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16. Abstract

Air quality has been an issue of growing importance to the transportation sector since the enactment of the Clean Air Act Amendments of 1990 and the Transportation Equity Act for the 21st Century in 1998. According to these acts, states and local governments are required to attain and maintain National Ambient Air Quality Standards. The MOBILE model is the mobile emission factor model used in estimating air pollutants generated by mobile sources. In order to obtain accurate emission estimates, MOBILE must be provided with sound input data that accurately reflect local conditions. Among many input factors, vehicle miles traveled (VMT) fractions—the percentage of VMT for each vehicle type by roadway functional class—play a critical role.

In this study a new methodology for estimating locally specific VMT fractions as an input to the MOBILE model was developed. Based on this methodology, VMT fractions were computed for the six non-attainment areas in Virginia: Frederick County, Fredericksburg, Hampton Roads, Northern Virginia, Richmond, and Roanoke. These estimates were compared with fractions estimated using existing methodologies. The comparison revealed significant differences. These differences, coupled with the fact that the proposed methodology uses significantly more local data and requires fewer assumptions than existing methods, illustrate the need for the Virginia Department of Transportation (VDOT) to reconsider its approach to applying the MOBILE model.

Based on the results of this research effort, it is recommended that VDOT's Environmental Division use the proposed VMT fraction estimation methodology to generate input to the MOBILE model for mobile source emission estimates. This methodology will benefit VDOT by estimating mobile source emissions that better reflect local conditions. The cost of implementing the recommendation is minimal. Estimation of VMT fractions is a current activity, and the new methodology requires equivalent or less effort to the existing approach. In addition, required data for the proposed methodology can be obtained at no additional cost.

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FINAL CONTRACT REPORT

A METHODOLOGY TO ESTIMATE VEHICLE MILES TRAVELED (VMT) FRACTIONS AS AN INPUT TO THE MOBILE EMISSION MODEL

Brian L. Smith, Ph.D.
Associate Professor

Yi Qi, Ph.D.
Research Associate

Hyungjun Park
Graduate Research Assistant

Department of Civil Engineering
University of Virginia

Project Manager
Michael A. Perfater, Virginia Transportation Research Council

Contract Research Sponsored by
the Virginia Transportation Research Council

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ABSTRACT

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Brian L. Smith, Ph.D.
Associate Professor
Department of Civil Engineering
University of Virginia

Yi Qi, Ph.D.
Research Associate
Department of Civil Engineering
University of Virginia

Hyungjun Park
Graduate Research Assistant
Department of Civil Engineering
University of Virginia

INTRODUCTION

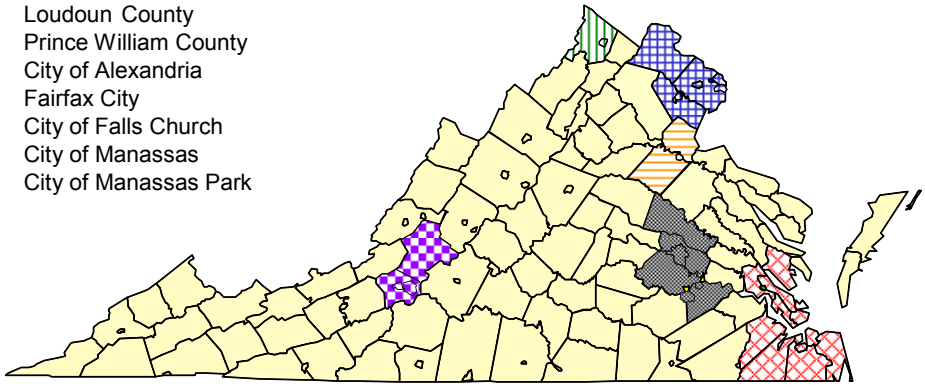
Mobile sources account for a significant portion of air pollutants. Therefore, in determining if a region satisfies National Ambient Air Quality Standards (NAAQS) set by the Environmental Protection Agency (EPA),[1] mobile source emissions must be estimated and taken into consideration. For this purpose the MOBILE vehicle emission factor model was developed. The EPA requires states and local governments outside of California to use MOBILE in developing the State Implementation Plan and transportation conformity determination. To provide accurate emission estimates, the MOBILE model requires significant input data, including fleet characteristics, environmental conditions, and vehicle activity.[2] Among the many input factors, vehicle miles traveled (VMT) fractions—the percentage of VMT for different types of vehicles by roadway functional class—play an important role.

A sensitivity analysis of MOBILE conducted by the Federal Highway Administration (FHWA) revealed two significant findings concerning input parameters.[3] First, three factors—roadway facility speed, VMT fractions by roadway functional class, and the fractions of VMT by vehicle type—exerted the greatest impact on estimated emissions. Second, by adjusting 14 parameters from the national default data provided by the EPA for use in MOBILE, significant changes in estimated emission rates were observed. Since the vehicle fleet composition varies by location, it is clear that the use of localized data rather than the EPA's national default data is critical. Based on this information, officials in the Virginia Department of Transportation's (VDOT) Environmental Division have sought to improve the quality of input data to MOBILE for Virginia applications.

PURPOSE AND SCOPE

The purpose of this research was to develop and demonstrate a methodology for VDOT to use in deriving locally specific VMT fractions based on readily available data sources.

The geographic scope of this study is limited to the six air quality non-attainment areas in Virginia—Frederick County, Fredericksburg, Hampton Roads, Northern Virginia (NOVA), Richmond, and Roanoke—as displayed in Figure 1.



Frederick County Nonattainment Area
Frederick County*
City of Winchester*

Fredericksburg Nonattainment Area
Spotsylvania County*
Stafford County
City of Fredericksburg*

Northern VA/MD Nonattainment Area
Arlington County
Fairfax County
Loudoun County
Prince William County
City of Alexandria
Fairfax City
City of Falls Church
City of Manassas
City of Manassas Park

Roanoke Nonattainment Area
Botetourt County
Roanoke County
City of Roanoke
City of Salem
Town of Vinton

Richmond Nonattainment Area
Charles City County*
Chesterfield County
Hanover County
Henrico County
City of Colonial Heights
City of Hopewell
City of Petersburg*
Prince George*
City of Richmond

Hampton Roads Nonattainment Area
James City County
York County
City of Chesapeake
City of Hampton
Gloucester County*
Isle of Wight County*
City of Newport News
City of Norfolk
City of Poquoson
City of Portsmouth
City of Suffolk
City of Virginia Beach
City of Williamsburg

* Denotes area which have never been designated for ozone nonatt ainment

Figure 1. Ozone Non-attainment Areas in Virginia[4]

METHODS

To meet the objectives of this research, the following tasks were completed. The activities of Tasks 2, 3, and 4 resulted in the creation of a new proposed methodology for estimating VMT fractions.

1. *Review the State of the Practice.* A review of VDOT's current practice in estimating VMT fractions was conducted. Then, the research team reviewed the two most widely used national methodologies for estimating VMT fractions. The first, described in the report *Use of Locality-Specific Transportation Data for the Development of MOBILE Source Emissions Inventories* prepared by Cambridge Systematics in 1996,[5] is referred to as the "CS method" in this report. The second method, presented in NCHRP Report 394, *Improving Transportation Data for Mobile Source Emission Estimates* in 1997,[6] is referred to as the "NCHRP394 method" in this report.

2. *Develop a Locally Specific Vehicle-Mapping Table*. VMT is generally reported in FHWA vehicle types. These types are based on vehicle-axle arrangement and the number of units in a vehicle (i.e., a tractor-trailer would be a two-unit vehicle). On the other hand, the vehicle classifications required by MOBILE5 are primarily based on the vehicle weight and fuel type. A complete description of FHWA vehicle types and MOBILE vehicle types is provided in Table 1 and Table 2, respectively. Given the differences evident in the tables, a vehicle-mapping table that converts the VMT fractions from FHWA types to MOBILE5 vehicle types is necessary. Although the EPA has recommended a vehicle-mapping approach using national default values, a regional vehicle-mapping table is desirable since vehicle fleet composition varies by location. In this task a methodology was developed to derive locally specific vehicle-mapping tables based on vehicle registration data from the Department of Motor Vehicles (DMV) and Vehicle Inventory and Use Survey (VIUS) data. Applying the methodology in Virginia and subsequently comparing the results with mapping tables generated using the CS method, NCHRP394 method, and EPA default values concluded the task.

3. *Obtain VMT Fractions of FHWA Vehicle Types by Roadway Functional Class Using Traffic Monitoring System (TMS) Data.* In order to apply the mapping table developed in Task 2, it is necessary to begin with VMT fractions by FHWA vehicle type. In this task data from the Traffic Monitoring System (TMS) maintained by VDOT's Traffic Engineering Division were used to derive the VMT for 13 FHWA vehicle types by roadway functional class for each non-attainment area. TMS is the system VDOT uses to store and provide access to traffic data collected at roughly 100,000 sites throughout the commonwealth.

