particular time of year, for a continuous 6-hour period; one of the nine sites is no longer monitored.[14]

At the other end of the spectrum is Philadelphia, where the Delaware Valley Regional Planning Commission performed a statistically-derived sampling of 112 locations, stratified by functional classification of roadway and area type (e.g. urban, rural). The survey was conducted from mid-March to late-June of 1980, with the day for each site chosen at random. At each site, samples were taken over an 8-hour period from 7:00 am to 3:00 pm, Monday through Friday, with an automatic machine count of total VMT also being taken at the same time. To obtain regional totals, a weighted sum across roadway and area type was used. The confidence level associated with this survey is reported to be 95 percent for the regional LDT and HDT estimates.[15]

For the other localities, the particulars of the surveys differ, and, in turn, so does the confidence with which their estimates can be used. In general, they fall somewhere between Nashville and Philadelphia with respect to their level of confidence.

The vehicle classification scheme used by the different local areas also varied somewhat, especially in the detail with which trucks were classified. A general classification scheme for the visual counts consisted of: automobiles, light trucks, heavy trucks, buses, and motorcycles. The only concerns expressed by the local organizations involved the differentation between the LDT_1 and LDT_2 classes, and the diesel/gas splits for all classes. Because NEDS combines the two LDT categories, only the second of these concerns is pertinent to this comparison. However, based on the visual similarity of heavy LDTs and light HDVs, there is also a concern about a person's ability to accurately place these vehicles in their proper category.

Diesel/gas splits for heavy-duty vehicles were estimated by the local areas using a variety of methods. Several of the localities used vehicle registration data collected at either the local or state level. Detroit used state registration data directly[16], whereas Philadelphia and Seattle VMT-weighted the state registrations with average mileage accumulation rates [17,18]. Nashville simply used MOBILE2 default values to obtain the gas/diesel splits.[12] To varying degrees, these methods share the HDDV problem identified above with the NEDS methodology. Other (possibly better) methods include Reno's classification of all 2-axle, single-unit, dual-tire trucks and 2-axle buses as HDGVs, and all other heavy-duty vehicles as diesel.[19] In Detroit, initial attempts have been made at visually classifying HDGVs and HDDVs by the positioning of the exhaust pipe (horizontal versus vertical).[16] Before using any of these local estimates, confidence in the method used to derive the HDGV/HDDV VMT split will have to be established.

The strengths of the local data are centered upon the fact that the data are collected locally and generally involve some amount of actual visual monitoring. Seven of the eight cities utilized visual monitoring of some sort to obtain VMT breakdown by class, and most reduced their data statistically. However, the VMT breakdown for at least one city was that for the entire state.[18] Theoretically, a well-defined, statistically valid survey of this type would provide the best possible estimates, at least in differentiating between light-duty vehicles, light-duty trucks, and heavy-duty trucks. Most of these surveys appear to have been designed to attain a specified statistical confidence, though a detailed evaluation of each area's methodology has not yet been completed. In general, however, most of the local approaches appear to have fewer weaknesses than the NEDS methodology, and provide local distinction that the nationwide method does not.

<u>Comparison of Baseline Inventories</u>

Using the VMT estimates from each of the three approaches -- NEDS, nationwide, and localized -- 1981 NOx emissions inventories were calculated for each of the 12 cities being examined. Because the nationwide approach only produces a VMT breakdown and no estimate of total VMT for the local area, the total city VMT figure from the localized approach was used here as well. For the four cities that provide no local

VMT breakdown (Washington, D. C., Boston, Newark, and Denver), the local VMT estimates are based on the local VMT total, broken down using the average localized VMT breakdowns from the other eight cities. In all three analyses, MOBILE3 emission factors (without speed or temperature correction) were used to develop the NOx inventories.[6] (For further details on the individual calculations and city-specific results, see the Appendix.) Estimates of non-motor vehicle emissions (designated "other"), which included emissions from off-highway vehicles and stationary area sources (e.g., home heating), are taken from NEDS under all three approaches.

A comparison of the 1981 VMTs and NOx emissions inventories developed with the three methods is presented in Table 3; the figures shown are the combined totals for the 12 cities in the analysis.* As indicated in the table, the fraction of VMT attributed to HDDVs under the localized approach (2.6 percent) is nearer to that under the nationwide approach (2.0 percent) than that of the NEDS approach (4.3 percent). The VMT fractions (by vehicle class) estimated for each city using each approach are summarized in Table 4. As shown, for every one of the cities, NEDS attributed a significantly higher share of VMT to HDDVs than did either of the other two methods. Thus, the various local approaches appear to avoid the HDDV problem associated with the NEDS methodology.

With respect to the LDT fraction (Tables 3 and 4), the differences are not quite as great in magnitude, however, again the NEDS method results in a higher LDT fraction than the other two methods (average values of 15.8, 12.1, and 13.8 for the NEDS, local and nationwide approaches, respectively). This pattern occurs for each city, except for Nashville where NEDS estimates 18.8 percent for LDT VMT, compared to 20.2 percent with the local method. For Newark, the LDT fractions are equal.

These differences in VMT breakdown translate into larger inconsistencies in breakdown of NOx emissions by vehicle class, as the bottom portion of Table 3 indicates. Although the figures vary from city to city, NEDS consistently estimates a higher HDDV contribution to emissions; overall, the combined-city figures show a HDDV fraction of 27.2 percent with NEDS, compared to only 18.4 and 14.1 percent with the local and nationwide approaches, respectively. Also, consistent with trends in the VMT breakdown, NEDS reports a higher LDT fraction of emissions than does the localized approach (12.2 versus 9.9 percent).

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* The area modelled for each locality is actually the Standard Metropolitan Statistical Area (SMSA).

Table 3

Combined Base-year Motor Vehicle Inventories: Three Approaches*

VMT, Millions (%)

	Localized Approach		Nationwide Approach		NEDS Approach	
LDV	171065.7	(85.2)	162283.2	(80.8)	156531.4	(81.0)
LDT	19007.8	(9.5)	27716.7	(13.8)	24446.4	(12.7)
HDGV	5464.5	(2.7)	6828.7	(3.4)	3903.4	(2.0)
HDDV	5307.5	(2.6)	4016.9	(2.0)	8280.8	(4.3)
Total	200845.5	(100.0)	200845.5	(100.0)	193162.0	(100.0)

NOx Emissions, 1000 tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach	
LDV	476.23	(66.7)	454.32	(64.3)	435.85	(57.2)
LDT	71.03	(9.9)	107.93	(15.3)	93.20	(12.2)
HDGV	35.77	(5.0)	44.68	(6.3)	25.50	(3.3)
HDDV	131.51	(18.4)	99.78	(14.1)	207.19	(27.2)
Total	714.54	(100.0)	706.71	(100.0)	761.74	(99.9)

* Eleven urban areas shown in Table 1, plus Detroit.

Table 4

Effect of Three Approaches on Class-specific Fractions of Total 1981 VMT

City	LDV Fraction (%)			LDT Fraction (%)			HDGV Fraction (%)			HDDV Fraction (%)		
	Local	Nationwide	NEDS	Local	Nationwide	NEDS	Local	Nationwide	NEDS	Local	Nationwide	NEDS
Nashville	75.3	80.8	68.9	20.2	13.8	18.8	2.5	3.4	2.9	2.0	2.0	9.4
Seattle	79.3	80.8	73.5	13.1	13.8	21.3	4.3	3.4	1.0	3.3	2.0	4.2
Reno	78.2	80.8	60.7	16.6	13.8	29.4	2.1	3.4	1.5	3.1	2.0	8.4
Phila	82.5	80.8	81.0	10.6	13.8	11.5	2.4	3.4	2.3	4.5	2.0	5.2
Tucson	71.3	80.8	70.9	23.6	13.8	24.2	3.9	3.4	1.3	1.2	2.0	3.7
NYC	88.0	80.8	87.5	6.9	13.8	7.4	3.6	3.4	2.2	1.5	2.0	2.9
Chicago	90.2	80.8	81.2	4.7	13.8	11.1	2.7	3.4	2.0	2.4	2.0	5.7
Boston	85.2	80.8	84.4	9.4	13.8	10.1	2.7	3.4	2.0	2.7	2.0	3.5
Newark	85.2	80.8	85.3	9.4	13.8	9.4	2.7	3.4	1.8	2.7	2.0	3.5
Wash, DC	85.2	80.8	83.8	9.4	13.8	11.3	2.7	3.4	2.0	2.7	2.0	2.9
Denver	85.2	80.8	73.2	9.4	13.8	20.8	2.7	3.4	1.8	2.7	2.0	4.2
Detroit	83.7	80.8	80.1	12.2	13.8	14.4	1.5	3.4	2.2	2.6	2.0	3.4
Average	82.4	80.8	77.5	12.1	13.8	15.8	2.8	3.4	1.9	2.6	2.0	4.8

Comparison of Future NOx Inventories

Using the baseline NOx inventories discussed in the previous section, future NOx inventories were projected for each of the eleven cities assuming five different emission control strategies:

	Model Year Applicable	LDT_1/LDT_2 (g/mi)	HDE (g/BHP-hr)
(1)	1987	2.3/2.3	10.7
(2)	1987	2.3/2.3	6.0
(3)	1987	1.2/1.7	6.0
(4)	1987	2.3/2.3	6.0
	1990	2.3/2.3	4.0
(5)	1987	1.2/1.7	6.0
	1990	1.2/1.7	4.0

Because of indications that the local data (where available) are the most accurate, the following analysis focuses on the future projections based on the 1981 inventories developed with the localized approach.

The degree of growth in NOx emissions between the baseline year (1981, in this case) and the future year of projection is an important consideration in assessing the environmental impact of various control scenarios. Tables 5 and 6 quantify these growths by dividing future emissions by baseline (1981) emissions; in other words, any values in the tables greater than one indicate growth over baseline emissions. All five control scenarios are examined and three years of projection (1990, 1995, and 2000) are included. Although city-specific growths are shown only for the local approach (i.e., 1981 inventories based on local data), totals for all eleven cities combined are shown for all three approaches for comparison. The growth in both motor vehicle and total discounted NOx emission inventories are presented in Tables 5 and 6, respectively.* Total discounted emissions are also depicted graphically in Figures 1 through 6.

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* Total discounted emissions differ from total emissions in that stationary point sources (e.g., power plants) are not included due to their minor impact on annual ambient NO_2 levels measured by fixed site monitors.

Table 5

MOTOR VEHICLE NOx EMISSIONS (Ratio Relative to 1981 Baseline)

Local Approach

	2.3/10.7 Stds.			2.3/6.0 Stds.			1.2/1.7/6.0 Stds.			2.3/4.0 Stds			1.2/1.7/4.0 Stds.		
Cities	1990	1995	2000	1990	1995	2000	1990	1995	2000	1990	1995	2000	1990	1995	2000
Boston	0.91	1.06	1.30	0.84	0.88	1.03	0.83	0.86	1.00	0.84	0.82	0.93	0.83	0.80	0.89
Chicago	0.88	1.01	1.23	0.81	0.84	0.98	0.80	0.83	0.96	0.81	0.78	0.88	0.80	0.77	0.86
Nshvll.	0.93	1.07	1.28	0.88	0.93	1.09	0.86	0.88	1.01	0.88	0.88	1.00	0.86	0.83	0.93
NYC	0.84	0.94	1.11	0.80	0.83	0.95	0.79	0.81	0.93	0.80	0.78	0.88	0.79	0.76	0.85
Newark	0.91	1.06	1.29	0.83	0.88	1.03	0.82	0.86	0.99	0.83	0.81	0.92	0.82	0.79	0.89
Phila.	0.99	1.20	1.52	0.87	0.94	1.11	0.87	0.91	1.08	0.87	0.84	0.97	0.87	0.82	0.94
Seattle	0.96	1.14	1.41	0.87	0.93	1.09	0.86	0.90	1.05	0.87	0.85	0.97	0.86	0.82	0.93
Tucson	0.91	1.01	1.19	0.88	0.93	1.07	0.87	0.88	0.98	0.88	0.89	1.01	0.85	0.83	0.91
Wash DC	0.91	1.06	1.30	0.83	0.88	1.03	0.82	0.86	0.99	0.83	0.82	0.93	0.83	0.79	0.89
Denver	1.13	1.38	1.70	1.04	1.15	1.35	1.02	1.13	1.31	1.04	1.07	1.22	1.02	1.04	1.17
Reno	1.21	1.46	1.85	1.10	1.23	1.44	1.03	1.21	1.36	1.10	1.13	1.31	1.03	1.10	1.23
Total	0.92	1.07	1.31	0.83	0.89	1.03	0.83	0.87	1.01	0.84	0.82	0.93	0.83	0.80	0.90
Nationwide Approach															
Total	0.91	1.04	1.25	0.85	0.91	1.05	0.84	0.87	1.00	0.85	0.85	0.96	0.84	0.82	0.91
NEDS Approach															
Total	1.00	1.22	1.53	0.89	0.96	1.14	0.88	0.93	1.10	0.89	0.87	1.00	0.88	0.84	0.96

Table 6

TOTAL DISCOUNTED NOx Emissions (Ratio Relative to 1981 Baseline)

Local Approach

	2.3/10.7 Stds.			2.3/6.0 Stds.			1.2/1.7/6.0 Stds.			2.3/4.0 Stds			1.2/1.7/4.0 Stds.		
Cities	1990	1995	2000	1990	1995	2000	1990	1995	2000	1990	1995	2000	1990	1995	2000
Boston	0.99	1.10	1.30	0.94	0.99	1.12	0.93	0.98	1.10	0.94	0.95	1.05	0.93	0.94	1.03
Chicago	0.97	1.10	1.29	0.93	0.99	1.12	0.92	0.98	1.11	0.93	0.94	1.05	0.92	0.94	1.04
Nshvll.	1.01	1.14	1.33	0.97	1.05	1.19	0.96	1.01	1.14	0.97	1.01	1.13	0.96	0.97	1.08
NYC	0.94	1.03	1.19	0.91	0.96	1.08	0.90	0.95	1.06	0.91	0.93	1.03	0.90	0.91	1.01
Newark	0.98	1.11	1.30	0.92	0.98	1.11	0.92	0.92	1.09	0.92	0.93	1.04	0.92	0.92	1.02
Phila.	1.04	1.21	1.46	0.97	1.04	1.19	0.96	1.03	1.17	0.97	0.98	1.10	0.96	0.97	1.08
Seattle	1.04	1.20	1.41	0.98	1.06	1.21	0.97	1.04	1.18	0.98	1.10	1.13	0.97	0.99	1.11
Tucson	1.00	1.11	1.27	0.98	1.06	1.19	0.97	1.02	1.13	0.98	1.03	1.15	0.97	1.00	1.09
Wash DC	0.98	1.12	1.33	0.93	0.99	1.13	0.92	0.98	1.11	0.93	0.94	1.06	0.92	0.93	1.03
Denver	1.15	1.32	1.53	1.11	1.22	1.37	1.10	1.21	1.35	1.11	1.18	1.31	1.10	1.17	1.29
Reno	1.18	1.35	1.60	1.13	1.23	1.40	1.12	1.22	1.36	1.13	1.18	1.33	1.12	1.17	1.29
Total	1.00	1.13	1.33	0.95	1.02	1.15	0.94	1.00	1.13	0.95	0.97	1.08	0.94	0.96	1.06
Nationwide Approach															
Total	1.00	1.16	1.29	0.96	1.03	1.16	0.95	1.01	1.13	0.96	0.99	1.10	0.95	0.97	1.07
NEDS Approach															
Total	1.05	1.23	1.49	0.97	1.04	1.22	0.96	1.01	1.18	0.97	0.98	1.11	0.96	0.96	1.08

Figure 1

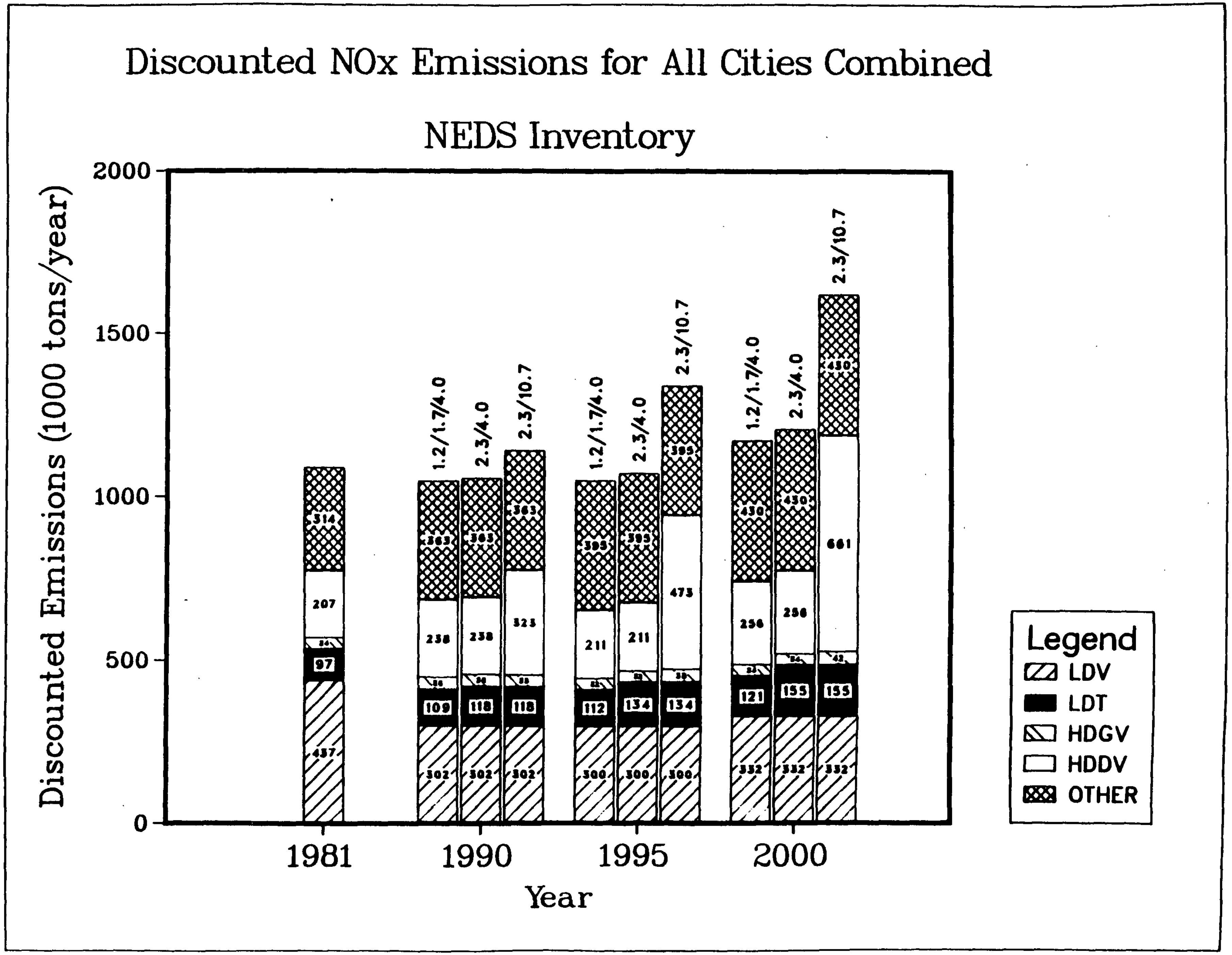
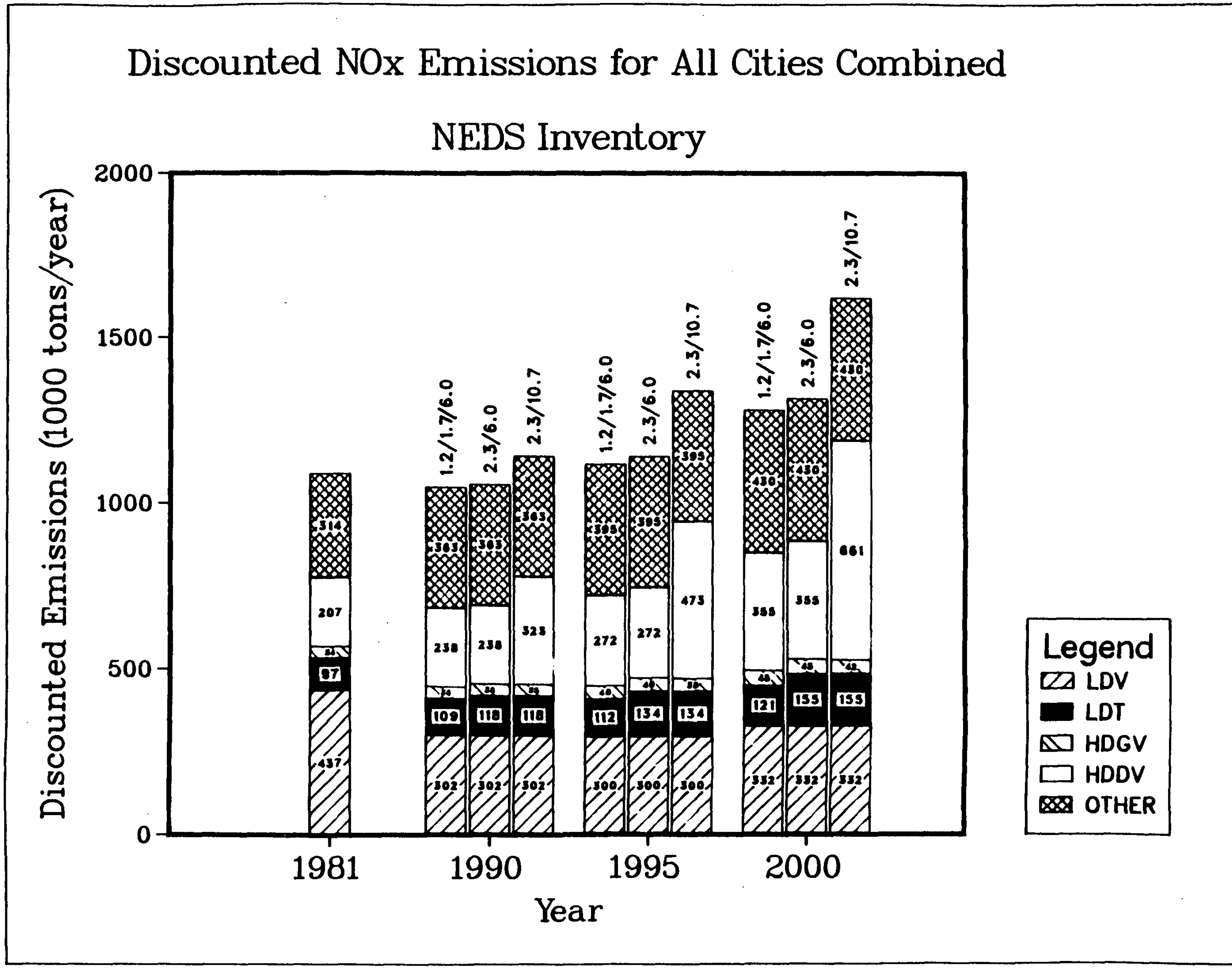
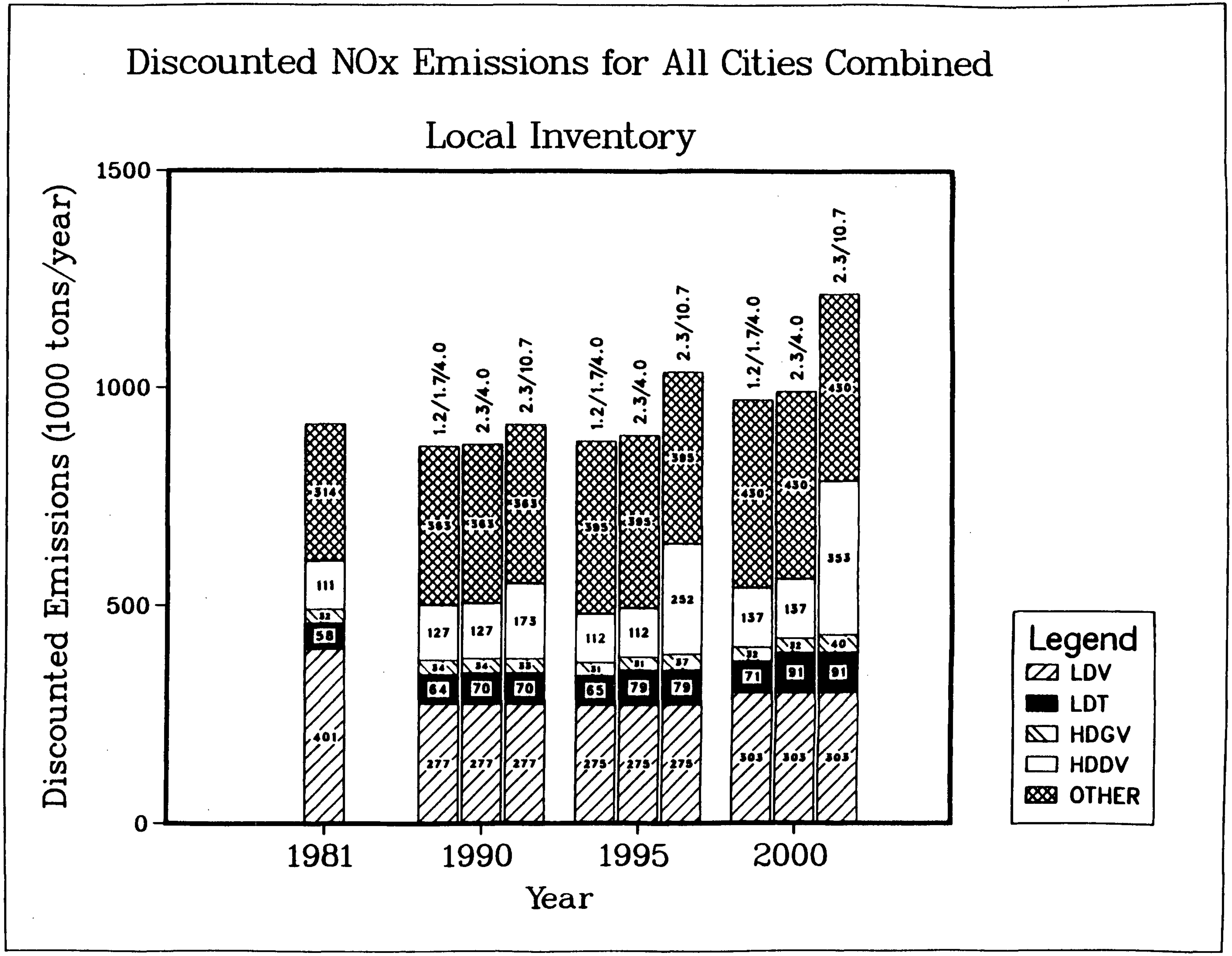

Discounted NOx Emissions for All Cities Combined
NEDS Inventory
Discounted Emissions (1000 tons/year)
2000
1500
1000
500
0
1981
1990
1995
2000
Year
Legend
LDV
LDT
HDGV
HDDV
OTHER
1.2/1.7/4.0
2.3/4.0
2.3/10.7
314
207
97
437
363
238
109
302
118
323
395
211
112
300
134
473
430
256
121
332
155
661

Figure 2



Discounted NOx Emissions for All Cities Combined
NEDS Inventory
Discounted Emissions (1000 tons/year)
2000
1500
1000
500
0
1981
1990
1995
2000
Year
1.2/1.7/6.0
2.3/6.0
2.3/10.7
Legend
LDV
LDT
HDGV
HDDV
OTHER