4. *Estimate VMT fractions for MOBILE Vehicle Types by Roadway Functional Classes.* First, the VMT fractions for FHWA vehicle types obtained in Task 3 were converted to VMT fractions for MOBILE5 vehicle types based on the vehicle-mapping table developed in Task 2. At the conclusion of this task, the VMT fraction estimated using the new methodology was compared with the VMT fractions currently used by

VDOT for estimating the mobile source emissions in the six non-attainment areas (VDOT's 2002 *Traffic Trend Report*[7]). In addition, using the guidance provided in *User's Guide to MOBILE6.1 and MOBILE6.2—Mobile Source Emission Factor Model*, the VMT fractions computed for MOBILE5 vehicle types were converted to MOBILE6 types.[2]

Table 1. FHWA Vehicle Types[8]

Code	Description
1	**Motorcycles (Optional)**: All two- or three-wheeled motorized vehicles. Typical vehicles in this category have saddle-type seats and are steered by handlebars rather than a wheel. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheeled motorcycles. This vehicle type may be reported at the option of the state but should not be reported with any other vehicle type.
2	**Passenger Cars**: All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers. Vehicles registered as passenger cars that are pickups, panels, vans, etc. (described as vehicle type 3), should be reported as vehicle type 3.
3	**Other Two-Axle, Four-Tire, Single-Unit Vehicles**: All two-axle, four-tire vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, and carryalls. Other two-axle, four-tire, single-unit vehicles pulling recreational or other light trailers are included in this classification.
4	**Buses**: All vehicles manufactured as traditional passenger-carrying buses with two-axles, six-tires, and three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. All two-axle, four-tire minibuses should be classified as other two-axle, four-tire, single-unit vehicles (type 3). Modified buses should be considered as trucks and be appropriately classified.
5	**Two-Axle, Six-Tire, Single-Unit Trucks**: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels.
6	**Three-Axle, Single-Unit Trucks**: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.
7	**Four-or-More Axle, Single-Unit Trucks**: All vehicles on a single frame with four or more axles.
8	**Four-or-Less Axle, Single-Trailer Trucks**: All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power-unit.
9	**Five-Axle, Single-Trailer Trucks**: All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power-unit.
10	**Six-or-More Axle, Single-Trailer Trucks**: All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power-unit.
11	**Five-or-Less Axle, Multi-Trailer Trucks**: All vehicles with five or less axles consisting of three or more units, one of which is a tractor or straight truck power-unit.
12	**Six-Axle, Multi-Trailer Trucks**: All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power-unit.
13	**Seven-or-More Axle, Multi-Trailer Trucks**: All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power-unit.

Table 2. MOBILE5 Vehicle Type Prepared by the EPA[2]

Number	Abbreviation	Description
1	LDGV	Light-Duty Gasoline Vehicles (Passenger Cars)
2	LDDV	Light-Duty Diesel Vehicles (Passenger Cars)
3	LDGT1	Light-Duty Gasoline Trucks 1 (0 to 6000 lb GVW)
4	LDGT2	Light-Duty Gasoline Truck 2 (6000 to 8500 lb GVW)
5	LDDT	Light-Duty Diesel Truck (under 8500 lb GVW)
6	HDGV	Heavy-Duty Gasoline Vehicles (over 8500 lb GVW)
7	HDDV	Heavy-Duty Diesel Vehicles (over 8500 lb GVW)
8	MC	Motorcycles (All)

RESULTS

Task 1—Review of the State of the Practice

Two widely used methods, CS and NCHRP394, along with the current VDOT practice for VMT fraction estimation, were reviewed in this task. Although the CS method includes an entire procedure for VMT fraction estimation, the NCHRP394 method provides only a method for how to develop a vehicle classification-mapping table.

Current VDOT Practice

Current VDOT practice relies primarily on national default data provided in the Cambridge Systematics report.[7] In fact, VDOT's practice differs only in the treatment of FHWA vehicle types 2 and 3. VDOT's sensors cannot consistently distinguish between these types of vehicles, thus they have been combined by VDOT's Environmental Division. This results in the mapping presented in Table 3 (for comparison sake, the EPA and CS guidance is presented along with the VDOT classification approach). Note that the vehicle-mapping table currently used by VDOT is not Virginia specific because the fraction values in the table are either obtained directly from the updated guidance by CS or derived based on the default MOBILE VMT mix values.

Table 3. Currently Used Vehicle-Mapping Tables

	FHWA Vehicle Types	MOBILE5 Category EPA Guidance		CS Guidance		VDOT	
1	Motorcycles	100.00%	MC	100.00%	MC	100.00%	MC
2	Passenger Cars	98.64%	LDGV	98.64%	LDGV	52.22%	LDGV
		1.36%	LDDV	1.36%	LDDV	35.34%	LDDV
3	Other 2-Axle, 4-Tire Vehicles	65.71%	LDGT1	64.39%	LDGT1	12.15%	LDGT1
		33.47%	LDGT2	32.79%	LDGT2	0.09%	LDGT2
		0.82%	LDDT	2.82%	LDDT	0.19%	LDDT
4	Buses	10.28%	HDGV	10.28%	HDGV	10.28%	HDGV
		89.72%	HDDV	89.72%	HDDV	89.72%	HDDV
Single-Unit Trucks							
5	2-Axle, 6-Tire	87.90%	HDGV	95.32%	HDGV	95.32%	HDGV
		12.10%	HDDV	4.68%	HDDV	4.68%	HDDV
6	3-Axle	50.00%	HDGV	9.14%	HDGV	9.14%	HDGV
		50.00%	HDDV	90.86%	HDDV	90.86%	HDDV
7	4-or-More Axle	50.00%	HDGV	2.63%	HDGV	2.63%	HDGV
		50.00%	HDDV	97.37%	HDDV	97.37%	HDDV
Single-Trailer Trucks							
8	4-or-Fewer Axle	100.00%	HDDV	100.00%	HDDV	100.00%	HDDV
9	5-Axle	100.00%	HDDV	100.00%	HDDV	100.00%	HDDV
10	6-or-More Axle	100.00%	HDDV	100.00%	HDDV	100.00%	HDDV
Multi-Trailer Trucks							
11	5-or-Fewer Axle	100.00%	HDDV	100.00%	HDDV	100.00%	HDDV
12	6-Axle	100.00%	HDDV	100.00%	HDDV	100.00%	HDDV
13	7-or-More Axle	100.00%	HDDV	100.00%	HDDV	100.00%	HDDV

Cambridge Systematics Method (CS Method)

A distinguishing characteristic of the CS method is the use of VIUS data to develop mapping fractions from FHWA types 3, 5, 6, and 7 to MOBILE5 vehicle types. The U.S. Census Bureau conducts the Vehicle Inventory and Use Survey every 5 years as a part of the economic census.[10, 11] This survey is performed to provide national- and state-level estimates of the physical and operational characteristics of all trucks in the United States. A stratified random sampling method was adapted to select 136,000 trucks from 89 million private and commercial trucks registered nationwide in July 2002.

Beyond the use of the VIUS data, the CS method simply adapts EPA guidance fractions for the rest of the types (1, 2, 4, and 8–13). The CS method is summarized in Table 4.

Table 4. CS Method Summary

FHWA Category → MOBILE5A Category			Fractions	Data and information used
1	Motorcycles	MC	EPA suggested	
2	Passenger Cars	LDGV LDDV	EPA suggested	
3	Other 2-Axle, 4-Tire Vehicles	LDGT1 LDGT2 LDDT	Updated	○ VIUS: BODYTYPE and FUEL ○ EPA suggested fractions for LDGT1 and LDGT2
4	Buses	HDGV HDDV	EPA suggested	
Single-Unit Trucks				
5	2-Axle, 6-Tire	HDGV HDDV	Updated	○ VIUS: AXLE_CONFIG and FUEL
6	3-Axle	HDGV HDDV		
7	4-or-More Axle	HDGV HDDV		
Single-Trailer Trucks				
8	4-or-Fewer Axle	HDDV	100%	
9	5-Axle	HDDV	100%	
10	6-or-More Axle	HDDV	100%	
Multi-Trailer Trucks				
11	5-or-Fewer Axle	HDDV	100%	
12	6-Axle	HDDV	100%	
13	7-or-More Axle	HDDV	100%	

For mapping FHWA type 3, vehicles in this type are first identified from VIUS data according to the vehicle body-type information (BODYTYPE field in VIUS). Then, based on the fuel-type information (FUEL field in VIUS), the identified FHWA type 3 vehicles are classified into light-duty gasoline truck (LDGT) and light-duty diesel truck (LDDT) categories. Finally, the LDGT vehicles are distributed into LDGT1 and LDGT2 vehicle types by using the default fractions provided by EPA guidance.

For mapping FHWA types 5 through 7, the axle-configuration information (AXLE_CONFIG field in VIUS) is first used to identify these three types of vehicles. Then, fuel-

type information is used to classify vehicles into heavy-duty gasoline vehicle (HDGV) and heavy-duty diesel vehicle (HDDV) categories.

This vehicle-mapping method is easy to understand and simple to implement. However, some limitations are noted:

- The mapping for FHWA types 2 and 4 are adapted directly from EPA guidance. Thus, the mapping for these two types of vehicles is not locally specific.
- In developing the mapping for FHWA type 3, the default fractions for LDGT1 and LDGT2 provided by EPA guidance were used. Therefore, this mapping is not localized.
- The CS method exactly follows the mapping structure provided by EPA guidance. As a matter of fact, this mapping structure is based on a simplified assumption that all two-axle, four-tire, single-unit trucks (FHWA vehicle type 3) are light-duty trucks with gross weight of less than 8,500 pounds and all other trucks (FHWA vehicle types 5-13) are heavy-duty trucks with gross weight of greater than 8,500 pounds. However, according to the local vehicle registration data from the Virginia DMV used in the study, it was observed that this assumption is not reasonable. For example, local DMV registration data show that 27 percent of FHWA type 5 (two-axle, six-tire, single unit) trucks weigh between 6,000 and 8,500 pounds. Therefore, 27 percent of FHWA type 5 trucks should not be classified as HDGV or HDDV. However, CS method categorizes these trucks as HDGV or HDDV because of the simplified assumption.

NCHRP394 Method

NCHRP394 developed a vehicle-mapping table based on more data sources and expert opinion than the CS method. In the NCHRP394 vehicle-mapping table, the vehicle mappings for all trucks (FHWA type 3 and FHWA types 5-13) are updated using VIUS data. The vehicle conversion factors for passenger cars (FHWA type 2) were calculated according to the information in the *Transportation Energy Data Book,*[12] and the vehicle mapping for buses (FHWA type 4) was derived by using information including national transportation statistics, the *Transportation Energy Data Book*, transportation studies, and expert opinion. The resulting mapping guidance is presented in Table 5.

The most important feature of this mapping method is that it does not exactly follow the mapping structure suggested by the EPA guidance. As seen in Table 5, two-axle, four-tire, single-unit trucks (FHWA vehicle type 3) also can describe heavy-duty trucks, and a significant percentage of two-axle, six-tire, single-unit trucks (FHWA vehicle type 5) describe light-duty trucks. These results are consistent with the observations from Virginia DMV and VIUS data, two other data sources used for this study. To develop this kind of vehicle-mapping table, both vehicle fuel-type information (FUEL field in VIUS) and vehicle-weight information (VIUS_GVW field in VIUS) must be used. In addition, in order to identify different types of trucks, the axle-configuration information (AXLE_CONFIG field in VIUS) is required.