Figure 3



Discounted NOx Emissions for All Cities Combined
Local Inventory
Discounted Emissions (1000 tons/year)
1500
1000
500
0
1981
1990
1995
2000
Year
1.2/1.7/4.0
2.3/4.0
2.3/10.7
Legend
LDV
LDT
HDGV
HDDV
OTHER

Figure 4

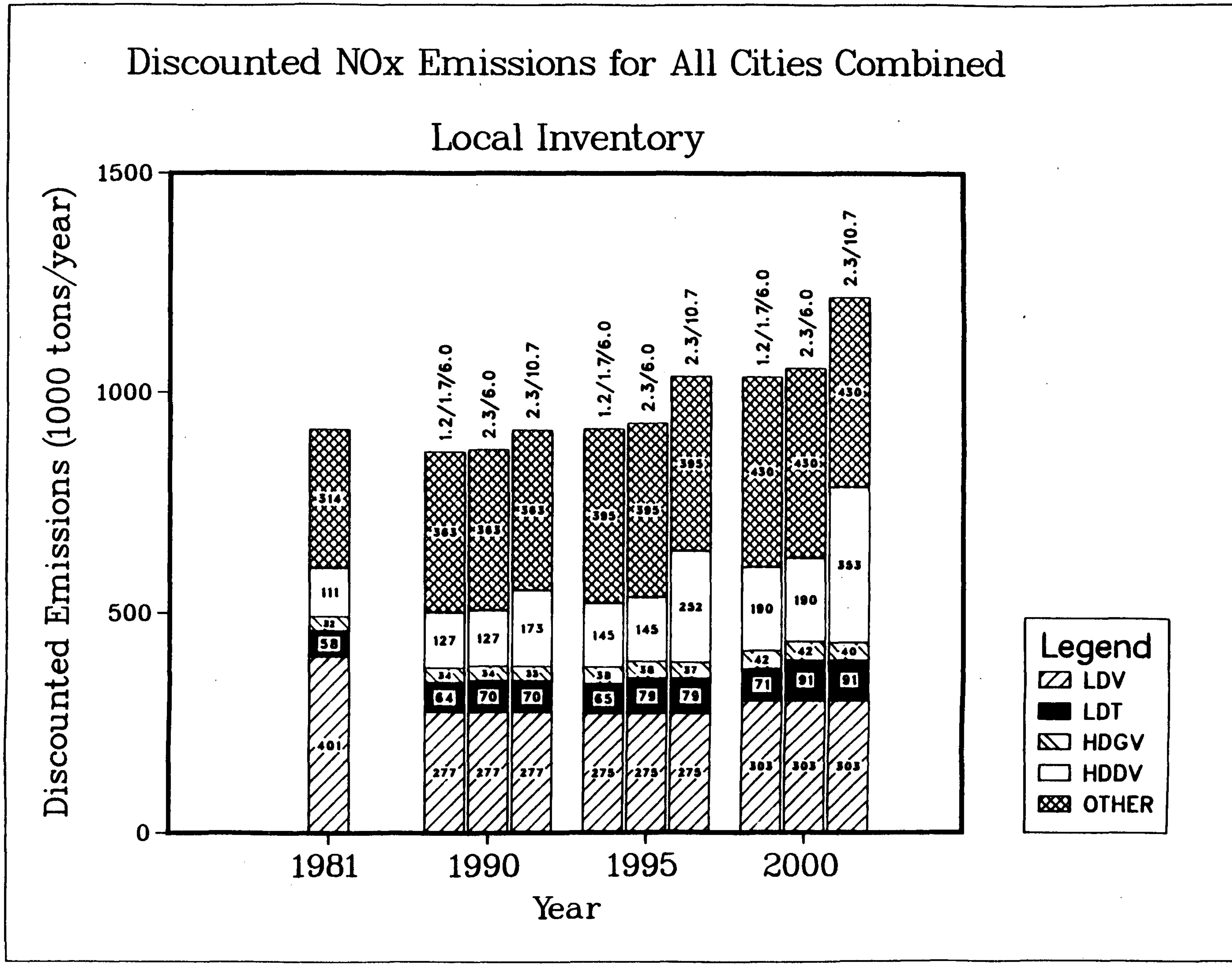
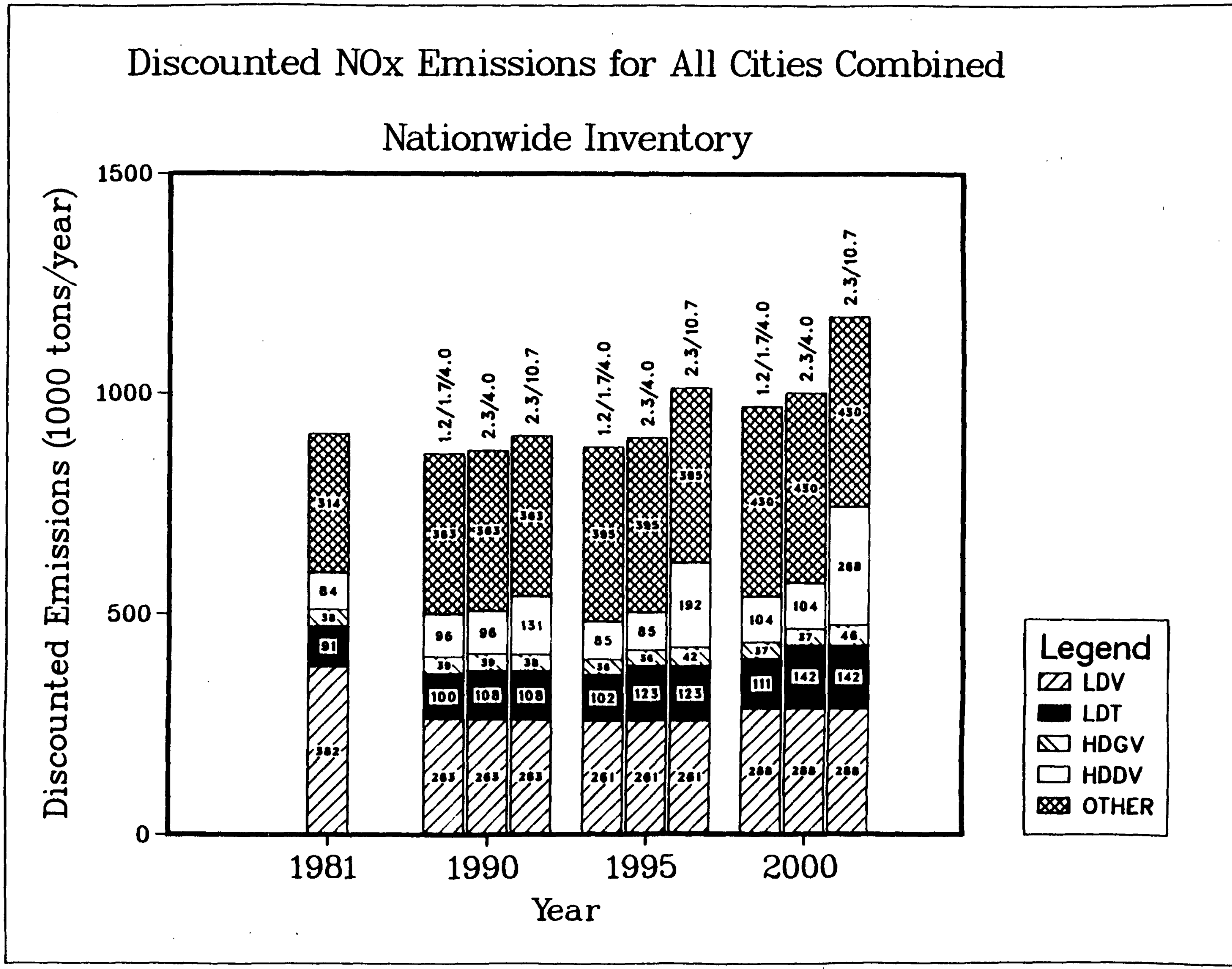
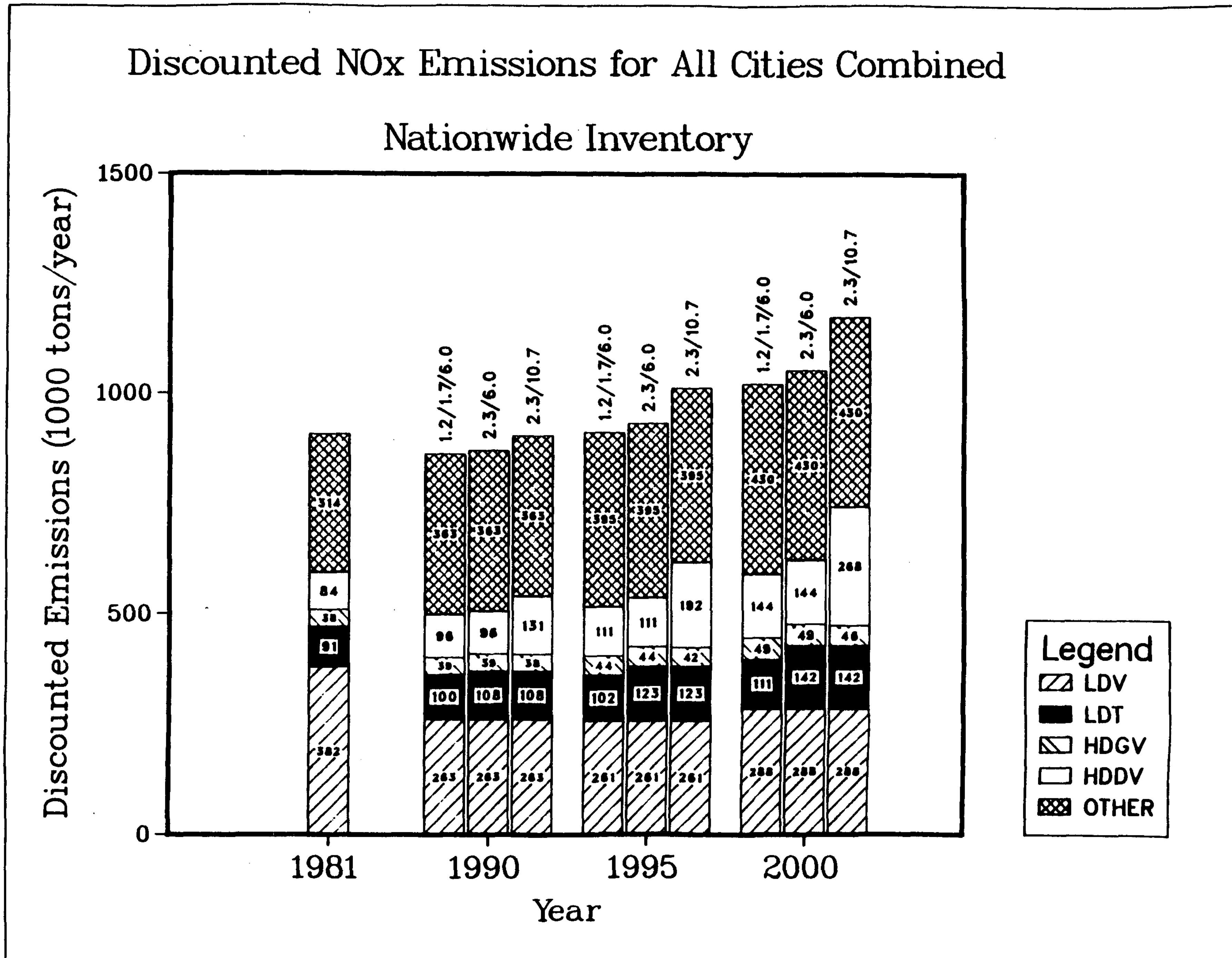

Discounted NOx Emissions for All Cities Combined
Local Inventory
Discounted Emissions (1000 tons/year)
1500
1000
500
0
1981
1990
1995
2000
Year
1.2/1.7/6.0
2.3/6.0
2.3/10.7
Legend
LDV
LDT
HDGV
HDDV
OTHER

Figure 5



Discounted NOx Emissions for All Cities Combined
Nationwide Inventory
Discounted Emissions (1000 tons/year)
1500
1000
500
0
1981
1990
1995
2000
Year
1.2/1.7/4.0
2.3/4.0
2.3/10.7
Legend
LDV
LDT
HDGV
HDDV
OTHER

Figure 6



Discounted NOx Emissions for All Cities Combined
Nationwide Inventory
Discounted Emissions (1000 tons/year)
1500
1000
500
0
1981
1990
1995
2000
Year
1.2/1.7/6.0
2.3/6.0
2.3/10.7
Legend
LDV
LDT
HDGV
HDDV
OTHER

Overall, the effect of using the local approach to develop the baseline inventories is a decrease in the amount of future growth under all scenarios compared to the NEDS-based projections. As expected, the effect of local versus NEDS data is more pronounced in Table 5, where only the growth in motor vehicle emissions is examined. For example, in the year 2000, with no further control of emissions (first scenario) NEDS-based projections show a 53-percent growth in vehicle emissions, compared to the lower 31-percent growth estimated using the localized approach (a 22-percent difference). However, with respect to total discounted NOx (Table 6), the magnitude of the difference is slightly less than before, with a NEDS-based growth of 49 percent, compared to the localized figure of 33 percent (only a 16-percent discrepancy). This difference decreases as LDT and HDE NOx controls become more stringent until, under the fifth scenario, the difference in the year 2000 is only 2 percent.

Conclusions

Based on the findings presented above, some basic conclusions can be made regarding the suitability of the NEDS approach to creating base-year motor vehicle NOx inventories for specific cities. First, NEDS appears to consistently predict a significantly higher HDDV fraction of total urban VMT (and thus emissions) than that estimated using either the localized or the nationwide approaches. This difference appears to be due to the use of registrations to apportion statewide VMT, which would not be expected to be accurate for HDDVs. Second, for every city but one, the NEDS fraction for LDT VMT is also higher than that estimated by each individual city; however, the magnitude of the LDT difference is smaller than that for HDDVs and the cause is not as clear. Thus, there appears to be sufficient reason to search for more accurate VMT estimates.

The nationwide approach appears to avoid the HDDV problem, but treats all cities the same. The local VMT estimates appear to also avoid the HDDV problem, but not completely. As the evaluation of the detailed methodology of each local area has has been only partially completed to date, no final judgments can be made at this time concerning the most accurate source of the motor vehicle NOx inventory for each city for which NOx emissions are a concern.

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APPENDIX

I. NEDS Approach

- A. Description of Methodology
- B. Sources of Data
- C. Basis for FHwA's VMT Estimates

II. Nationwide Approach

- A. Description of Methodology
- B. Sources of Data
- C. Basis for EEA's VMT Estimates
- D. Urban VMT Growth Rates (based on EEA)

III. Localized Approach

- A. Description of Local Methods
- B. Details of Calculations

IV. MOBILE3 Emission Factors Used in NOx Inventory Development

NEDS EMISSION INVENTORY METHODOLOGY

Step I: Split FHwA's nationwide VMT into LDV, LDT, HDGV, and HDDV classes.

Step II: Calculate county gasoline and diesel fuel consumption for four vehicle classes: HDDV, HDGV, LDT and LDV.

Step III: Calculate nationwide fuel economies for four vehicle classes, using FHwA VMT and nationwide fuel consumptions.

Step IV: Multiply county fuel consumption by nationwide fuel economy (mpg) to yield county VMT for each vehicle class.

Step V: Multiply class-specific county VMTs by appropriate emission factors to yield county inventories, broken down by vehicle class.

Step I: Split FHwA's Nationwide VMT Between Classes

A. LDV: FHwA's nationwide VMT data can be used directly because passenger cars are reported as a separate category. Diesel VMT is calculated using model-year sales, survival rates, and mileage accumulation rates, and then subtracted from total LDV VMT.

B. LDT and HDV: FHwA's nationwide VMT data are not divided into the proper weight categories nor separted between gas and diesel; therefore, above approach cannot be used directly.

- For each vehicle class (LDT_1, LDT_2, HDGV, HDDV), the following equation is used:

$$\text{Estimated Nationwide VMT by Class} = \sum_{m=1}^{20} \left(\text{Model-Year Sales}\right)_m \times \left(\text{Survival Rate}\right)_m \times \left(\text{Mileage Accumulation Rate by Model Year}\right)_m$$

NOTE: m = Model years in the 1981 in-use fleet; model-year sales for LDT categories include only gasoline vehicles.

- The calculated VMTs for all four classes (LDT_1, LDT_2, HDGV, and HDDV) are summed, and the fraction of total truck VMT by class is computed.

- These fractions are then applied to FHwA's estimate of total nationwide VMT for trucks and buses, to yield VMT figures for each class.

Step II: Calculate Fuel Consumption by County for HDDV, HDGV, and LD Classes

A. HD Diesel Fuel Consumption by County:

$$\text{HDDV Fuel Usage} = \left(\left(\frac{\text{County HDDV Registrations}}{\text{State HDDV Registrations}}\right) \times \left(\text{State diesel fuel} - \text{State diesel bus fuel}\right)\right) + \left(\frac{\text{County pop.}}{\text{State pop}} \times \text{State diesel bus fuel}\right)$$

Assumptions:

1. All diesel fuel is consumed by heavy-duty vehicles.
2. HDDV registrations include all diesel trucks over 6,000 lbs. GVW (inclusion of LDT_2 -- 6,000- 8,500 lbs. -- adjusted for in later steps).
3. All commercial buses run on diesel fuel.

B. HD Gasoline Consumption by County:

$$\text{HDGV fuel usage} = \sum_{w=1}^{3} \left(\frac{\left(\text{County HDGV registrations}_w\right) \times \left(\text{average annual mileage accumulation rates}_w\right)}{(\text{MPG})_w} \right) + \left(\left(\frac{\text{County population}}{\text{State population}}\right) \times (\text{State bus gasoline})\right)$$

Assumptions:

1. HDGV registrations are divided into three GVW classes: 6,001-10,000 lbs., 10,001- 19,500 lbs., and 19,501-26,000 lbs.; adjustment for LDT_2 made with MPG.
2. All institutional buses (school bus, etc.) run on gasoline.

NOTE: The figures used for MPG here are "fudge factors," computed internally by NEDS; for w = 1 to 3, MPGs are 99.9, 6.3, and 2.7, respectively. The first MPG is highly overestimated to "remove" LDT_2 fuel consumption from HD gasoline usage.

C. LD Gasoline Consumption by County:

- For states that report VMT for each county (not broken down by class):

$$\text{LD Gasoline Usage} = \left(\frac{\text{County VMT}}{\text{State VMT}} \times \text{Total State Gasoline Usage} \right) - \left(\text{Heavy-Duty Gasoline Usage} \right)$$

- For states that do not report VMT by county:

$$\text{LD Gasoline Usage} = \left(\frac{(\text{County LDV} + LDT_1 \text{ Registrations}) \times (\text{Index})}{\text{Statewide Sum of } ((\text{County LDV} + LDT_1 \text{ Registrations}) \times (\text{Index}))} \right)$$

$$\times \ (\text{Total State Gasoline}) - (\text{Heavy-Duty Gasoline})$$

Assumptions:

1. "Index" refers to a relative mileage accumulation index for each county; ranges from 0.67 for a predominently urban county, to 1.15 for a predominently rural county.
2. "Heavy-duty gasoline" is that calculated in part B.

D. Split County LD Gasoline Consumption Between LDV and LDT Classes

$$\text{LDV Fraction of LD Gasoline} = \frac{(\text{LDV Registrations}) \times (\text{LDV Factor})}{(\text{LDV Reg} \times \text{LDV Factor}) + (LDT_1 \text{ Reg} \times LDT_1 \text{ Factor}) + (LDT_2 \text{ Reg.} \times LDT_2 \text{ Factor})}$$

- Factors for each class take into account relative fuel economies and mileage accumulation rates:

  LDV factor = 8.1
  LDT_1 factor = 8.7
  LDT_2 factor = 12.3

- LDT fraction of LD gasoline = 1 - (LDV faction of LD gasoline)

- Fuel consumption (by county):

  LDV usage = (LDV fraction) X (total LD gasoline)
  LDT usage = (LDT fraction) X (total LD gasoline)

NOTE: LDT_1 and LDT_2 fuel consumption is combined into one category.

Step III: Calculate Nationwide Average Fuel Economies by Class

- For each vehicle class (LDV, LDT, HDGV, HDDV):

$$MPG = \frac{\text{Nationwide (FHwA-based) VMT}}{\text{Nationwide Sum of County Fuel Consumption}}$$

- The NEDS class-specific fuel economies for 1981 are:

LDV = 16.85 MPG
*LDT = 12.81 MPG
HDGV = 4.89 MPG
HDDV = 5.78 MPG

* LDT_1 and LDT_2 VMTs are combined and divided by LDT fuel consumption figures to yield an overall MPG for LDTs.

Step IV: Calculate County VMT by Vehicle Class

- For each class (LDV, LDT, HDGV, HDDV):

$$\text{County VMT by Class} = \left(\text{Calculated County Fuel Consumption}\right) \times \left(\text{Calculated Nationwide MPG}\right)$$

- Some states (approximately 15) report estimated total VMT by county; however, no breakdowns by vehicle class are provided. Therefore, the calculated class-specific VMTs (above) for each of these counties are used to determine a fractional breakdown of VMT by class, which is then applied to the measured county VMT total. Then, county VMTs are adjusted so that their sum is equal to the state VMT total reported by FHwA.

- For the other 35 states, where no county data are available, calculated VMTs and breakdowns are used (already consistent with FHwA's VMT totals for these states).

Step V: Calculate NOx Emissions Inventory for Each County

- Calculated county VMT figures are multiplied by the appropriate NOx emission factors to yield tons of pollutant for each county, broken down by vehicle class.

- The 1981 NEDS inventories are based on MOBILE2.5 emission factors, taking "vehicle speed correction" into account. These speed factors are chosen on the basis of urban versus rural VMT within each county; for urban travel, an average speed of 19.6 mph is assumed, while the rural speed is estimated at 45 mph. Emission factors are adjusted for each condition.

- The states that report VMT by county already specify urban and rural miles. For the other states, county VMTs are split up using the rural/urban fractions of county populations from the 1980 U. S. Census, which defines urban areas as those with populations greater then 2,500 and other "non-incorporated urbanized areas".

- Because the splits are population-based, the same urban fractions are assumed for all vehicle classes within each county; therefore, use of a speed correction factor has no effect on the breakdown of VMT by vehicle class within that county. In addition, there is also no effect on county-by-county allocation of VMT.

- For purposes of comparison within this report, the NEDS inventories were updated using MOBILE3 NOx emission factors. Because the emission factor ratios used in the rollback model are based on the average vehicle speed of the urban driving cycle (19.6 mph, correction factor equal to 1.0), these MOBILE3 emission factors were also used to calculate the NEDS baseline inventory.

Sources Used in NEDS Approach

	Factors	Sources
°	State fuel consumption figures	1982 Highway Statistics (FHwA)
°	County vehicle registrations	1979 R.L. Polk
°	County population counts	1980 U. S. Census
°	Bus fuel consumption figures	1982 Highway Statistics (FHwA)
°	HDGV fleet average annual mileage accumulation rates (miles/vehicle/year)	1977 Truck Inventory and Use Survey (TIUS)
°	Index for mileage accumulation (urban/rural)	1974 Walden Research Corp. report
°	Nationwide annual VMT	1982 Highway Statistics (FHwA)
°	Model-year sales & survival rates (1981 calendar year)	1983 MVMA Facts and Figures
°	Model-year mileage accumulation rates (1981 calendar year)	MOBILE2.5

Basis for FHwA's Nationwide VMT Estimates

I. Highway Performance Monitoring System (HPMS)

Three major types of data submitted by each state:

A. Universe road mileage data: complete inventory of road mileage classified by functional system, jurisdiction, and selected operational characteristics.

B. Sample road mileage data: specific inventory, condition, and operational data for the sample panels of roadways used to obtain samples of VMT counts. These data are used to obtain expansion factors so that sample VMT data can be adjusted to represent the universe of road mileage.

C. VMT data (sample statistics)

- Stratified by area type.

1. Rural
2. Small Urban (population 5000-49,999)
3. Individual Urbanized Areas (population 50,000 and over)

- Stratified by functional class of roadways:

1. Principal Arterial - Interstate
2. Principal Arterial - Other Freeways and Expressways (Urbanized and Small Urban Only)
3. Other Principal Arterial
4. Minor Arterial
5. Collector (Major and Minor for Rural Only)
6. Local (this data is estimated)

- Further stratified within functional class of roadway by daily traffic volume.

- Local road data is usually estimated.
- No breakdown by vehicle type.
- Provides data for construction of Table VM-2 and VMT figures in the extreme right hand column of Table VM-1.
- Areawide data expanded from samples to the universe using expansion factors from sample mileage data.
- Sample data for interstates is complete. No expansion necessary.

II. FHwA's Construction of Table VM-1

Vehicle Miles Travelled

A. Totals (column 11, rows 1-8): from HPMS data
B. Breakdown by vehicle class (columns 1-10, rows 1-8):

- Based on samples of class-specific VMT breakdowns by class obtained at 600-700 truck weight sites throughout the nation (mostly rural with heavy truck travel) and at 300-400 other sites (mostly urban) in only six states: Maine, Georgia, Tennessee, Minnesota, Oklahoma, Oregon, with supplementary data from Texas and Nebraska.
- Above data segregated into five regions (based on accessibility of information) and each region stratified into 26 groups by area type (urban/rural), functional road classification, and volume of traffic.
- Twelve vehicle classes recorded at the 300-400 other sites; more at truck weight sites, no differentation by fuel type (cars, motorcycles, pickups and vans, buses, 8 truck types: single-axle and up).
- These 12 vehicle classes aggregated over the nation and combined into the six shown in Table VM-1.

Number of Motor Vehicles Registered (row 9):

- FHwA estimates taken from state registration information, summed over entire year; some duplication possible due to sales of used vehicles.

Total Motor Fuel Consumed (row 11, column 11):

- Obtained from monthly data from state motor fuel tax agencies.
- Off-highway-use fuel removed.
- Can be some problem with diesel fuel as home heating oil may be used as a substitute.

Average Miles Travelled Per Gallon of Fuel Consumed (row 13):

- Iterative process.
- For the first iteration, the previous year's estimates are used along with estimated increase. This is adjusted in later iterations as seen below.

Remainder of Table (Average Miles Travelled Per Vehicle, Fuel Consumed by Vehicle Type, Average Fuel Consumption per Vehicle):

- Iterative process.
- First iteration: compute directly from other figures.
- Check for consistency of results: i.e., does fuel consumed by individual vehicle classes sum to total fuel consumed? Are average miles travelled consistent with National Personal Transportation Survey (NPTS), Truck Inventory and Use Survey (TIUS)?
- Second and further iterations: adjust the MPG and other figures for passenger cars and combination trucks as they are, respectively, the prime consumers of gasoline and diesel fuel. NOTE: The figures for VMT by class, motor vehicle registrations by class, and total motor fuel consumed are held constant and are not adjusted in these iterations.

Other Comments

- A vehicle classification study was performed from late summer 1980 to early fall of 1981 at a total of 139 sites by five local agencies for FHwA (Delaware Valley Regional Planning Commission, States of Arkansas, Iowa, Minnesota, and Washington). This information is used as a check on the VMT breakdown by class obtained from the site data.