Table 5. Vehicle-Mapping Guidance Proposed in NCHRP394

FHWA Vehicle Type	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1. Motorcycles	100.00%							
2. Passenger Cars		98.80%	1.20%					
3. 2-Axle, 4-Tire Single Units				90.62%	3.99%	1.76%	2.99%	0.65%
4. Buses						20.09%		79.91%
5. 2-Axle, 6-Tire Single Units				10.69%	9.92%	50.36%	1.89%	27.14%
6. 3-Axle Single Units				0.71%	0.01%	14.44%	0.01%	84.83%
7. 4+- Axle Single Units				0.06%	0.45%	4.56%	0.36%	94.57%
8. 4-Axle Single Trailer				0.06%	0.02%	5.13%	0.01%	94.77%
9. 5-Axle Single Trailer				0.00%		1.01%	0.02%	98.97%
10. 6+-Axle Single Trailer				0.00%		0.95%		99.05%
11. 5-Axle Multi Trailer								100.00%
12. 6-Axle Multi Trailer								100.00%
13. 7+-Axle Multi Trailer								100.00%

Despite the advantages discussed, this vehicle-mapping method has the following limitations:

- In developing the mapping for FHWA type 2, national data are used. Thus, the developed vehicle-mapping result is not locally specific.
- The method for mapping FHWA type 4 is complicated and uses many different types of data, some of which are not readily available, such as expert opinions.
- In developing the mapping for FHWA type 3, about 93 percent of 2002 VIUS data for this type of vehicle do not provide good gross vehicle-weight information, thus NCHRP394 method is not desirable for this type of vehicle.

Task 2—Develop a Locally Specific Vehicle-Mapping Table

In this task a new methodology for developing a locally specific vehicle-mapping table was developed by modifying and extending the existing vehicle-mapping methods according to their strengths and limitations. First, using DMV vehicle registration data, vehicle mappings for FHWA types 2 through 4 were developed. Next, the NCHRP394 method was used to derive vehicle mappings for FHWA types 5 through 13 based on VIUS data.

In order to obtain descriptive vehicular information that best reflects local vehicle populations, the research team obtained registration data for all vehicles in the state of Virginia from the DMV. These data include a number of vehicle descriptors (see Table 6), including information that was useful to this project, such as vehicle type, vehicle body type, fuel type, and gross weight.

Since existing methods have limitations in mapping FHWA types 2 through 4 to MOBILE vehicle types, the new method proposes a preferred way of preparing the mappings for these types. In this proposed method, the DMV vehicle registration data serve as the foundation for developing the mapping from FHWA vehicle types 2 through 4 to MOBILE vehicle types, capitalizing on DMV information on vehicle type, vehicle body type, fuel type, and gross weight.

Table 6. Data Field Included in Vehicle Registration Data from DMV[9]

Fields	Comments
Vehicle Type (code)	To be used in classifying FHWA vehicle types
Vehicle Type (description)	
Vehicle Body Type	To be used in classifying FHWA vehicle types
Vehicle Body Type (description)	
Fuel Type (code)	To be used in distributing FHWA vehicle type to MOBILE5 type
Fuel Type (description)	
Gross Weight	To be used in distributing FHWA vehicle type to MOBILE5 type
Gross Weight Rating	
Title Number	
Vehicle Year	
Vehicle Make (description)	
Garaged Jurisdiction (code)	
Garaged Jurisdiction (description)	
Empty Weight	
Gross Combined Weight Rating	
VIN Number	

For FHWA types 5 through 13, the NCHRP394 method was used because the research team concluded that this method is more efficient than the CS method. The 2002 VIUS data contain suitable detailed information to support distinguishing these types of trucks, such as axle-arrangement information, fuel-type information, and vehicle-weight information.
The proposed vehicle-mapping method is summarized in Table 7, after which the method for developing a Virginia-specific mapping table is demonstrated. The section concludes with a comparison of the results using this proposed method with those using existing methods.

Table 7. Proposed Vehicle-Mapping Method Summary

FHWA Category → MOBILE Category			Fractions	Data and information used
1	Motorcycles	MC	EPA suggested	
2	Passenger Cars	LDGV LDDV	Updated	DMV Vehicle Registration Data: Vehicle Type, Vehicle Body Type, Fuel Type, Gross Weight
3	Other 2-Axle, 4-Tire Vehicles	LDGT1 LDGT2 LDDT HDGV HDDV		
4	Buses	HDGV HDDV		
Single-Unit Trucks				
5	2-Axle, 6-Tire	LDGT1 LDGT2 LDDT HDGV HDDV	Updated	VIUS: AXLE_CONFIG, FUEL, and VIUS_GVW
6	3-Axle			
7	4-or-More Axle			
Single-Trailer Trucks				
8	4-or-Fewer Axle			
9	5-Axle			
10	6-or-More Axle			
Multi-Trailer Trucks				
11	5-or-Fewer Axle			
12	6-Axle			
13	7-or-More Axle			

Method Demonstration—Virginia Vehicle-Mapping Table

A sample application of the methodology is described in two steps: developing mappings for FHWA vehicle types 2 through 4 and developing mappings for FHWA types 5 through 13.

Mappings for FHWA Vehicle Types 2 –4

The proposed new method for mapping FHWA vehicle types 2 through 4 uses statewide vehicle registration data obtained from the Virginia DMV—because they contain suitable information (i.e., vehicle type, vehicle body type, fuel type, gross weight) for distinguishing FHWA type 2 (passenger cars), type 3 (other 2-axle, 4-tire, single-unit vehicles), and type 4 (bus)—and maps them to MOBILE types. In addition, the DMV data can represent regional vehicle percentages for types 2, 3, and 4 because the average trip length of these types of vehicles encompassing all trip purposes is reported as 9.1 miles.[13] Therefore, FHWA type 2, 3, and 4 vehicles are usually considered to be short-trip makers, traveling mostly within the state.

Step 1— Obtain Vehicle Registration Data from DMV. In this step the research team acquired current vehicle registration data from the Virginia DMV and subsequently checked the quality to identify and correct erroneous data. For this purpose the data description table containing acceptable values for each field was obtained from the DMV and used to check if wrong values were included in the data. Note that 2004 DMV registration data—not 2002—were used in this research because 2004 data were the best data available at the time of the analysis. However, the use of VIUS and DMV data from the same year is recommended for future analyses.

Step 2— Select Vehicles Belonging to FHWA Types 2, 3, and 4. Vehicles belonging to FHWA types 2, 3, and 4 were identified from DMV data according to the vehicle-type and vehicle body-type information. The vehicle-type information served as the primary criterion for vehicle classification, and the vehicle body-type information was used as secondary criterion for refining vehicle classification. The vehicle classification results are presented in Table 8.

Table 8. Vehicle Classification Results from DMV Type to FHWA Type

DMV Vehicle Type				No. of Vehicles by FHWA Type			
Code	Description	No. of Vehicles	%	Type 2	Type 3	Type 4	N/A
PC	Pass Carry	5,696,188	70.69	4,655,554	1,040,627	-	7
LD	Light Duty	1,269,797	15.76	-	1,269,797	-	-
PN	Panel Truck	262	0.00	-	262	-	-
VN	Van	495,958	6.15	-	495,958	-	-
VT	Van Truck	38,704	0.48	-	38,704	-	-
BS	Bus	29,740	0.37	-	-	29,740	-
TK	Truck	262,825	3.26	-	306	-	262,519
MC	Motorcycle	218,533	2.71	-	-	-	218,533
LS	Low Speed	42	0.00	-	-	-	42
TR	Tractor	40,913	0.51	-	-	-	40,913
TW	Tow Truck	5,372	0.07	-	-	-	5,372
	Total	8,058,334	100.00	4,655,554	2,845,654	29,740	527,386

Step 3—Further Classify Selected Vehicles Based on Fuel Type and Gross Weight. In this step the vehicles classified as FHWA types 2, 3, and 4 in the previous step were further categorized based on the fuel-type and gross weight information in the DMV data. The classification results are presented in Table 9. Note that, although the use of gross weight rating (GWR, the total weight of the loaded vehicle, which includes the vehicle itself and the cargo that is loaded within that vehicle.) in this task is desirable, the research team used gross weight (calculated by the manufacturers as to be the amount of weight that the vehicle will be when the vehicle itself is weighed filled with gasoline and loaded according to manufacturer's specifications.) columns instead of GWR in this demonstration because most GWR data in the DMV data were zero.