- Beginning with this year (1984) states are being required to report travel activity by vehicle type in each functional class. However, statistically sound measurements are not required as of yet. Estimates based on available data are allowed. The vehicle types are: motorcycles (optional), passenger cars, buses, single-unit trucks, single-trailer trucks, multi-trailer trucks, other. This is part of HPMS, so it will be divided into rural, small urban and urbanized areas.

Nationwide Approach

Step I: Split EEA's nationwide annual VMT -- already divided by class (LDV, LDT_1, LDT_2, and HD classes 2B, 3-5, 6, and 7-8) -- into gasoline and diesel fractions.

Step II: Convert total nationwide gasoline and diesel VMT (by class) into urban fractions.

Step III: Calculate annual nationwide urban NOx inventories by vehicle class, using nationwide urban VMT and MOBILE3 emission factors.

Nationwide Approach

Calculation of Light-Duty Urban VMT:

- Same calculation carried out separately for LDV, LDT_1, and LDT_2 classes.

- Division between gasoline and diesel fractions:

$$VMTD = VMT \times \frac{\sum (RF)(DMA)(DSF)}{\sum (RF)(GMA)(1-DSF) + \sum (RF)(DMA)(DSF)}$$

$$VMTG = VMT - VMTD$$

Where:

VMTD = nationwide diesel VMT (by class)
VMTG = nationwide gasoline VMT (by class)
VMT = EEA's class-specific VMT (total nationwide)
RF = light-duty registration distribution by age (gas and diesel same)
DMA = diesel mileage-accumulation rate (by age)
GMA = gasoline mileage-accumulation rate (by age)
DSF = diesel fraction of total sales (by model year)

- Conversion to Urban VMT:

  UVMTD = VMTD * UF
  UVMTG = VMTG * UF

  Where:

  UVMTD = class-specific urban diesel VMT (nationwide)
  UVMTG = class-specific urban gasoline VMT (nationwide)
  UF = urban fraction of VMT (gas and diesel same); constant 0.594, 0.488, and 0.488 for LDV, LDT_1 and LDT_2, respectively.

Calculation of Heavy-Duty Urban VMT:

- Same calculation carried out separately for HD Classes IIB, III-V, VI, and VII-VIII.

- Division between gasoline and diesel fractions, and conversion to urban VMT accomplished in the same step. (Because HD urban fractions change with model year, it is necessary to include these urban terms within the summations, in the numerator only.)

$$UVMTD = VMT \times \frac{\sum (DRF)(DMA)(TDR)(UFD)}{\sum (GRF)(GMA)(TGR) + \sum (DRF)(DMA)(TDR)}$$

$$UVMTG = VMT \times \frac{\sum (GRF)(GMA)(TGR)(UFG)}{\sum (GRF)(GMA)(TGR) + \sum (DRF)(DMA)(TDR)}$$

Where:

UVMTD = Class-sepcific urban diesel VMT (nationwide)
UVMTG = Class-specific urban gasoline VMT (nationwide)
VMT = EEA's class-specific VMT (total nationwide)
DRF = HDDV registration distribution (by age)
GRF = HDGV registration distribution (by age)
TDR = Calendar-year HDDV registrations (by class)
TGR = Calendar-year HDGV registrations (by class)
DMA = Diesel mileage-accumulation rate (by age)
GMA = Gasoline mileage-accumulation rate (by age)
UFD = Urban fraction of diesel VMT (by model year)
UFG = Urban fraction of gasoline VMT (by model year)

Sources Used in Nationwide Approach

Vehicle Class	Factors Used	Sources
LDV	Total nationwide VMT (by calendar year)	EEA's 10th Quarterly Report
	Registration distribution (by age)	MOBILE3 (1977 & 1981 R.L. Polk)
	Mileage accumulation rates (by age)	MOBILE3 (General Motors Research (GMR), derived from 1979 National Purchase Dairy Research, Inc. (NPD))
	Diesel sales fractions (by model year)	MOBILE3; Diesel Particulate Study (DPS) (Jack Faucett; Data Resources)
	Urban fraction of VMT (all model years)	FHwA (1982)
LDT	Total nationwide VMT (by calendar year)	EEA's 10th Quarterly Report
	Registration distribution (by age)	MOBILE3 (1978 & 1981 R. L. Polk)
	Mileage accumulation rates (by age)	MOBILE3 (1977 Truck Inventory and Use Survey (TIUS))
	Diesel sales fractions & Urban fraction of VMT	Same sources as LDV
HDV	Total nationwide VMT (by calendar year)	EEA's 10th Quarterly Report
	Registration distribution (by age)	MOBILE3 (1972 & 1977 TIUS)
	Mileage accumulation rates (by age)	MOBILE3 (1977 TIUS)
	Total vehicle registrations (by calendar year)	EEA's 10th Quarterly Report
	Urban fraction of VMT (by model year)	Heavy-Duty Conversion Factor Analysis (1977 TIUS)

Basis for EEA's Estimates of Historic Nationwide VMT

1. Obtain total cars and total trucks in use from R.L. Polk* registration data.

2. Obtain gas/diesel, domestic/imported, light/heavy truck splits by applying scrappage rates (found in the literature) to actual model year sales.

3. Obtain vehicle mileage-accumulation rates in a base year from NPD** for light-duty vehicles and trucks, and TIUS (77) for heavy-duty trucks.

4. Use Federal Highway data in Table VM-1 to get change in average annual mileage-accumulation rates. No other data from Table VM-1 used.

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* R.L. Polk registration data: vehicles in use as of July 1; adjustments made for scrappage and duplicates.

** NPD: National Panel Diary by NPD Research, Inc., Port Jefferson, New York.
- a diary panel survey of 5000 families.
- data collected contains information on 1) fuel purchases: date, gallons, type of fuel, total costs; 2) vehicle type; and 3) miles travelled.
- average length of participation in survey is 10 months.

Annual Urban VMT Growth Rates Used in NOx Projections

- The table below lists the estimated percentage growth in VMT from base-year (1981) to year of projection, for each of the vehicle classes.
- These growth rates are based on EEA's nationwide VMT estimates (Tenth Quarterly Fuel Consumption Model), separated into gasoline and diesel fractions and converted to urban VMT using the Nationwide Approach (explained in detail in this Appendix).
- The following growth rates were used in future NOx projections with all three approaches (NEDS, nationwide, and local); they were also used to convert some 1980 local VMT data into 1981 figures.

Annual Fleet Urban VMT Growth Rates
(Percent Change from 1981 Base Year)

Year	LDGV	LDDV	LDV	LDGT	LDDT	LDT	HDGV	HDDV
1982	-1.76	29.16	-1.24	-0.41	56.41	0.46	0.33	5.07
1983	-1.01	25.67	-0.50	0.38	51.25	1.35	0.52	4.08
1984	-0.38	24.19	0.14	1.27	48.74	2.38	1.14	4.92
1985	0.06	22.96	0.60	1.69	46.26	2.95	1.45	5.66
1986	0.36	21.93	0.91	1.91	43.42	3.28	1.57	6.18
1987	0.60	21.05	1.17	2.04	40.95	3.53	1.64	6.56
1988	0.79	20.36	1.38	2.10	38.83	3.72	1.75	6.79
1989	0.95	19.81	1.56	2.09	36.90	3.83	1.83	6.88
1990	1.05	19.36	1.69	2.03	35.08	3.89	1.93	6.90
1991	1.15	18.76	1.81	1.99	33.28	3.94	1.94	6.87
1992	1.23	18.06	1.89	1.96	31.56	3.96	1.98	6.83
1993	1.30	17.31	1.96	1.92	29.95	3.96	2.03	6.79
1994	1.35	16.57	2.00	1.90	28.48	3.96	2.04	6.73
1995	1.39	15.85	2.03	1.87	27.14	3.95	2.07	6.68
1996	1.42	15.14	2.04	1.85	25.86	3.92	2.09	6.61
1997	1.43	14.45	2.03	1.83	24.67	3.89	2.09	6.53
1998	1.43	13.80	2.01	1.82	23.54	3.84	2.08	6.43
1999	1.43	13.19	1.99	1.80	22.49	3.78	2.07	6.32
2000	1.42	12.62	1.96	1.79	21.51	3.72	2.06	6.21

Source: "Rollback II With Variable Mobile Source Growth Rates," Memorandum from Mark Wolcott, TEB, to Charles L. Gray, ECTD, October 29, 1984.

Local Methodologies and Calculations

Chicago, Illinois

The estimate of total VMT for the Chicago SMSA was determined as follows. The Illinois Department of Transportation (IDOT) provided data on vehicle miles travelled in Northeastern Illinois based on characteristics of highways in this area and in Illinois as a whole. The values for 1980 and 1981 are:

	Average Weekday VMT (IDOT)
1980	96014225
1981	97848249

The Chicago Area Transportation Study (CATS), as part of its network modelling, made adjustments to the 1980 value based upon traffic counts made by themselves and IDOT, and to account for non-network traffic. This resulted in a value for 1980 of 113,199,890.[2] The same adjustment factor was then applied here, as well as a factor of 365 days per year, to derive an adjusted total VMT for 1981 of 42.1 billion miles.

The sources for the above data were continuous machine counts taken at 165 non-expressway sites and an undetermined number of expressway sites. Visual vehicle classification counts were taken at all of the 165 non-expressway sites at one time. At selected expressway sites, approximately ten at a time, visual vehicle classification counts have been made more frequently, although not at the same sites each time.[3] The following four vehicle classes were defined at each site and then broken into the eight vehicle classes used by the MOBILE model:[4]

(1) passenger cars;
(2) light trucks - 4 tires;
(3) medium trucks - 3 axle or 6 tires; and
(4) heavy trucks - all others.

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[1] Illinois Environmental Protection Agency, Division of Air Pollution Control, Proposed Revision to the State Implementation Plan for Ozone, Chicago, 23 December 1983.
[2] Chicago Air Transportation Study 1982 State Implementation Plan Submittal for Northeastern Illinois, Chicago, 24 June 1982.
[3] Chicago Area Transportation Study, Conversation with Roy Vell, 30 October 1984.
[4] Ibid.

The local VMT breakdown used here was that for 1982 as provided by the Illinois EPA. Combined with the 1981 total VMT estimates, the following estimate of VMT by vehicle class was obtained:

	VMT %[6]	1981 VMT (millions)
LDGV	86.6	36,465
$LDGT_1$	02.8	1,179
$LDGT_2$	01.6	674
HDGT	02.7	1,137
LDDV	02.7	1,137
LDDT	00.2	84
HDDV	02.4	1,011
MC	01.0	421

Using the MOBILE3 emission factors, NOx emissions for each vehicle class were calculated. The LDV and LDT classes were created by summing their subclasses, and the MC VMT and emissions were redistributed based upon VMT share. The final inventories are presented in Table A-1.

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[5] Op Cit, 1982 SIP Submittal.

[6] Illinois EPA, Division of Air Pollution Control, The Effect of U.S. EPA Proposals to Relax Vehicle Emission Standards on Chicago Air Quality, Springfield, Illinois, October 1981.

Table A-1

1981 Annual Comparisons
Chicago

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	37984.0	(90.2)	34025.5	(80.8)	28989.4	(81.2)
LDT	1979.2	(4.7)	5811.3	(13.8)	3959.5	(11.1)
HDGV	1137.0	(2.7)	1431.8	(3.4)	720.9	(2.0)
HDDV	1010.6	(2.4)	842.2	(2.0)	2043.9	(5.7)
Total	42110.8	(100.0)**	42110.8	(100.0)	35713.7	(100.0

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach***	
LDV	111.81	(72.6)	101.64	(64.4)	86.60	(53.6)
LDT	7.86	(5.1)	24.15	(15.3)	16.45	(10.2)
HDGV	7.95	(5.2)	10.01	(6.3)	5.04	(3.1)
HDDV	26.41	(17.1)	22.00	(13.9)	53.39	(33.1)
Total	154.03	(100.0)	157.80	(99.9)	161.48	(100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** Before adjustment for unaccounted traffic was made by Chicaco Area Transportation Study, this value was 35715.0, or essentially the same figure estimated by the NEDS approach.

*** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Detroit, Michigan

Local total VMT data were only available for five of the six counties that comprise the Detroit SMSA: Livingston, Macomb, Oakland, St. Clair, and Wayne. No data was available for Lapeer County, so the 1981 VMT from NEDS was used for this county instead. The data for the other counties was obtained from the Southeastern Michigan Council of Governments (SEMCOG).[1]

SEMCOG obtained their 1981 total VMT estimates by taking a base year (1980) estimate of travel and applying growth rates, by county, derived from the U.T.P.S. network model. The base year data was obtained from historical vehicle counts along many of the 7500 coded links in SEMCOG's jurisdiction, and another series of vehicle counts made to improve traffic estimation for air quality purposes.[2]

The estimate of total VMT for the combined counties of Livingston, Macomb, Oakland, St. Clair, and Wayne equalled 81,361,000 miles/day.[3] A factor of 365 was applied here to yield an annual VMT of 29.7 billion miles. To this, the NEDS value for Lapeer County of 0.54 billion miles[4] was added to arrive at a total 1981 VMT for the Detroit SMSA of 30.2 billion miles.

The local estimates for VMT breakdown were also obtained from SEMCOG. The primary source for these estimates was the 1980 Regional Vehicle Classification and Occupancy Study. One-hundred and fifteen sites were intended to be surveyed, but only 43 of these were used in determining a breakdown by vehicle type.[5]

At each site the following vehicles were classified[6]:

(1) passenger car;
(2) passenger/commercial van;
(3) passenger/commercial light-duty truck (i.e., Ford Bronco);

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[1] SEMCOG, meeting with Chuck Hersey and Adeile Nwanko, 25 October 1984.
[2] SEMCOG, <u>Procedures Used in Generating the Mobile Source Emission Inventory</u>, Detroit, MI, June 1984, p. 27-8.
[3] Ibid, p.42.
[4] NEDS Area Source Reports.
[5] Op Cit. SEMCOG Meeting
[6] SEMCOG, <u>Regional Vehicle Classification and Occupancy Study</u>, Detroit, MI, November 1982, revised January 1983, p. 18

(4) heavy-duty trucks: large single-unit trucks;
(5) semi-trucks: large tractor-trailer combination vehicles;
(6) motorcycles

The sites were located along 5 different types of roadway:[7]

(1) urban freeway;
(2) urban arterial, major;
(3) urban arterial, minor;
(4) rural freeway; and
(5) rural arterial.