Table 9. Vehicle Classification Using Gross Weight and Fuel Type

	Type 2		Type 3						Type 4	
Fuel Type	Count	%	< 6000lb	%	6001-8500	%	> 8500	%	Count	%
Diesel Subtotal	20,424	0.44	24,546	1.09	30,979	5.40	3,548	13.23	20,429	68.69
Diesel	20,379	0.44	24,497	1.09	30,968	5.40	3,547	13.23	20,429	68.69
Diesel or natural gas	7	0.00	12	0.00	5	0.00	1	0.00	-	0.00
Diesel or hydrogen	1	0.00	3	0.00	-	0.00	-	0.00	-	0.00
Diesel of hythane	2	0.00	2	0.00	1	0.00	-	0.00	-	0.00
Diesel or Liq. Nat. gas	19	0.00	8	0.00	3	0.00	-	0.00	-	0.00
Diesel or Petro. Gas	16	0.00	24	0.00	2	0.00	-	0.00	-	0.00
Gasoline Subtotal	4,635,130	99.56	2,220,537	98.91	542,784	94.60	23,260	86.77	9,311	31.31
Gas	4,582,375	98.43	2,210,421	98.46	541,114	94.31	23,202	86.55	9,246	31.09
Gas or natural gas	14,919	0.32	36,080	1.61	1,080	0.19	11	0.04	4	0.01
Gas or hydrogen	70	0.00	59	0.00	11	0.00	-	0.00	-	0.00
Gas or hythane	4	0.00	-	0.00	1	0.00	-	0.00	-	0.00
Gas or Liq. Nat. gas	5	0.00	4	0.00	-	0.00	-	0.00	2	0.01
Gas or Petro. Gas	9	0.00	26	0.00	9	0.00	-	0.00	-	0.00
Compressed Nat. gas	2,799	0.06	368	0.02	445	0.08	32	0.12	32	0.11
Electric	221	0.00	83	0.00	6	0.00	-	0.00	12	0.04
Ethane	171	0.00	120	0.01	17	0.00	2	0.01	2	0.01
Gas and elec. Combi	7,683	0.17	125	0.01	3	0.00	-	0.00	-	0.00
Hydrogen	75	0.00	22	0.00	14	0.00	1	0.00	1	0.00
Hythane	27	0.00	16	0.00	1	0.00	2	0.01	1	0.00
Liquified Nat. gas	7	0.00	8	0.00	1	0.00	-	0.00	-	0.00
Liquified Petro. Gas	17	0.00	28	0.00	19	0.00	5	0.02	-	0.00
Methane	8	0.00	4	0.00	-	0.00	-	0.00	-	0.00
Natural	61	0.00	103	0.00	56	0.01	1	0.00	10	0.03
Nonpower	5	0.00	14	0.00	4	0.00	4	0.01	-	0.00
Solar	16	0.00	13	0.00	3	0.00	-	0.00	1	0.00
Total	4,655,554	100	2,245,083	100	573,763	100	26,808	100	29,740	100

Step 4—Derive Vehicle Mappings for FHWA Types 2, 3, and 4. Based on the vehicle percentages in the shaded cells in Table 9, the final vehicle classification mappings from FHWA types 2, 3, and 4 to MOBILE5 vehicle types were derived and are presented in Table 10.

Table 10. Final Vehicle-Mapping Table for FHWA Type 2, 3, and 4

FHWA Vehicle Type	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
2. Passenger Cars		4,635,130 99.56%	20,424 0.44%					
3. 2-Axle, 4-Tire Single Units				2,220,537 78.03%	542,784 19.07%	23,260 0.82%	55,525 1.95%	3,548 0.12%
4. Buses						9,311 31.31%		20,429 68.69%

Step 5—Aggregate Fractions for FHWA Types 2 and 3. Based on communication with VDOT personnel, the research team concluded that most traffic count stations cannot correctly distinguish between FHWA type 2 (passenger car) and type 3 (pickups, panels, vans, etc.). Therefore, this step prepares another mapping result by combining type 2 and type 3 as presented in Table 11. Note that this mapping table was used for the remaining tasks.

Table 11. Final Vehicle-Mapping for Aggregated FHWA Types 2 and 3 and Type 4

FHWA Vehicle Type	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
2. Passenger Cars 3. 2-Axle, 4-Tire Single Units		4,635,130 61.79%	20,424 0.27%	2,220,537 29.60%	542,784 7.24%	23,260 0.31%	55,525 0.74%	3,548 0.05%
4. Buses						9,311 31.31%		20,429 68.69%

Mappings for FHWA Vehicle Types 5-13

VUIS data from 2002 were used for preparing the mappings for FHWA types 5 through 13. The following information in VIUS data was used: vehicle annual mileage (MILES_ANNL field in VIUS), fuel-type information (FUEL field in VIUS), axle-configuration information (AXLE_CONFIG field in VIUS), and gross vehicle-weight information (VIUS_GVW field in VIUS). The mappings were carried out in three steps.

Step 1—Categorize Vehicles into FHWA Types 5-13. Based on the Information of AXLE_CONFIG Field. First, the axle-configuration information in the AXLE_CONFIG field was used for classifying vehicles into FHWA types 5-13 as shown in Table 12.

Step 2—Categorize Vehicles into MOBILE Types Based on the Information of FUEL and VIUS_GVW Field. The fuel-type information in the FUEL field and the gross vehicle-weight information in the VIUS_GVW field were used to classify the vehicles into MOBILE types. Among 16 fuel types in VIUS data, five types (02 Diesel, 11 Diesel and natural gas, 12 Diesel and propane, 13 Diesel and alcohol fuels, and 14 Diesel and electricity) belong to the diesel category, and the remaining fuel types (01 Gasoline, 03 Natural gas, 04 Propane, 05 Alcohol fuels, 06 Electricity, 07 Gasoline and natural gas, 08 Gasoline and propane, 09 Gasoline and alcohol fuels, 10 Gasoline and electricity, 15 Not reported, and 16 Not applicable) belong to the gasoline category. The gross vehicle-weight information in the VIUS_GVW field in VIUS was used to further classify vehicles into heavy-duty (HD) and light-duty (LD1 and LD2) vehicle types, as illustrated in Table 13.

Table 12. AXLE_CONFIG Codes for Categorizing FHWA Types 5-13

FHWA Vehicle Type	AXLE_CONFIG codes in VIUS data
5. 2-Axle, 6-Tire Single Units	02 Straight 2
6. 3-Axle, Single Units	03 Straight 3
7. 4+-Axle, Single Units	04 Straight 4, 05 Straight 5
8. 3/4Axle Single Trailer	06 Straight 6, 07 Straight 7, 09 Straight 9, 10 Straight 10, 12 Straight 12, 21 Tractor 1, 22 Tractor 2, 24 Tractor 4, 25 Tractor 5, 27 Tractor 7
9. 5-Axle Single Trailer	08 Straight 8, 11 Straight 11, 13 Straight 13, 15 Straight 15, 23 Tractor 3, 26 Tractor 6, 28 Tractor 8, 30 Tractor 10
10. 6+-Axle Single Trailer	14 Straight 14, 16 Straight 16, 17 Straight 17, 18 Straight 18, 19 Straight 19, 20 Straight 20, 29 Tractor 9, 31 Tractor 11, 32 Tractor 12
11. 4/5-Axle Multi Trailer	33 Tractor 13, 37 Tractor 17
12. 6-Axle Multi Trailer	34 Tractor 14, 38 Tractor 18, 41 Tractor 21
13. 7+-Axle Multi Trailer	35 Tractor 15, 36 Tractor 16, 39 Tractor 19, 40 Tractor 20, 42 Tractor 22, 43 Tractor 23, 44 Tractor 24, 45 Tractor 25, 46 Tractor 26, 47 Tractor 27 48 Tractor 28, 49 Tractor 29, 50 Tractor 30, 51 Tractor 31, 52 Tractor 32, 53 Tractor 33, 54 Tractor 34, 55 Tractor 35, 56 Tractor 36, 57 Tractor 37, 58 Tractor 38, 59 Tractor 39, 60 Tractor 40, 61 Tractor 41, 62 Tractor 42, 63 Tractor 43, 64 Tractor 44

Table 13. Criteria for Mapping FHWA Types to MOBILE Types

Gross Weight / Fuel Type / FHWA Vehicle Type	0–6000 lb		6000–8500 lb		Over 8500 lb	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
5. 2-Axle, 6-Tire Single Units	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
6. 3-Axle Single Units	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
7. 4+-Axle Single Units	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
8. 3/4Axle Single Trailer	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
9. 5-Axle Single Trailer	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
10. 6+-Single Trailer	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
11. 4/5-Axle Multi Trailer	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
12. 6-Axle Multi Trailer	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV
13. 7+-Axle Multi Trailer	LDGT1	LDDT	LDGT2	LDDT	HDGV	HDDV

Step 3—Mapping FHWA Types 5-13 to MOBILE Types. To derive regional mapping fractions, only the vehicle annual mileage in Virginia (MILES_ANNL code 51 Virginia) was used. Finally, aggregating the vehicle annual mileage of the corresponding vehicle types in Virginia produced the Virginia specific vehicle-mapping table for FHWA types 5 to 13.

Comparison of Mapping Tables Generated by Alternative Methodologies

A complete vehicle-mapping table for Virginia developed by the proposed method is presented in Table 14, which also includes for comparison three Virginia vehicle-mapping tables developed from the NCHRP394 method, the CS method, and EPA national default values.

When comparing the mapping tables, the following key findings are evident:

- Significant differences between the mapping tables developed by the proposed method and the CS method were observed in FHWA type 5 and type 8. For type 5

Table 14. Vehicle-Mapping Tables

	FHWA Vehicle Type	MOBILE Vehicle Type							
		MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
Proposed Method	1. Motorcycles	100.00%							
	2. Passenger Cars &								
	3. 2-Axle, 4-Tire Single Units		61.79%	0.27%	29.60%	7.24%	0.31%	0.74%	0.05%
	4. Buses						31.31%		68.69%
	5. 2-Axle, 6-Tire Single Units				0.37%	26.98%	13.57%	7.55%	51.52%
	6. 3-Axle Single Units						0.95%		99.05%
	7. 4+-Axle Single Units						0.50%		99.50%
	8. 3/4Axle Single Trailer				2.22%	47.97%	2.00%		47.81%
	9. 5 Axle Single Trailer						0.00%		100.00%
	10. 6+ Single Trailer								100.00%
	11. 4/5 Axle Multi Trailer								100.00%
	12. 6 Axle Multi Trailer								100.00%
	13. 7+ Axle Multi Trailer								100.00%
NCHRP394 Method	1. Motorcycles	100.00%							
	2. Passenger Cars		98.80%	1.20%					
	3. 2-Axle, 4-Tire Single Units				76.41%	18.75%	3.18%	0.83%	0.82%
	4. Buses						20.09%		79.91%
	5. 2-Axle, 6-Tire Single Units				0.37%	26.98%	13.57%	7.55%	51.52%
	6. 3-Axle Single Units						0.95%		99.05%
	7. 4+-Axle Single Units						0.50%		99.50%
	8. 3/4-Axle Single Trailer				2.22%	47.97%	2.00%		47.81%
	9. 5-Axle Single Trailer						0.00%		100.00%
	10. 6+-Single Trailer								100.00%
	11. 4/5-Axle Multi Trailer								100.00%
	12. 6-Axle Multi Trailer								100.00%
	13. 7+-Axle Multi Trailer								100.00%
CS Method	1. Motorcycles	100.00%							
	2. Passenger Cars		98.64%	1.36%					
	3. 2-Axle, 4-Tire Single Units				63.40%	32.29%		4.31%	
	4. Buses						10.28%		89.72%
	5. 2-Axle, 6-Tire Single Units						40.92%		59.08%
	6. 3-Axle Single Units						0.95%		99.05%
	7. 4+-Axle Single Units						0.50%		99.50%
	8. 3/4-Axle Single Trailer								100.00%
	9. 5-Axle Single Trailer								100.00%
	10. 6+-Single Trailer								100.00%
	11. 4/5-Axle Multi Trailer								100.00%
	12. 6-Axle Multi Trailer								100.00%
	13. 7+-Axle Multi Trailer								100.00%
EPA Guidance	1. Motorcycles	100.00%							
	2. Passenger Cars		98.64%	1.36%					
	3. 2-Axle, 4-Tire Single Units				65.71%	33.47%		0.82%	
	4. Buses						10.28%		89.72%
	5. 2-Axle, 6-Tire Single Units						87.90%		12.10%
	6. 3-Axle Single Units						50.00%		50.00%
	7. 4+-Axle Single Units						50.00%		50.00%
	8. 3/4-Axle Single Trailer								100.00%
	9. 5-Axle Single Trailer								100.00%
	10. 6+-Single Trailer								100.00%
	11. 4/5-Axle Multi Trailer								100.00%
	12. 6-Axle Multi Trailer								100.00%
	13. 7+-Axle Multi Trailer								100.00%