The sites were surveyed during three different time periods:[8]

(1) 7:00 a.m. to 9:00 a.m.;
(2) 11:00 a.m. to 1:00p.m.; and
(3) 2:00 p.m. to 6:00 p.m.

In conjunction with the network traffic modelling, and a few assumptions, regional VMT percentages were derived for the eight vehicle classes used in the MOBILE models. A few of the key assumptions are stated below.

(1) Diesel penetration occurs within classes; i.e., an LDDV will replace a LDGV and not a LDGT;[9]
(2) VMT is proportional to registration for the purposes of splitting gas and diesel vehicles;[10]
(3) VMT percentage by trip type remains constant over time.[11]

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[7] Op Cit., SEMCOG Meeting
[8] Op Cit., Regional Vehicle..., p. 17
[9] Op Cit., Procedures, p. 12
[10] Ibid, p. 60
[11] Ibid, p. 62
[12] Ibid, p. 63

These assumptions yield the following breakdown of 1981 VMT by vehicle type for the Detroit SMSA.

	VMT %[12]	VMT (millions)
LDGV	81.9	24,767.0
$LDGT_1$	11.8	3,568.4
$LDGT_2$	0.2	60.5
HDGV	1.5	453.6
LDDV	1.4	423.4
LDDT	0.1	30.2
HDDV	2.6	786.3
MC	0.5	151.2

This VMT was then used with MOBILE3 emission factors to determine the 1981 NOx inventory. The LDVs and LDTs were summed across their subclasses, and the MC emissions and VMT were redistributed based upon VMT percentage. The final inventories are presented in Table A-2.

Table A-2

1981 Annual Comparisons
Detroit

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	25317.0	(83.7)	24434.3	(80.8)	20159.2	(80.1)
LDT	3677.4	(12.2)	4173.2	(13.8)	3619.3	(14.4)
HDGV	455.9	(1.5)	1028.2	(3.4)	548.2	(2.2)
HDDV	790.2	(2.6)	604.8	(2.0)	855.4	(3.4)
Total	30240.5	(100.0)	30240.5	(100.0)	25182.1	(100.1)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach**	
LDV	75.29	(67.1)	72.99	(64.4)	60.20	(59.4)
LDT	13.28	(11.8)	17.34	(15.3)	15.04	(14.8)
HDGV	3.17	(2.8)	7.18	(6.3)	3.80	(3.8)
HDDV	20.54	(18.3)	15.80	(13.9)	22.30	(22.0)
Total	112.28	(100.0)	113.31	(99.9)	101.34	(100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Nashville, Tennessee

The VMT breakdown by vehicle classification in Nashville-Davidson County was determined by visual counts at eight locations throughout the county. These locations include one interstate, five primary arterials, one minor arterial, and one airport entrance. The vehicles observed were put into the following classifications:

(1) passenger cars (standard and small),
(2) motorcycles,
(3) buses (commercial and school),
(4) single-unit trucks (single unit pickup or panel, single rear-tire, dual rear-tire), and
(5) tractor-trailers (3-axle, 4-axle, semi, etc.).[1]

The sample counts are performed by the Tennessee Department of Transportation (TDOT). They are performed once a year for a continuous six hour period. The sites were originally picked randomly and they remain the same every year. This is not a statistically determined sample, and TDOT does nothing beyond providing the data for each site.[2]

TDOT also makes counts of total VMT at 381 traffic count stations in Davidson County. These 381 stations cover five functional classifications: interstate, expressway, primary arterial, minor arterial, and collector. Local roads, not counted, are assumed to account for 8 percent of total traffic in Davidson County.[3]

These traffic count data are then applied by the Comprehensive Planning Division of the Metropolitan Government of Nashville and Davidson County. The total VMT data are first summed to provide totals by functional road classification.[4] The VMT breakdown by class is then determined for each functional classification from the TDOT data using the following assumptions:

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[1] Conversations with Rich Walpole, TDOT Transportation Mapping Division (9/17/84) and Bucky Crowell, Nashville Metro Government, Comprehensive Planning Division (10/22/84).
[2] Ibid.
[3] Metropolitan Planning Commission Memo, 1981 Nashville-Davidson County, Tennessee Mobile Source Emissions Inventory and Documentation of Methodology, Bucky Crowell (Comprehensive Planning Division) to Paul Bontrager (Metropolitan Health Department), June 24, 1982.
[4] Ibid.

(1) single-unit trucks comprise all of the light-duty trucks,
(2) buses and tractor-trailers comprise all of the heavy-duty trucks, and
(3) the VMT breakdown for collector roads is the same as that for minor arterials.

The VMT breakdowns for freeways and local roads came from older TDOT surveys that are not updated annually.[5] This makes these figures less certain, but these two functional classifications account for only 12.8 percent of the total VMT. Finally, the splits for gas vs. diesel and light-duty truck 1 and 2 were determined from MOBILE2 default estimates for vehicle mix.[6] For the year 1981, the 1980 VMT breakdown for minor arterials, collectors and local streets was adjusted to reflect the changes in MOBILE2 default values from 1980 to 1981.[7] The results are shown below.

1981 Nashville VMT Breakdown[8]

Road/ Vehicle Type	LDGV	LDGT 1	LDGT 2	HDGV	LDDV	LDDT	HDDV	MC
Local	.866	.044	.043	.002	.009	.028	.002	.006
Collector	.854	.040	.039	.014	.009	.025	.014	.005
Minor Arterial	.854	.040	.039	.014	.009	.025	.014	.005
Primary Arterial	.750	.141	.079	.010	.008	.001	.008	.003
Expressway	.792	.117	.066	.006	.009	.001	.005	.004
Interstate	.680	.142	.080	.048	.008	.002	.038	.002

1981 Nashville Daily VMT[9]

Local	750,831
Collector	372,423
Min. Arterial	501,178
Prim. Arterial	3,526,835
Expressway	447,699
Interstate	3,786,401
Total	9,385,365

[5] Op Cit. Phone Conversations.
[6] Op Cit. Metropolitan Planning Commission Memo.
[7] Ibid.
[8] Ibid.
[9] Ibid.

From the tables of 1981 Vehicle Mix by Functional Classification and Vehicle Type, and Daily Vehicle Miles of Travel by Functional Roadway Class (above), vehicle miles of travel by vehicle type were computed. The only assumption made was that Daily Vehicle Miles of Travel X 365 would equal Annual Vehicle Miles of Travel. These are the figures, therefore, that are used in all subsequent calculations involving Nashville-Davidson County. The final inventories are presented in Table A-3.

Table A-3

1981 Annual Comparisons
Nashville

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	4827.3	(75.3)	5179.9	(80.8)	4476.1	(68.9)
LDT	1295.0	(20.2)	884.7	(13.8)	1219.7	(18.8)
HDGV	160.3	(2.5)	218.0	(3.4)	186.9	(2.9)
HDDV	128.2	(2.0)	128.2	(2.0)	612.1	(9.4)
Total	6410.8	(100.0)	6410.8	(100.0)	6494.8	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach**	
LDV	14.42	(59.4)	15.47	(64.4)	13.37	(37.4)
LDT	5.38	(22.2)	3.68	(15.3)	5.07	(14.2)
HDGV	1.12	(4.6)	1.52	(6.3)	1.33	(3.7)
HDDV	3.35	(13.8)	3.35	(13.9)	16.00	(44.7)
Total	24.27	(100.0)	24.02	(99.9)	35.77	(100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

New York City

The New York City SMSA consists of eight counties in two states. Localized VMT estimates for each county had to be compiled from a number of sources, which are described below.

The following estimates of 1980 daily VMT by vehicle class for the counties of Bronx, New York, Queens, Rockland, Richmond, and Westchester were obtained from the New York Metropolitan Transportation Council (MTC).[1]

	1980 Daily VMT	1980 Annual VMT (millions)
LDV	52133900	19029.1 (88.5%)
LDGT	3786500	1382.1 (6.4%)
HDGV	2073200	756.7 (3.5%)
HDDV	885200	323.1 (1.5%)

The total VMT for these counties was derived using the Highway Evaluation Model, a network model. This model, originally calibrated in 1963 based upon a tri-state home interview and a truck survey, has been updated using 1970 Census Data, 1978 Taxi Survey data, and updated VMT estimates in 1975. These 1975 updates involved at least one 48-hour count on each link in the arterial and expressway networks.[2]

The breakdown by vehicle class was obtained from various surveys. For the two suburban counties, Westchester and Rockland, the mix was based on a 1975 traffic count survey on the Long Island Expressway.[3] For Manhattan and the rest of New York City, the mix was based upon 1973 and 1979 bridge and tunnel counts, respectively.[4] The classes were further subdivided using 1981 registration data from the New York State Department of Motor Vehicles.[5]

An estimate of 16,927,000 for the 1980 daily VMT in Bergen County, New Jersey, was obtained from the New Jersey DOT.[6] This was converted to an annual VMT by multiplying by 365. The 1981 annual VMT estimate for Putnam County, New York, of 749 million was taken from NEDS.[7]

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[1] New York Metropolitan Transportation Council, letter from David Jordan, Assoc. Transp. Analyst, 28 September 1984.
[2] Tri-State Regional Planning Commission, 1982 SIP Revision, New York, March 1982, pp. 1,7.
[3] Ibid, p. 19.
[4] Ibid, p. 35.
[5] Ibid.
[6] Ibid, p. 30
[7] NEDS area source reports.

To convert these estimates into a 1981 SMSA estimate of VMT by vehicle class, several steps were taken:

(1) The 1980 total for Bergen County was broken down by class using the breakdown for the six New York counties.
(2) The 1980 VMTs for each class were updated to 1981 using growth factors, by vehicle class, derived from the Nationwide Method (shown earlier in the Appendix).
(3) A new 1981 VMT breakdown was established.
(4) The 1981 total for Putnam County was split between classes using the new 1981 breakdown for the other counties.
(5) The class-specific VMTs for all of the counties were totalled.

This resulted in the following 1981 VMT breakdown by vehicle class:

	Total 1981 VMT
LDV	25155.6 (87.9)
LDGT	1985.7 (6.9)
HDGV	1050.0 (3.6)
HDDV	444.2 (1.5)

These results, with the MOBILE3 emission factors, were used to determine the mobile source NOx inventory. The final inventories are presented in Table A-4.

Table A-4

1981 Annual Comparisons
New York City

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	25155.6	(88.0)	23137.5	(80.8)	25523.3	(87.5)
LDT	1985.7	(6.9)	3951.7	(13.8)	2157.2	(7.4)
HDGV	1050.0	(3.6)	973.6	(3.4)	633.1	(2.2)
HDDV	444.2	(1.5)	572.7	(2.0)	854.1	(2.9)
Total	28635.5	(100.0)	28635.5	(100.0)	29167.7	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach**	
LDV	75.15	(73.4)	69.12	(64.4)	76.24	(68.1)
LDT	8.25	(8.1)	16.43	(15.3)	8.96	(8.0)
HDGV	7.34	(7.2)	6.81	(6.3)	4.42	(4.0)
HDDV	11.60	(11.3)	14.96	(13.9)	22.31	(19.9)
Total	102.34	(100.0)	107.32	(99.9)	111.93	(100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Philadelphia

The estimates of total VMT and the VMT breakdown by vehicle class for the Philadelphia SMSA were provided by the Delaware Valley Regional Planning Commission (DVRPC). The DVRPC has used these estimates in the 1982 SIPs for Pennsylvania and New Jersey.

Total VMT by county is obtained from a transportation modelling system to estimate current and future travel. This system is equivalent to the network models described before. The model estimates for 1979, 1980, and 1987 are as follow:[1]

Year	Daily VMT
1979	59,250,000
1980	61,821,000
1987	65,951,000

In order to obtain an estimate for 1981 total VMT, a linear extrapolation between 1980 and 1987 could have been used. This method was rejected as being inaccurate, however, based upon the economic conditions known to exist. The following method was used instead.

$$\begin{matrix}1981 \\ \text{VMT Phil.}\end{matrix} = \left(\begin{matrix}1980 \\ \text{VMT Phil.}\end{matrix}\right) \times \left(\frac{\text{1981 VMT Nation}}{\text{1980 VMT Nation}}\right) \times \left(\frac{\dfrac{\text{1987 VMT Phil.}}{\text{1980 VMT Phil.}}}{\dfrac{\text{1987 VMT Nation}}{\text{1980 VMT Nation}}}\right)$$

Where:

(X VMT) Phil. = total VMT in year X for the Phil. SMSA.
(X VMT) Nation = total VMT in year X for nationwide urban from the nationwide method.
(1980 VMT) nation = 840,640,000,000
(1981 VMT) nation = 857,560,000,000
(1987 VMT) nation = 945,930,000,000

The result is a 1981 daily VMT for the Philadelphia SMSA of 59,789,773 and a 1981 total VMT of 21.8 billion miles.

The VMT breakdown by vehicle class was obtained from a 1980 vehicle occupancy and vehicle mix monitoring program performed by the DVRPC. The intent of the study was to establish regional and more disaggregate estimates for light

[1] Delaware Valley Regional Planning Commission, _Delaware Valley Highway Emissions Inventory_, Philadelphia, PA, September 1982.

and heavy truck percentages with a confidence level of 95 percent, and average regional passenger vehicle occupancy with a confidence level of 65 percent.[2]

The final survey consisted of 112 monitoring sites stratified by functional classification of roadway (freeways and expressways, principal arterials, minor arterials, and collectors), and area type (central business district, urban, suburban, and rural). The individual sites were surveyed on days from 18 March until 30 June 1980, chosen at random, excluding holidays and weekends. At most stations, automatic machine counts were taken in conjunction with the visual counts. The visual counts were taken from 7:00 a.m. to 3:00 p.m. the day of the count.

The vehicles classified were as follow:

(1) passenger vehicles;
(2) light trucks - pickup or panel, single rear-tires;
(3) heavy trucks - dual rear-tires, 3 axles, 4 or more axles, all semi or full trailers;
(4) buses; and
(5) motorcycles.

The results from the vehicle classification survey were used by the DVRPC in the determination of their highway emissions inventory. HDGV and HDDV VMT was split using the product of state vehicle registrations and mileage accumulation rates from the 1977 TIUS for Pennsylvania and New Jersey combined. This resulted in the diesel share of HDV VMT being 65 percent. The light-duty trucks were split into the two weight classes based upon national sales statistics by model year. This resulted in a two-to-one split for LDT_1 over LDT_2.[3]

The final VMTs and the breakdown by class were as follow:

	VMT %[4]	VMT (millions)
LDV	82.0	17895.0
LDT_1	7.2	1571.3
LDT_2	3.6	785.6
HDGV	2.5	545.6
HDDV	4.7	1025.7

[2] Delaware Valley Regional Planning Commission, Automobile Occupancy and Truck Travel Monitoring for Transportation Air Quality Planning, Philadelphia, PA, February 1981.
[3] Op Cit. Highway Emissions Inventory
[4] Ibid, and conversation with Ron Roggenburk, DVRPC, October 1984.

These values, combined with the properly weighted MOBILE3 emission factors were used to generate the mobile source NOx emission inventory for the Philadelphia SMSA. The final inventories are presented in Table A-5.

Table A-5

1981 Annual Comparisons
Philadelphia

VMT, Millions (%)

	Localized Approach	Nationwide Approach*	NEDS Approach
LDV	18002.0 (82.5)	17631.0 (80.8)	19033.0 (81.0)
LDT	2312.9 (10.6)	3011.2 (13.8)	2707.6 (11.5)
HDGV	523.7 (2.4)	741.9 (3.4)	547.9 (2.3)
HDDV	981.9 (4.5)	436.4 (2.0)	1220.1 (5.2)
Total	21820.5 (100.0)	21820.5 (100.0)	23508.6 (100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach	Nationwide Approach	NEDS Approach**
LDV	53.78 (58.2)	52.67 (64.4)	56.86 (54.8)
LDT	9.37 (10.1)	12.51 (15.3)	11.25 (10.8)
HDGV	3.66 (4.0)	5.18 (6.3)	3.83 (3.7)
HDDV	25.66 (27.7)	11.40 (13.9)	31.87 (30.7)
Total	92.47 (100.0)	81.76 (99.9)	103.81 (100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Reno, Nevada

The estimates for daily VMT for the Reno SMSA (Washoe County) were obtained from the Reno Regional Transportation Commission. The breakdown of VMT by vehicle class was provided by the Nevada Department of Transportation to the Reno Regional Transportation Council.

The Reno Regional Transportation Commission uses the U.T.P.S. network modelling system to estimate daily VMT for the Washoe County area. The models have been calibrated and validated twice by traffic counts, but the current estimates are direct outputs of the model.[1]

The 1983 estimates for daily VMT by functional classification of roadway as provided are as follow:

Roadway	1983 Daily VMT[2]
Local	260,710
Collector	188,710
Minor Arterial	1,550,560
Major Arterial	396,220
Freeway	1,183,780

The Nevada Department of Transportation (NDOT) does periodic vehicle classification surveys from which a vehicle mix can be determined.[3] The urban survey is for statewide urban, which also includes Las Vegas, so the resulting estimates are not specific to Reno.

The surveys were performed in 1978 on the five functional classifications of roadways, with the larger roadways being surveyed more frequently. The number of sites surveyed has varied from year to year, and the results are reported only by functional class and not by site. Freeway sites are monitored for a minimum of twenty-four hours and the other road classes for a minimum of eighteen hours. Some adjustment is made for the day of the week. The vehicles classified at each site are:

1) Cars
2) Small Cars
3) Pickups
4-31) Trucks in detail

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[1] Reno Regional Transportation Council, Conversations with Tom Brinkman, October 1984.
[2] Ibid.
[3] Nevada Department of Transportation, conversations with Dan Gross, October 1984.

These 31 vehicle types were reassigned into the eight vehicle classes used by the MOBILE models under the following assumptions:[4]

LDGV =	.97* (cars + small cars)
$LDGT_1$ =	.73* (pickups)
$LDGT_2$ =	.25* (pickups)
HDGT =	all 2-axle single unit dual tire trucks + all 2 axle buses
LDDV =	.02* (cars + small cars)
LDDT =	.02* (pickups)
HDDT =	all 3-axle single unit dual tire and larger trucks + all 3-axle buses
MC =	.01* (cars + small cars)

The factors for diesel percentage and light duty truck size were obtained from many methods, including parking lot surveys of parked vehicles and are updated periodically.[5]

The results (for 1978, with diesel updates) are summarized in the matrix below:[6]

Road Type / Vehicle Type	LDGV	LDGT 1	LDGT 2	HDGV	LDDV	LDDT	HDDV
Local	.846	.092	.031	.011	.017	.003	.000
Collector	.780	.133	.045	.017	.061	.004	.005
Minor Arterial	.778	.133	.045	.018	.016	.004	.006
Major Arterial	.779	.132	.044	.022	.016	.004	.012
Freeway	.704	.121	.040	.028	.014	.003	.090

Total VMT for each vehicle type was calculated for this report by multiplying the percentage of each vehicle type in each functional road classification by the total VMT for that functional classification and summarizing by vehicle type. This yields 1983 daily VMT by vehicle type as:

<u>1983 Daily VMT</u>

LDGV	2712561
$LDGT_1$	450847
$LDGT_2$	151134
HDGV	75849
LDDV	55173
LDDT	12875
HDDV	121542

[4,5] Ibid.
[6] Op Cit, Tom Brinkman

In order to convert these into 1981 annual estimates, growth rates for urban VMT for each vehicle class, as determined from the nationwide method are used.[7] These results are multiplied by 365 days/year and yield:

1981 Annual VMT

LDGV	1,010,411,300
$LDGT_1$	158,075,330
$LDGT_2$	57,354,634
HDGV	27,395,594
LDDV	12,747,560
LDDT	2,044,748
HDGV	40,957,548

Using the above estimates of 1981 annual VMT and MOBILE3 high altitude emission factors, the NOx emission inventory was calculated. The LDV and LDT estimates were then calculated simply by summing up their subcategories. These final results are presented in Table A-6.

[7] The nationwide method is described earlier in this Appendix.

Table A-6

1981 Annual Comparisons
Reno

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	1023.2	(78.2)	1057.8	(80.8)	887.9	(60.7)
LDT	217.5	(16.6)	180.7	(13.8)	429.7	(29.4)
HDGV	27.4	(2.1)	44.5	(3.4)	22.1	(1.5)
HDDV	41.0	(3.1)	26.2	(2.0)	123.3	(8.4)
Total	1309.1	(100.0)	1309.2	(100.0)	1463.0	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach**	
LDV	2.14	(54.2)	2.21	(61.0)	1.85	(29.4)
LDT	0.61	(15.4)	0.52	(14.4)	1.12	(17.8)
HDGV	0.13	(3.3)	0.21	(5.8)	0.11	(1.7)
HDDV	1.07	(27.1)	0.68	(18.8)	3.22	(51.1)
Total	3.95	(100.0)	3.62	(100.0)	6.30	(100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Seattle, Washington[1]

The estimates for total VMT and VMT breakdown by vehicle class for Seattle, Washington, were obtained from the Washington State Department of Transportation.

Total VMT for the two counties that make up the Seattle-Everett SMSA, King and Snohomish, are estimated using the Urban Transportation Planning System (U.T.P.S.) network modelling system. Some calibration is done with traffic counts.

The VMT breakdown by class was obtained from the State Energy Office, which was only able to provide a VMT breakdown for the entire state of Washington. The vehicle mix was determined from statewide vehicle registration and applying mileage accumulations by model year from AP-42 (March 1981). No visual counts were known to have been made. The figures that were provided are as follow:

1981 Calendar Year VMT by County:

King:	8,871,343,000
Snohomish:	2,080,452,000

Statewide Vehicle Mix:

Vehicle Type	VMT %	VMT (millions)
LDGV	72.9%	7983.9
$LDGT_1$	7.7%	843.3
$LDGT_2$	4.6%	503.8
HDGV	4.1%	460.0
LDDV	5.7%	624.3
LDDT	0.7%	76.7
HDDV	3.3%	361.4
MC	0.9%	98.6

The county VMTs were summed and the statewide vehicle mix was used to generate VMT by vehicle class. MOBILE3 emission factors were then applied to obtain NOx emissions. LDGV and LDDV were combined to form LDV, and the same was done with $LDGT_1$, $LDGT_2$, and LDDT to form LDT. MC VMT and emissions were redistributed to the other vehicle classes based upon VMT share. The final inventories are presented in Table A-7.

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[1] Phone conversations with Dave Kircher, Project Administrator, Puget Sound Air Pollution Administration, October 1984.

Table A-7

1981 Annual Comparison
Seattle

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	8613.5	(79.3)	8774.9	(80.8)	8412.6	(73.5)
LDT	1424.6	(13.1)	1498.7	(13.8)	2431.8	(21.3)
HDGV	460.3	(4.3)	369.2	(3.4)	117.9	(1.0)
HDDV	361.6	(3.3)	217.2	(2.0)	478.5	(4.2)
Total	10860.0	(100.0)	10860.0	(100.0)	11440.8	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach**	
LDV	24.87	(57.7)	26.21	(64.4)	25.13	(51.8)
LDT	5.68	(13.2)	6.23	(15.3)	10.11	(20.8)
HDGV	3.19	(7.4)	2.58	(6.3)	0.82	(1.7)
HDDV	9.36	(21.7)	5.67	(13.9)	12.50	(25.7)
Total	43.10	(100.0)	40.69	(99.9)	48.56	(100.0)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Tucson, Arizona

Estimates of daily VMT and vehicle mix for Tucson, Arizona were obtained from the Arizona DOT via the Pima County Association of Governments.[1] The data that was provided is as follows:

1981 Daily VMT: 10,156,000 miles

Vehicle Type	Freeways	Arterial
LDV	72.6	69.9
LDT	18.0	26.0
HDG	7.5	2.2
HDD	1.3	1.2
MC	0.6	0.6

In order to obtain a regional breakdown, the freeway and arterial breakdown were combined using a weighting factor of .31 for freeways and .69 for arterials, derived from data in the 1982-83 Statistical Abstract on nationwide urban VMT.[2] This regional breakdown was then used to determine 1981 daily VMT by vehicle class, and then multiplied by 365 to yield 1981 VMT.

	VMT %	1981 Daily (millions)	1981 Annual (millions)
LDV	70.9	7.201	2628.2
LDT	23.5	2.387	871.1
HDV	3.9	0.396	144.6
HDV	1.2	0.122	44.5
MC	0.6	0.061	22.2

These VMT values were then used to determine 1981 NOx emissions using MOBILE3 emission factors. The emissions and VMT by motorcycles were redistributed by VMT share. The final inventories are presented in Table A-8.

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[1] Pima County Association of Governments, conversation with Nick Buccholz, October, 1984.

[2] U.S. Department of Commerce, Bureau of the Census Statistical Abstract of the United States 1982-83.

Table A-8

1981 Annual Comparisons
Tucson

VMT, Millions (%)

	Localized Approach		Nationwide Approach*		NEDS Approach	
LDV	2643.0	(71.3)	2995.2	(80.8)	2547.0	(70.9)
LDT	874.8	(23.6)	511.6	(13.8)	870.0	(24.2)
HDGV	144.6	(3.9)	126.0	(3.4)	46.1	(1.3)
HDDV	44.5	(1.2)	74.1	(2.0)	131.0	(3.7)
Total	3706.9	(100.0)	3706.9	(100.0)	3594.1	(100.1)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach**	
LDV	7.86	(57.6)	8.95	(64.4)	7.61	(50.8)
LDT	3.62	(26.5)	2.13	(15.3)	3.62	(24.2)
HDGV	1.01	(7.4)	0.88	(6.3)	0.32	(2.2)
HDDV	1.16	(8.5)	1.94	(13.9)	3.42	(22.9)
Total	13.65	(100.0)	13.90	(99.9)	14.97	(100.1)

* Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Other Cities

For several of the cities, estimates of the VMT breakdown by vehicle class were unavailable. An estimate of total VMT for the SMSA was generally available, however. In order to estimate the mobile source NOx inventory for these cities, the local estimate of total VMT and the average VMT breakdown for the eight cities which did provide data were used. The resulting inventories are presented in Tables A-9 through A-12.

A summary of how the total VMT for each of these cities was obtained follows.

Boston

The estimates of total VMT for the Boston SMSA were obtained from the Central Planning Division of the Massachusetts DOT.[1] The 1981 value provided was 44,480,000/day, which corresponds to 16.2 billion miles per year.

Washington, DC

The estimates of total VMT for the Washington DC SMSA were obtained by county for the year 1980 from the Transportation Planning Board of the Washington Council of Governments (WASHCOG). One county, Charles County, MD, was not included, and the 1981 estimate from the NEDS area source report for this county was used.