the CS method identified only two categories being present: 40.92 percent for heavy-duty gasoline vehicle (HDGV) and 59.08 percent for heavy-duty diesel vehicle (HDDV). However, as seen in Table 14, the percentage of light-duty gasoline truck 2 (LDGT2) was calculated to be 26.98 percent by the proposed method. In addition, for FHWA type 8, the CS method maps all type 8 vehicles to HDDV; while the proposed method identified that 47.97 percent of type 8 vehicles are LDGT2.

- The EPA guidance approach produces results similar to the CS method. Moreover, a significant difference between EPA guidance and the proposed method was observed in FHWA type 6 and type 7. EPA guidance simply assumes vehicles in type 6 and type 7 are equally apportioned to HDGV (50 percent) and HDDV (50 percent). However, based on the VIUS data, the proposed method found that almost all vehicles in type 6 (99.05 percent) and type 7 (99.50 percent) belong to HDDV category.

Based on these results, it is clear that the mapping table developed using the proposed methodology is significantly different than the mapping tables developed using other methods. The suggested mapping table is a regionally "responsive" vehicle-mapping table because of the use of local data, that is, DMV data and VIUS data. By using this mapping table, it can be expected that more reliable and accurate estimates of local VMT fractions and mobile source emission would be derived.

Task 3—Obtain VMT Fractions of FHWA Vehicle Types

In this task, based on VMT data contained in the Traffic Monitoring System (TMS) maintained by VDOT's Traffic Engineering Division, the VMT fractions of 13 FHWA vehicle types by roadway functional classes were developed for the six non-attainment areas in Virginia. The VMT fractions of FHWA vehicle types were then converted into MOBILE vehicle types in Task 4.

The REPORTVMTDATAGRANULAR table in the TMS database was selected for use in this task. This table summarizes the VMT of sections in Virginia. Appropriate information included in this table is FHWA vehicle types, jurisdiction, and roadway functional classes. Therefore, total VMT by roadway functional classes and FHWA vehicle types for each non-attainment area can be easily obtained from this table. The obtained VMT data are presented in Tables 15 through 20.

Table 15. VMT by Functional Class and FHWA Type in Frederick County

Functional Class	FHWA Vehicle Type											
	1	2&3	4	5	6	7	8	9	10	11	12	13
1	1151	808000	7321	24379	7196	691	23001	185641	1292	11973	3051	2
2	1301	491404	2757	15494	3923	767	5710	38088	1728	396	179	3
6	3099	381303	2548	7122	7338	784	3406	16737	620	165	63	3
7	1462	347468	2500	6970	5289	783	2126	3076	413	32	10	113
8	183	64522	531	1486	1206	201	382	422	49	11	4	7
9	0	186767	0	0	0	0	0	0	0	0	0	0
11	4	2900	26	87	26	3	82	666	5	43	11	0
12	0	0	0	0	0	0	0	0	0	0	0	0
14	640	99098	660	1771	1071	120	392	499	82	27	23	73
16	420	86030	319	1583	767	79	366	607	45	20	1	20
17	554	114473	579	1989	999	110	351	337	81	6	2	22
19	0	81629	0	0	0	0	0	0	0	0	0	0
Total	8815	2663593	17241	60881	27816	3538	35815	246073	4314	12674	3344	242

Table 16. VMT by Functional Class and FHWA Type in Fredericksburg

Functional Class	FHWA Vehicle Type											
	1	2&3	4	5	6	7	8	9	10	11	12	13
1	7536	2308981	23649	56804	15956	1876	30997	337138	5678	10209	2708	17
2	3545	1408238	10157	38184	10803	3378	16383	112686	2408	3389	635	11
6	3548	835224	6144	19232	11938	4369	9071	30364	1332	616	84	42
7	4620	904601	6578	16357	10071	3144	4688	10216	683	119	25	30
8	474	79805	757	1384	565	57	481	691	52	1	0	0
9	17	542115	51	102	40	9	17	45	3	0	0	0
11	2131	582824	6918	13825	4545	444	8338	88735	1371	2816	821	4
12	14	16251	53	281	34	7	38	40	3	0	0	0
14	2247	602419	2984	7974	4303	846	3541	10816	713	38	1	56
16	724	208646	1006	2105	1269	432	801	1119	76	7	0	1
17	768	217167	864	1908	978	321	570	337	45	12	0	13
19	0	164303	0	0	0	0	0	0	0	0	0	0
Total	25624	7870575	59161	158156	60503	14883	74926	592188	12362	17208	4275	174

Table 17. VMT by Functional Class and FHWA Type in Hampton Roads

Functional Class	FHWA Vehicle Type											
	1	2&3	4	5	6	7	8	9	10	11	12	13
1	1131	634456	3123	10981	3227	657	3683	19509	450	416	57	1
2	866	327150	2194	7520	2862	273	5604	45370	663	831	302	2
6	216	237005	1533	3388	1802	534	1052	5068	279	2	5	15
7	194	170532	1363	2874	1538	344	906	1826	118	6	1	0
8	108	56569	894	1250	273	83	685	1648	32	3	0	0
9	3	157160	24	41	9	0	10	93	0	0	1	0
11	14576	9304782	41823	176659	67773	7795	60441	334538	6646	6058	1454	11
12	2803	1556831	6445	27940	12745	3940	9558	48465	1265	891	297	104
14	13274	5901304	28994	84828	30620	7244	24261	59102	3067	447	135	479
16	24300	7778285	38548	76422	43405	9138	22896	32438	2010	274	43	337
17	6789	2239856	13943	20441	9622	1700	4955	6960	319	108	38	81
19	956	4045020	972	2147	440	46	544	118	19	5	0	0
Total	65216	32408949	139854	414491	174316	31754	134595	555135	14866	9040	2333	1028

Table 18. VMT by Functional Class and FHWA Type in NOVA

Functional Class	FHWA Vehicle Type											
	1	2&3	4	5	6	7	8	9	10	11	12	13
1	6450	3115911	26664	68526	12497	4235	28739	269263	4088	7630	1970	3
2	3036	2011859	13061	46330	13566	4275	11068	57322	2193	1152	244	6
6	3481	1156481	8079	36456	9121	2736	8312	22920	1746	126	15	11
7	5246	1625870	14862	43316	20716	10392	10336	8164	1207	25	10	74
8	364	123964	989	3728	1461	284	705	355	85	2	0	1
9	146	719810	156	650	84	13	229	64	52	0	0	0
11	16793	10928900	72335	202423	45561	14134	59823	448001	8989	13227	3103	104
12	3551	2268848	13647	30864	7572	2271	5752	9818	905	140	2	91
14	15242	8372698	47941	117873	33928	14785	19856	34964	4058	340	41	777
16	17601	7936749	45455	74865	28418	6915	14912	15979	1160	185	42	193
17	4072	1919084	14740	18863	7650	1806	4129	2834	347	32	3	29
19	137	2790733	384	537	201	47	64	55	9	1	1	9
Total	76119	42970907	258312	644431	180774	61894	163925	869738	24840	22860	5432	1297

Table 19. VMT by Functional Class and FHWA Type in Richmond

Functional Class	FHWA Vehicle Type											
	1	2&3	4	5	6	7	8	9	10	11	12	13
1	3666	1338558	12745	23664	10818	1063	14437	162794	1903	5010	1205	15
2	467	387496	1379	6357	1835	196	1861	8796	156	702	89	0
6	873	385251	1548	4706	2330	393	1689	3950	220	9	3	1
7	1715	506038	3480	9989	4839	1138	3445	6152	418	19	30	9
8	367	97882	725	2647	448	111	883	389	15	3	0	0
9	17	314020	92	402	76	11	70	220	9	4	1	1
11	10520	6521190	45328	130434	41849	8582	67589	523941	8480	13202	4056	21
12	2649	1750654	7115	25477	8115	1724	7495	17738	622	1107	152	35
14	8500	4091749	18069	56899	24709	5531	15424	44751	1928	2220	311	400
16	9145	4127459	19835	40198	22224	3872	10822	17639	1145	225	42	202
17	2967	1555715	10026	16569	5625	828	4926	5060	255	388	38	76
19	92	2674253	844	516	272	24	378	621	3	16	0	0
Total	40978	23750263	121187	317857	123140	23474	129020	792051	15155	22903	5929	760

Table 20. VMT by Functional Class and FHWA Type in Roanoke

Functional Class	FHWA Vehicle Type											
	1	2&3	4	5	6	7	8	9	10	11	12	13
1	2034	657185	7967	20728	4988	623	20341	292657	3187	19625	5020	35
2	1129	487262	2810	12017	3814	400	5005	41375	459	1634	314	0
6	132	123161	291	573	336	43	113	113	0	0	0	0
7	929	259820	2054	2700	2536	756	823	2827	212	81	3	10
8	16	15633	166	155	152	17	34	335	29	0	0	0
9	15	132103	6	15	12	0	8	3	0	0	0	0
11	2495	1029389	8299	26971	7630	1019	18968	214395	3250	13600	3290	27
12	432	167959	1455	4650	1802	135	2686	21869	240	1693	396	0
14	2397	1233514	4887	22460	6817	2189	6211	28624	1013	961	167	117
16	1884	618664	1681	5587	2875	221	1618	2752	38	24	10	0
17	732	365910	1230	3083	3135	634	1105	1788	46	3	20	2
19	4	560342	16	35	16	32	7	2	2	0	0	0
Total	12198	5650943	30862	98974	34112	6069	56920	606740	8473	37620	9221	192

Task 4—Estimate VMT Fractions for MOBILE Vehicle Types by Roadway Functional Class

In this task the VMT fractions for MOBILE vehicle types by roadway functional class were derived for each non-attainment area. To begin, the VMT fractions of FHWA vehicle types derived in Task 3 were converted to the VMT fractions for MOBILE5 vehicle types based on the vehicle-mapping table prepared in Task 2. The VMT fractions estimated using the new methodology were then compared with the volume fractions currently used by VDOT for estimating the mobile source emissions in the six non-attainment areas. In addition, MOBILE6 VMT fractions were estimated based on MOBILE5 VMT fractions using the guidance provided in *User's Guide to MOBILE6.1 and MOBILE6.2 – Mobile Source Emission Factor Model*.