The estimate for all of the counties from WASHCOG totalled 45,451,000 miles/day in 1980.[2] This was multiplied by 365 and then by a growth factor derived from the nationwide urban method to yield a 1981 annual estimate of 16.9 billion miles. Adding in the value from NEDS for Charles County,[3] this yielded a total of 1981 VMT of 17.6 billion for the Washington, D.C. SMSA.

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[1] Massachusetts Department of Transportation, Central Planning Division, conversation with Robert Siebert, October 1984.
[2] Washington Council of Governments, Transportation Planning Board, conversation with Ron Sarros, September 21, 1984.
[3] NEDS area source reports.

Table A-9

1981 Annual Comparisons
Boston

VMT, Millions (%)

	Localized Approach*		Nationwide Approach**		NEDS Approach	
LDV	13802.4	(85.2)	13089.6	(80.8)	14252.0	(84.4)
LDT	1522.8	(9.4)	2235.6	(13.8)	1705.5	(10.1)
HDGV	437.4	(2.7)	550.8	(3.4)	342.2	(2.0)
HDDV	437.4	(2.7)	324.0	(2.0)	585.3	(3.5)
Total	16200.0	(100.0)	16200.0	(100.0)	16885.0	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach***	
LDV	33.97	(66.5)	32.18	(64.4)	35.03	(63.2)
LDT	5.21	(10.2)	7.65	(15.3)	5.83	(10.5)
HDGV	2.52	(4.9)	3.17	(6.3)	1.97	(3.6)
HDDV	9.40	(18.4)	6.97	(13.9)	12.58	(22.7)
Total	51.10	(100.0)	49.97	(99.9)	55.41	(100.0)

* No local breakdown available; average local breakdown from other 8 cities applied to the VMT figure provided by locality.

** Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

*** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Table A-10

1981 Annual Comparisons
Washington, D.C.

VMT, Millions (%)

	Localized Approach*		Nationwide Approach**		NEDS Approach	
LDV	14897.2	(85.2)	14127.9	(80.8)	13002.9	(83.8)
LDT	1643.6	(9.4)	2412.9	(13.8)	1755.2	(11.3)
HDGV	472.1	(2.7)	594.5	(3.4)	306.2	(2.0)
HDDV	472.1	(2.7)	349.7	(2.0)	446.3	(2.9)
Total	17485.0	(100.0)	17485.0	(100.0)	15510.6	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach***	
LDV	36.67	(66.5)	34.73	(64.4)	31.96	(64.8)
LDT	5.62	(10.2)	8.25	(15.3)	6.00	(12.2)
HDGV	2.72	(4.9)	3.42	(6.3)	1.76	(3.6)
HDDV	10.15	(18.4)	7.52	(13.9)	9.59	(19.4)
Total	55.16	(100.0)	53.92	(99.9)	49.31	(100.0)

* No local breakdown available; average local breakdown from other 8 cities applied to VMT figure provided by locality.

** Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

*** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Denver, Colorado

The estimate of 25,900,000 miles per day (9.45 billion miles per year) for 1981 VMT for the Denver SMSA was obtained from the Colorado State Highway Department.[4] In the Denver area, approximately 25 traffic counters are used, and some seasonal adjustments are made in the estimates. The local (city streets) VMT is estimated.

Newark, NJ

The estimates of VMT for the Newark SMSA were obtained by county for the year 1980 from the New Jersey Department of Transportation.[5] The total for the four counties was 35.3 million miles per day, which translates into a 1980 annual total of 12.8 billion miles. This value was converted into a 1981 estimate using a growth rate determined from the nationwide urban method, resulting in a total VMT for 1981 of 13.1 billion miles.

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[4] Colorado State Highway Department, conversation with Dick Mango, October 3, 1984.

[5] New Jersey, DOT, Documentation of New Jersey Department of Transportation Methodology Used in Developing Emissions Inventories for Hydrocarbon, Carbon Monoxide, and Nitrogen Oxide for Mobile Sources, December 1981, p. 15.

Table A-11

1981 Annual Comparisons
Denver

VMT, Millions (%)

	Localized Approach*		Nationwide Approach**		NEDS Approach	
LDV	8054.8	(85.2)	7638.8	(80.8)	8488.6	(73.2)
LDT	888.7	(9.4)	1304.7	(13.8)	2410.5	(20.8)
HDGV	255.3	(2.7)	321.4	(3.4)	206.2	(1.8)
HDDV	255.3	(2.7)	189.1	(2.0)	483.9	(4.2)
Total	9454.0	(100.0)	9454.0	(100.0)	11589.2	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach***	
LDV	13.83	(61.7)	13.10	(60.9)	14.55	(46.2)
LDT	2.10	(9.4)	3.09	(14.4)	5.71	(18.2)
HDGV	1.00	(4.5)	1.25	(5.8)	0.80	(2.5)
HDDV	5.49	(24.5)	4.07	(18.9)	10.40	(33.1)
Total	22.42	(100.1)	21.51	(100.0)	31.46	(100.0)

* No local breakdown available; average local breakdown from other 8 cities applied to VMT figure provided by locality.

** Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

*** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

Table A-12

1981 Annual Comparisons
Newark

VMT, Millions (%)

	Localized Approach*		Nationwide Approach**		NEDS Approach	
LDV	10745.7	(85.2)	10190.8	(80.8)	10759.4	(85.3)
LDT	1185.6	(9.4)	1740.5	(13.8)	1180.4	(9.4)
HDGV	340.5	(2.7)	428.8	(3.4)	225.7	(1.8)
HDDV	340.5	(2.7)	252.2	(2.0)	446.9	(3.5)
Total	12612.3	(100.0)	12612.3	(100.0)	12612.4	(100.0)

NOx Emissions, 1000 Tons (%)

	Localized Approach		Nationwide Approach		NEDS Approach***	
LDV	26.44	(66.5)	25.05	(64.4)	26.45	(63.9)
LDT	4.05	(10.2)	5.95	(15.3)	4.04	(9.8)
HDGV	1.96	(4.9)	2.47	(6.3)	1.30	(3.1)
HDDV	7.32	(18.4)	5.42	(13.9)	9.61	(23.2)
Total	39.77	(100.0)	38.89	(99.9)	41.40	(100.0)

* No local breakdown available; average local breakdown from other 8 cities applied to the VMT figure provided by locality.

** Nationwide VMT calculated using local VMT total, and breakdown of urban VMT (by vehicle class) from the nationwide approach.

*** NEDS emissions inventory updated with MOBILE3 NOx emission factors (original NEDS based on MOBILE2.5).

MOBILE3 Emission Factors

- Calendar-year NOx emission factors for each individual vehicle class are presented in tables on the following two pages (low and high-altitude).
- These emission factors were calculated using EPA's MOBILE3 computer program, assuming six different emission control scenarios (described in tables).
- By multiplying the 1981 annual VMT figures for each vehicle class by these class-specific NOx emission factors (in grams per mile), base-year inventories can be calculated.
- Future inventories can be estimated by applying the appropriate emission factor ratios (future year over baseline) and the VMT growth rates (shown in an earlier section) to the 1981 NOx inventory calculated above.
- Shown below are vehicle mix figures from MOBILE3, which were used in combining some of the local data into the appropriate vehicle classes.

Vehicle Mix Figures

Vehicle Type	Default Vehicle Mix
LDGV	0.662
LDDV	0.008
$LDGT_1$	0.133
$LDGT_2$	0.088
LDDT	0.002
HDGV	0.040
HDDV	0.060
MC	0.007

TABLE 1

LOW ALTITUDE NOX EMISSION RESULTS FROM MOBILE3 ASSUMING THAT
AMBIENT TEMPERATURE = 75 F; COLD/HOT START = 20.6/27.3/20.6
VEHICLE SPEED = 19.6 MPH FOR LD & MC, 20.0 MPH FOR HD; MOBILE3 CALCULATED VMT MIX.

STRATEGY 1: 1.2 G/MI LDT1, 1.7 G/MI LDT2, 6.0/4.0 G/BHP-HR HDE

CY	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1981	2.73	3.29	4.50	6.36	1.45	1.94	23.70	0.62	4.34
1990	1.57	2.89	3.22	5.47	1.10	1.44	15.14	0.85	2.65
1995	1.43	2.46	2.77	4.48	1.03	1.38	9.82	0.85	2.12
2000	1.42	2.13	2.47	4.21	1.03	1.39	8.46	0.85	1.96

STRATEGY 2: 2.3 G/MI LDT, 6.0/4.0 G/BHP-HR HDE

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
2.73	3.29	4.50	6.36	1.45	1.94	23.70	0.62	4.34
1.57	3.18	3.39	5.47	1.10	1.63	15.14	0.85	2.70
1.43	3.09	3.17	4.48	1.03	1.65	9.82	0.85	2.23
1.42	2.98	3.00	4.21	1.03	1.68	8.46	0.85	2.10

STRATEGY 3: 2.3 G/MI LDT, CURRENT HDE EMISSION LEVELS

CY	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1981	2.73	3.29	4.50	6.36	1.45	1.94	23.70	0.62	4.34
1990	1.57	3.18	3.39	5.41	1.10	1.63	19.05	0.85	2.89
1995	1.43	3.09	3.17	5.33	1.03	1.65	19.21	0.85	2.69
2000	1.42	2.98	3.00	5.20	1.03	1.68	19.20	0.85	2.62

STRATEGY 4: 2.3 G/MI LDT, 10.7 G/BHP-HR HDE

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
2.73	3.29	4.50	6.36	1.45	1.94	23.70	0.62	4.34
1.57	3.18	3.39	5.41	1.10	1.63	20.68	0.85	2.97
1.43	3.09	3.17	5.33	1.03	1.65	21.74	0.85	2.81
1.42	2.98	3.00	5.20	1.03	1.68	21.93	0.85	2.74

STRATEGY 5: 1.2 G/MI LDT1, 1.7 G/MI LDT2, 6.0 G/BHP-HR HDE

CY	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1981	2.73	3.29	4.50	6.36	1.45	1.94	23.70	0.62	4.34
1990	1.57	2.89	3.22	5.47	1.10	1.44	15.14	0.85	2.65
1995	1.43	2.46	2.77	5.56	1.03	1.38	12.65	0.85	2.30
2000	1.42	2.13	2.47	5.52	1.03	1.39	11.94	0.85	2.17

STRATEGY 6: 2.3 G/MI LDT, 6.0 G/BHP-HR HDE

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
2.73	3.29	4.50	6.36	1.45	1.94	23.70	0.62	4.34
1.57	3.18	3.39	5.47	1.10	1.63	15.14	0.85	2.70
1.43	3.09	3.17	5.56	1.03	1.65	12.65	0.85	2.41
1.42	2.98	3.00	5.52	1.03	1.68	11.94	0.85	2.31

TABLE 2

HIGH ALTITUDE NOx EMISSION RESULTS FROM MOBILE3 ASSUMING THAT
AMBIENT TEMPERATURE = 75 F; COLD/HOT START = 20.6/27.3/20.6
VEHICLE SPEED = 19.6 MPH FOR LD & MC, 20.0 MPH FOR HD; MOBILE3 CALCULATED VMT MIX.

STRATEGY 1: 1.2 G/MI LDT1, 1.7 G/MI LDT2, 6.0/4.0 G/BHP-HR HDE

CY	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1981	1.90	2.36	3.00	4.33	1.45	1.90	23.70	0.41	3.45
1990	1.45	2.68	2.89	4.16	1.10	1.43	15.14	0.57	2.47
1995	1.42	2.39	2.68	3.67	1.03	1.38	9.82	0.57	2.07
2000	1.43	2.12	2.46	3.55	1.03	1.39	8.46	0.57	1.94

STRATEGY 2: 2.3 G/MI LDT, 6.0/4.0 G/BHP-HR HDE

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1.90	2.36	3.00	4.33	1.45	1.90	23.70	0.41	3.45
1.45	2.97	3.07	4.16	1.10	1.62	15.14	0.57	2.52
1.42	3.03	3.07	3.67	1.03	1.65	9.82	0.57	2.17
1.43	2.97	3.00	3.55	1.03	1.68	8.46	0.57	2.08

STRATEGY 3: 2.3 G/MI LDT, CURRENT HDE EMISSION LEVELS

CY	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1981	1.90	2.36	3.00	4.33	1.45	1.90	23.70	0.41	3.45
1990	1.45	2.97	3.07	3.75	1.10	1.62	19.05	0.57	2.69
1995	1.42	3.03	3.07	3.74	1.03	1.65	19.21	0.57	2.60
2000	1.43	2.97	3.00	3.67	1.03	1.68	19.20	0.57	2.56

STRATEGY 4: 2.3 G/MI LDT, 10.7 G/BHP-HR HDE

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1.90	2.36	3.00	4.33	1.45	1.90	23.70	0.41	3.45
1.45	2.97	3.07	3.75	1.10	1.62	20.68	0.57	2.77
1.42	3.03	3.07	3.74	1.03	1.65	21.74	0.57	2.72
1.43	2.97	3.00	3.67	1.03	1.68	21.93	0.57	2.68

STRATEGY 5: 1.2 G/MI LDT1, 1.7 G/MI LDT2, 6.0 G/BHP-HR HDE

CY	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1981	1.90	2.36	3.00	4.33	1.45	1.90	23.70	0.41	3.45
1990	1.45	2.68	2.89	4.16	1.10	1.43	15.14	0.57	2.47
1995	1.42	2.39	2.68	4.53	1.03	1.38	12.65	0.57	2.23
2000	1.43	2.12	2.46	4.58	1.03	1.39	11.94	0.57	2.13

STRATEGY 6: 2.3 G/MI LDT, 6.0 G/BHP-HR HDE

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
1.90	2.36	3.00	4.33	1.45	1.90	23.70	0.41	3.45
1.45	2.97	3.07	4.16	1.10	1.62	15.14	0.57	2.52
1.42	3.03	3.07	4.53	1.03	1.65	12.65	0.57	2.34
1.43	2.97	3.00	4.58	1.03	1.68	11.94	0.57	2.27