VMT Fractions for MOBILE5 Vehicle Type

Using VMT tables of FHWA types for each non-attainment area as described in Task 3 and the Virginia specific vehicle-mapping table between FHWA types and MOBILE5 types obtained in Task 2, the VMT fractions for MOBILE5 vehicle types for each non-attainment area can be estimated. The VMT fractions for each non-attainment area are presented in Tables 21–26.

Table 21. MOBILE5 VMT Fractions for Frederick County

Functional Class	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	0.11%	46.50%	0.20%	22.33%	7.09%	0.80%	0.73%	22.24%
2	0.23%	54.05%	0.24%	25.93%	7.56%	0.83%	0.86%	10.30%
6	0.73%	55.68%	0.25%	26.70%	7.36%	0.73%	0.79%	7.77%
7	0.39%	57.99%	0.26%	27.80%	7.57%	0.78%	0.84%	4.36%
8	0.26%	57.78%	0.25%	27.70%	7.61%	0.85%	0.85%	4.68%
9	0.00%	61.79%	0.27%	29.60%	7.24%	0.31%	0.74%	0.05%
11	0.11%	46.53%	0.21%	22.34%	7.07%	0.80%	0.73%	22.22%
12	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14	0.61%	58.62%	0.26%	28.10%	7.50%	0.74%	0.83%	3.34%
16	0.47%	58.90%	0.26%	28.23%	7.56%	0.66%	0.84%	3.08%
17	0.46%	59.19%	0.26%	28.37%	7.52%	0.69%	0.83%	2.67%
19	0.00%	61.79%	0.27%	29.60%	7.24%	0.31%	0.74%	0.05%
Whole area	0.29%	53.36%	0.24%	25.60%	7.34%	0.74%	0.79%	11.65%

Table 22. MOBILE5 VMT Fractions for Fredericksburg

Functional Class	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	0.27%	50.93%	0.22%	24.43%	7.04%	0.82%	0.76%	15.52%
2	0.22%	54.05%	0.24%	25.93%	7.46%	0.82%	0.83%	10.46%
6	0.38%	55.98%	0.25%	26.85%	7.59%	0.81%	0.83%	7.32%
7	0.48%	58.16%	0.26%	27.88%	7.50%	0.76%	0.83%	4.14%
8	0.56%	58.52%	0.26%	28.05%	7.57%	0.82%	0.83%	3.39%
9	0.00%	61.76%	0.27%	29.59%	7.24%	0.32%	0.74%	0.08%
11	0.30%	50.53%	0.22%	24.24%	7.00%	0.85%	0.75%	16.11%
12	0.08%	60.05%	0.26%	28.78%	7.60%	0.64%	0.85%	1.74%
14	0.35%	58.53%	0.26%	28.06%	7.46%	0.63%	0.80%	3.91%
16	0.33%	59.64%	0.26%	28.58%	7.42%	0.59%	0.79%	2.38%
17	0.34%	60.18%	0.27%	28.84%	7.40%	0.55%	0.79%	1.64%
19	0.00%	61.79%	0.27%	29.60%	7.24%	0.31%	0.74%	0.05%
Whole area	0.29%	54.71%	0.24%	26.23%	7.29%	0.75%	0.79%	9.70%

Table 23. MOBILE5 VMT Fractions for Hampton Roads

Functional Class	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	0.17%	57.85%	0.25%	27.73%	7.47%	0.67%	0.82%	5.04%
2	0.22%	51.35%	0.23%	24.64%	7.21%	0.73%	0.76%	14.86%
6	0.09%	58.37%	0.26%	27.98%	7.40%	0.68%	0.80%	4.42%
7	0.11%	58.64%	0.26%	28.11%	7.54%	0.77%	0.82%	3.75%
8	0.17%	56.80%	0.25%	27.24%	7.73%	1.04%	0.83%	5.93%
9	0.00%	61.72%	0.27%	29.57%	7.24%	0.32%	0.74%	0.14%
11	0.15%	57.37%	0.25%	27.50%	7.48%	0.68%	0.82%	5.75%
12	0.17%	57.56%	0.25%	27.59%	7.47%	0.66%	0.82%	5.49%
14	0.22%	59.26%	0.26%	28.40%	7.50%	0.65%	0.81%	2.91%
16	0.30%	59.87%	0.26%	28.69%	7.40%	0.59%	0.79%	2.09%
17	0.29%	60.05%	0.26%	28.78%	7.37%	0.62%	0.79%	1.83%
19	0.02%	61.71%	0.27%	29.56%	7.25%	0.32%	0.74%	0.11%
Whole area	0.19%	58.98%	0.26%	28.27%	7.43%	0.60%	0.80%	3.46%

Table 24. MOBILE5 VMT Fractions for NOVA

Functional Class	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	0.18%	54.30%	0.24%	26.04%	7.27%	0.79%	0.80%	10.39%
2	0.14%	57.44%	0.25%	27.54%	7.55%	0.78%	0.85%	5.44%
6	0.28%	57.19%	0.25%	27.42%	7.80%	0.91%	0.91%	5.24%
7	0.30%	57.73%	0.25%	27.68%	7.72%	0.92%	0.88%	4.52%
8	0.28%	58.06%	0.26%	27.84%	7.82%	0.93%	0.91%	3.92%
9	0.02%	61.67%	0.27%	29.55%	7.26%	0.33%	0.75%	0.15%
11	0.14%	57.17%	0.25%	27.40%	7.40%	0.73%	0.81%	6.10%
12	0.15%	59.82%	0.26%	28.67%	7.48%	0.67%	0.82%	2.13%
14	0.18%	59.72%	0.26%	28.62%	7.47%	0.67%	0.82%	2.26%
16	0.22%	60.23%	0.27%	28.86%	7.39%	0.61%	0.79%	1.64%
17	0.21%	60.09%	0.26%	28.79%	7.39%	0.67%	0.79%	1.79%
19	0.00%	61.76%	0.27%	29.59%	7.24%	0.32%	0.74%	0.08%
Whole area	0.17%	58.64%	0.26%	28.11%	7.42%	0.68%	0.81%	3.92%

Table 25. MOBILE5 VMT Fractions for Richmond

Functional Class	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	0.23%	52.49%	0.23%	25.17%	6.99%	0.75%	0.74%	13.40%
2	0.11%	58.50%	0.26%	28.04%	7.49%	0.62%	0.82%	4.17%
6	0.22%	59.37%	0.26%	28.46%	7.47%	0.59%	0.80%	2.83%
7	0.32%	58.20%	0.26%	27.90%	7.62%	0.77%	0.84%	4.09%
8	0.35%	58.45%	0.26%	28.03%	7.94%	0.88%	0.89%	3.18%
9	0.01%	61.61%	0.27%	29.52%	7.26%	0.34%	0.75%	0.25%
11	0.14%	54.64%	0.24%	26.20%	7.31%	0.73%	0.79%	9.94%
12	0.15%	59.34%	0.26%	28.44%	7.52%	0.62%	0.82%	2.84%
14	0.20%	59.21%	0.26%	28.38%	7.47%	0.62%	0.81%	3.06%
16	0.22%	59.97%	0.26%	28.74%	7.40%	0.59%	0.79%	2.04%
17	0.19%	59.99%	0.26%	28.75%	7.45%	0.65%	0.80%	1.92%
19	0.00%	61.73%	0.27%	29.57%	7.24%	0.32%	0.74%	0.12%
Whole area	0.16%	57.91%	0.26%	27.76%	7.36%	0.63%	0.79%	5.14%

Table 26. MOBILE5 VMT Fractions for Roanoke

Functional Class	MOBILE5 Vehicle Type							
	MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	0.20%	39.26%	0.17%	18.86%	6.08%	0.76%	0.62%	34.06%
2	0.20%	54.13%	0.24%	25.96%	7.35%	0.75%	0.81%	10.55%
6	0.11%	61.00%	0.27%	29.23%	7.31%	0.45%	0.77%	0.88%
7	0.34%	58.86%	0.26%	28.21%	7.30%	0.68%	0.78%	3.56%
8	0.10%	58.42%	0.26%	27.99%	7.19%	0.75%	0.77%	4.52%
9	0.01%	61.76%	0.27%	29.59%	7.24%	0.31%	0.74%	0.07%
11	0.19%	47.85%	0.21%	22.96%	6.84%	0.75%	0.73%	20.48%
12	0.21%	51.05%	0.22%	24.49%	7.23%	0.83%	0.78%	15.19%
14	0.18%	58.21%	0.26%	27.90%	7.51%	0.66%	0.83%	4.45%
16	0.30%	60.17%	0.27%	28.83%	7.41%	0.51%	0.79%	1.73%
17	0.19%	59.87%	0.26%	28.69%	7.37%	0.53%	0.78%	2.31%
19	0.00%	61.78%	0.27%	29.60%	7.24%	0.31%	0.74%	0.06%
Whole area	0.19%	53.29%	0.23%	25.56%	7.06%	0.64%	0.75%	12.27%

Comparison with Traffic Trend Report

The VMT fractions developed in this study were compared with the volume fractions in VDOT's 2002 *Traffic Trend Report;*[7] the latter are currently used by VDOT for estimating mobile source emissions.

The key distinction between the methodology proposed in this report and the *Traffic Trend Report* is that the latter uses vehicle volume fractions as the surrogate measure of VMT fractions. There were significant differences between the results from the proposed methodology and the *Traffic Trend Report*.

For all six non-attainment areas the VMT fractions derived from the proposed methodology have a higher percentage for light-duty gasoline vehicle (LDGV, between 53.29 and 58.98 percent) and heavy-duty diesel vehicle (HDDV, between 3.46 and 12.27 percent) compared to those in the *Traffic Trend Report* (LDGV, between 47.83 and 49.89 percent, and HDDV, between 2.50 and 6.00 percent). On the other hand, in case of light-duty gasoline truck (LDGT1and LDGT2), the percentages developed by the proposed methodology are much lower than the percentages in the *Traffic Trend Report* (see Table 27).

Table 27. Estimated VMT Fractions and Volume Fractions in Traffic Trend Report

Area		MOBILE Vehicle Type							
		MC	LDGV	LDDV	LDGT1	LDGT2	HDGV	LDDT	HDDV
Frederick Co	Proposed	0.29%	53.36%	0.24%	25.60%	7.34%	0.74%	0.79%	11.65%
	TTR	0.56%	47.86%	0.08%	32.39%	11.14%	2.04%	0.17%	5.76%
Fredericksburg	Proposed	0.29%	54.71%	0.24%	26.23%	7.29%	0.75%	0.79%	9.70%
	TTR	0.57%	48.19%	0.08%	32.61%	11.21%	1.88%	0.18%	5.28%
Hampton Roads	Proposed	0.19%	58.98%	0.26%	28.27%	7.43%	0.60%	0.80%	3.46%
	TTR	0.38%	49.67%	0.09%	33.61%	11.56%	1.68%	0.18%	2.84%
Northern Virginia	Proposed	0.17%	58.64%	0.26%	28.11%	7.42%	0.68%	0.81%	3.92%
	TTR	0.28%	49.89%	0.09%	33.76%	11.61%	1.71%	0.18%	2.50%
Richmond	Proposed	0.16%	57.91%	0.26%	27.76%	7.36%	0.63%	0.79%	5.14%
	TTR	0.29%	49.21%	0.08%	33.30%	11.45%	1.80%	0.18%	3.68%
Roanoke	Proposed	0.19%	53.29%	0.23%	25.56%	7.06%	0.64%	0.75%	12.27%
	TTR	0.34%	47.83%	0.08%	32.37%	11.13%	2.07%	0.17%	6.00%

These differences in VMT fractions will influence emission estimates. As seen from the sensitivity analysis of MOBILE6,[3] the emissions of pollutants including volatile organic compounds (VOC), nitrogen oxides (NOx), and carbon monoxide (CO) are very sensitive to VMT fractions. Roughly, reallocating 1 percent of VMT fraction from light-duty truck 4 (LDT4) to heavy-duty gasoline vehicle 2B (HDV2B) resulted in 0.01gram/mile reduction in VOC, 0.025 gram/mile increase in NOx, and 0.2 gram/mile reduction in CO. Considering these emissions are multiplied by VMT, generally in the millions, the changes in pollutants are significant.

VMT Fractions for MOBILE6 Vehicle Type

The methodology proposed in this study is intended to estimate VMT fractions for MOBILE5 vehicle types; currently available data sources do not provide the details necessary to develop MOBILE6 VMT fractions. Yet, given that the EPA now recommends the use of MOBILE6, this section provides a brief instruction on converting MOBILE5 VMT fractions to MOBILE6 VMT fractions based on the guidance provided in *User's Guide to MOBILE6.1 and MOBILE6.2 –Mobile Source Emission Factor Model.*[2]

The first step in converting the VMT of MOBILE5 vehicle types to the VMT of MOBILE6 vehicle types entails aggregating the fractions into five vehicle groups:

1. LDV Group = LDGV + LDDV
2. LDT Group 1 = LDGT1 + LDDT
3. LDT Group 2 = LDGT2
4. HDV Group = HDGV + HDDV
5. MC Group = MC

Next, the fractions of the five groups are apportioned to each of 16 MOBILE6 vehicle types based on the calculation method presented in Table 28. Coefficients (A–N) are the vehicle class adjustment factors for the appropriate calendar year prepared in Appendix D of the MOBILE6 manual. Following the procedure outlined, the MOBILE6 VMT fractions for six non-attainment areas were obtained and presented in Tables 29 through 34.

Table 28. MOBILE6 VMT Fraction Calculation[2]

16 Combined MOBILE6 Vehicle Classes	VMT Fraction Calculation
LDV	LDV Group
LDT1	LDT Group 1 * A
LDT2	LDT Group 1 * B
LDT3	LDT Group 2 * C
LDT4	LDT Group 2 * D
HDV2b	HDV Group * E
HDV3	HDV Group * F
HDV4	HDV Group * G
HDV5	HDV Group * H
HDV6	HDV Group * I
HDV7	HDV Group * J
HDV8a	HDV Group * K
HDV8B	HDV Group * L
HDBS	HDV Group * M
HDBT	HDV Group * N
MC	MC Group

Table 29. MOBILE6 VMT Fractions for Frederick County (Unit: %)

Functional Class	MOBILE6 Vehicle Type															
	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
1	46.71	5.33	17.73	4.85	2.23	7.45	0.74	0.58	0.44	1.63	1.94	2.13	7.58	0.38	0.17	0.11
2	54.29	6.19	20.60	5.18	2.38	3.60	0.36	0.28	0.21	0.79	0.94	1.03	3.66	0.18	0.08	0.23
6	55.92	6.35	21.14	5.04	2.32	2.75	0.27	0.21	0.16	0.60	0.72	0.79	2.80	0.14	0.06	0.73
7	58.25	6.62	22.02	5.19	2.39	1.66	0.17	0.13	0.10	0.36	0.43	0.48	1.69	0.08	0.04	0.39
8	58.03	6.60	21.96	5.21	2.40	1.79	0.18	0.14	0.10	0.39	0.47	0.51	1.82	0.09	0.04	0.26
9	62.06	7.01	23.33	4.96	2.28	0.12	0.01	0.01	0.01	0.03	0.03	0.03	0.12	0.01	0.00	0.00
11	46.73	5.33	17.74	4.84	2.23	7.45	0.74	0.58	0.44	1.63	1.94	2.13	7.58	0.38	0.17	0.11
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	58.88	6.68	22.25	5.14	2.36	1.32	0.13	0.10	0.08	0.29	0.34	0.38	1.34	0.07	0.03	0.61
16	59.16	6.71	22.35	5.18	2.38	1.21	0.12	0.09	0.07	0.27	0.32	0.35	1.23	0.06	0.03	0.47
17	59.45	6.75	22.46	5.15	2.37	1.09	0.11	0.08	0.06	0.24	0.28	0.31	1.11	0.05	0.03	0.46
19	62.06	7.01	23.33	4.96	2.28	0.12	0.01	0.01	0.01	0.03	0.03	0.03	0.12	0.01	0.00	0.00
Whole area	53.60	6.10	20.29	5.03	2.31	4.01	0.40	0.31	0.23	0.88	1.04	1.15	4.08	0.20	0.09	0.29

Table 30. MOBILE6 VMT Fractions for Fredericksburg (Unit: %)

Functional Class	MOBILE6 Vehicle Type															
	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
1	51.15	5.82	19.37	4.82	2.22	5.29	0.52	0.41	0.31	1.16	1.38	1.51	5.38	0.27	0.12	0.27
2	54.29	6.18	20.57	5.11	2.35	3.65	0.36	0.28	0.21	0.80	0.95	1.04	3.71	0.18	0.08	0.22
6	56.22	6.39	21.28	5.20	2.39	2.63	0.26	0.20	0.15	0.58	0.68	0.75	2.67	0.13	0.06	0.38
7	58.41	6.63	22.07	5.14	2.36	1.58	0.16	0.12	0.09	0.35	0.41	0.45	1.61	0.08	0.04	0.48
8	58.78	6.67	22.21	5.19	2.38	1.36	0.14	0.11	0.08	0.30	0.35	0.39	1.39	0.07	0.03	0.56
9	62.03	7.01	23.32	4.96	2.28	0.13	0.01	0.01	0.01	0.03	0.03	0.04	0.13	0.01	0.00	0.00
11	50.75	5.77	19.22	4.80	2.21	5.49	0.54	0.42	0.32	1.20	1.43	1.57	5.58	0.28	0.13	0.30
12	60.32	6.84	22.78	5.20	2.39	0.77	0.08	0.06	0.04	0.17	0.20	0.22	0.78	0.04	0.02	0.08
14	58.79	6.67	22.19	5.11	2.35	1.47	0.15	0.11	0.09	0.32	0.38	0.42	1.49	0.07	0.03	0.35
16	59.90	6.78	22.59	5.09	2.34	0.96	0.10	0.07	0.06	0.21	0.25	0.27	0.98	0.05	0.02	0.33
17	60.44	6.84	22.78	5.07	2.33	0.71	0.07	0.05	0.04	0.15	0.18	0.20	0.72	0.04	0.02	0.34
19	62.06	7.01	23.33	4.96	2.28	0.12	0.01	0.01	0.01	0.03	0.03	0.03	0.12	0.01	0.00	0.00
Whole area	54.95	6.24	20.78	4.99	2.30	3.38	0.34	0.26	0.20	0.74	0.88	0.97	3.44	0.17	0.08	0.29

Table 31. MOBILE6 VMT Fractions for Hampton Roads (Unit: %)

Functional Class	MOBILE6 Vehicle Type															
	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
1	58.10	6.59	21.95	5.12	2.35	1.85	0.18	0.14	0.11	0.40	0.48	0.53	1.88	0.09	0.04	0.17
2	51.58	5.87	19.53	4.94	2.27	5.04	0.50	0.39	0.29	1.11	1.31	1.44	5.13	0.25	0.12	0.22
6	58.63	6.65	22.13	5.07	2.33	1.65	0.16	0.13	0.10	0.36	0.43	0.47	1.68	0.08	0.04	0.09
7	58.90	6.68	22.25	5.16	2.38	1.46	0.15	0.11	0.09	0.32	0.38	0.42	1.49	0.07	0.03	0.11
8	57.05	6.49	21.59	5.30	2.44	2.25	0.22	0.17	0.13	0.49	0.59	0.64	2.29	0.11	0.05	0.17
9	61.99	7.00	23.31	4.96	2.28	0.15	0.01	0.01	0.01	0.03	0.04	0.04	0.15	0.01	0.00	0.00
11	57.62	6.54	21.78	5.13	2.36	2.08	0.21	0.16	0.12	0.46	0.54	0.59	2.12	0.10	0.05	0.15
12	57.81	6.56	21.85	5.11	2.35	1.99	0.20	0.15	0.12	0.44	0.52	0.57	2.02	0.10	0.05	0.17
14	59.52	6.75	22.47	5.14	2.36	1.15	0.11	0.09	0.07	0.25	0.30	0.33	1.17	0.06	0.03	0.22
16	60.13	6.81	22.67	5.07	2.33	0.87	0.09	0.07	0.05	0.19	0.23	0.25	0.88	0.04	0.02	0.30
17	60.31	6.83	22.73	5.05	2.32	0.79	0.08	0.06	0.05	0.17	0.21	0.23	0.81	0.04	0.02	0.29
19	61.98	7.00	23.31	4.96	2.28	0.14	0.01	0.01	0.01	0.03	0.04	0.04	0.14	0.01	0.00	0.02
Whole area	59.24	6.72	22.35	5.09	2.34	1.32	0.13	0.10	0.08	0.29	0.34	0.38	1.34	0.07	0.03	0.19

Table 32. MOBILE6 VMT Fractions for NOVA (Unit: %)

Functional Class	MOBILE6 Vehicle Type															
	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
1	54.54	6.20	20.64	4.98	2.29	3.62	0.36	0.28	0.21	0.79	0.94	1.03	3.68	0.18	0.08	0.18
2	57.70	6.56	21.83	5.17	2.38	2.01	0.20	0.16	0.12	0.44	0.52	0.58	2.05	0.10	0.05	0.14
6	57.44	6.54	21.79	5.35	2.46	1.99	0.20	0.15	0.12	0.44	0.52	0.57	2.02	0.10	0.05	0.28
7	57.99	6.60	21.96	5.29	2.43	1.76	0.17	0.14	0.10	0.39	0.46	0.50	1.79	0.09	0.04	0.30
8	58.31	6.64	22.10	5.35	2.46	1.57	0.16	0.12	0.09	0.34	0.41	0.45	1.60	0.08	0.04	0.28
9	61.94	7.00	23.29	4.97	2.29	0.16	0.02	0.01	0.01	0.03	0.04	0.04	0.16	0.01	0.00	0.02
11	57.42	6.52	21.70	5.07	2.33	2.21	0.22	0.17	0.13	0.48	0.57	0.63	2.25	0.11	0.05	0.14
12	60.09	6.81	22.68	5.12	2.36	0.90	0.09	0.07	0.05	0.20	0.24	0.26	0.92	0.05	0.02	0.15
14	59.99	6.80	22.64	5.12	2.35	0.95	0.09	0.07	0.06	0.21	0.25	0.27	0.96	0.05	0.02	0.18
16	60.50	6.85	22.80	5.06	2.33	0.73	0.07	0.06	0.04	0.16	0.19	0.21	0.74	0.04	0.02	0.22
17	60.35	6.83	22.75	5.07	2.33	0.80	0.08	0.06	0.05	0.17	0.21	0.23	0.81	0.04	0.02	0.21
19	62.03	7.01	23.32	4.96	2.28	0.13	0.01	0.01	0.01	0.03	0.03	0.04	0.13	0.01	0.00	0.00
Whole area	58.90	6.68	22.24	5.09	2.34	1.49	0.15	0.11	0.09	0.33	0.39	0.42	1.51	0.07	0.03	0.17

Table 33. MOBILE6 VMT Fractions for Richmond (Unit: %)

Functional Class	MOBILE6 Vehicle Type															
	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
1	52.72	5.99	19.93	4.79	2.20	4.58	0.45	0.35	0.27	1.00	1.19	1.31	4.66	0.23	0.11	0.23
2	58.75	6.67	22.19	5.13	2.36	1.55	0.15	0.12	0.09	0.34	0.40	0.44	1.58	0.08	0.04	0.11
6	59.63	6.76	22.50	5.12	2.35	1.11	0.11	0.09	0.06	0.24	0.29	0.32	1.13	0.06	0.03	0.22
7	58.46	6.64	22.10	5.22	2.40	1.57	0.16	0.12	0.09	0.34	0.41	0.45	1.60	0.08	0.04	0.32
8	58.71	6.68	22.24	5.44	2.50	1.31	0.13	0.10	0.08	0.29	0.34	0.38	1.34	0.07	0.03	0.35
9	61.89	6.99	23.27	4.97	2.29	0.19	0.02	0.01	0.01	0.04	0.05	0.05	0.19	0.01	0.00	0.01
11	54.88	6.23	20.76	5.01	2.30	3.45	0.34	0.27	0.20	0.76	0.90	0.99	3.51	0.17	0.08	0.14
12	59.60	6.76	22.50	5.15	2.37	1.12	0.11	0.09	0.07	0.25	0.29	0.32	1.14	0.06	0.03	0.15
14	59.47	6.74	22.44	5.11	2.35	1.19	0.12	0.09	0.07	0.26	0.31	0.34	1.21	0.06	0.03	0.20
16	60.23	6.82	22.71	5.07	2.33	0.85	0.08	0.07	0.05	0.19	0.22	0.24	0.86	0.04	0.02	0.22
17	60.25	6.83	22.72	5.10	2.35	0.83	0.08	0.06	0.05	0.18	0.22	0.24	0.84	0.04	0.02	0.19
19	62.00	7.00	23.31	4.96	2.28	0.14	0.01	0.01	0.01	0.03	0.04	0.04	0.15	0.01	0.00	0.00
Whole area	58.16	6.59	21.95	5.04	2.32	1.86	0.19	0.14	0.11	0.41	0.49	0.53	1.90	0.09	0.04	0.16

Table 34. MOBILE6 VMT Fractions for Roanoke (Unit: %)

Functional Class	MOBILE6 Vehicle Type															
	LDV	LDT1	LDT2	LDT3	LDT4	HDV2b	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
1	39.43	4.50	14.98	4.17	1.92	11.26	1.12	0.87	0.66	2.47	2.93	3.22	11.46	0.57	0.26	0.20
2	54.37	6.18	20.59	5.04	2.32	3.66	0.36	0.28	0.21	0.80	0.95	1.04	3.72	0.18	0.08	0.20
6	61.27	6.93	23.06	5.01	2.30	0.43	0.04	0.03	0.03	0.09	0.11	0.12	0.44	0.02	0.01	0.11
7	59.12	6.70	22.29	5.00	2.30	1.37	0.14	0.11	0.08	0.30	0.36	0.39	1.40	0.07	0.03	0.34
8	58.68	6.64	22.12	4.93	2.27	1.70	0.17	0.13	0.10	0.37	0.44	0.49	1.73	0.09	0.04	0.10
9	62.04	7.01	23.32	4.96	2.28	0.12	0.01	0.01	0.01	0.03	0.03	0.04	0.13	0.01	0.00	0.01
11	48.06	5.47	18.22	4.68	2.15	6.87	0.68	0.53	0.40	1.51	1.79	1.96	6.99	0.35	0.16	0.19
12	51.27	5.84	19.44	4.95	2.28	5.18	0.51	0.40	0.30	1.14	1.35	1.48	5.27	0.26	0.12	0.21
14	58.47	6.64	22.09	5.14	2.36	1.65	0.16	0.13	0.10	0.36	0.43	0.47	1.68	0.08	0.04	0.18
16	60.43	6.84	22.78	5.07	2.33	0.73	0.07	0.06	0.04	0.16	0.19	0.21	0.74	0.04	0.02	0.30
17	60.13	6.81	22.66	5.05	2.32	0.92	0.09	0.07	0.05	0.20	0.24	0.26	0.93	0.05	0.02	0.19
19	62.05	7.01	23.33	4.96	2.28	0.12	0.01	0.01	0.01	0.03	0.03	0.03	0.12	0.01	0.00	0.00
Whole area	53.53	6.08	20.23	4.84	2.23	4.18	0.41	0.32	0.24	0.92	1.09	1.19	4.25	0.21	0.10	0.19

CONCLUSIONS

- *The proposed methodology for estimating locally specific VMT fractions as an input to the MOBILE model developed in this study would likely result in more reliable emissions estimates than the method currently used by VDOT.* In this study, VMT fractions were computed with the proposed methodology for the six non-attainment areas in Virginia—Frederick County, Fredericksburg, Hampton Roads, Northern Virginia (NOVA), Richmond, and Roanoke—and compared with fractions estimated by existing methodologies. The comparison revealed significant differences. These differences, coupled with the fact that the proposed methodology uses significantly more local data and requires fewer assumptions than existing methods, indicate that the proposed methodology would likely result in more reliable emissions estimates.

- *Locally specific data should be used in estimating emissions in non-attainment areas.* As shown in Task 4, VMT fractions exhibit different patterns in each of the six non-attainment areas in Virginia. Considering that the sensitivity analysis of MOBILE by FHWA pointed out emission estimation is very sensitive to the changes in input factors,[3] the use of localized input data rather than the national default data is critical.

- *The method proposed in this study is able to provide locally specific VMT fractions through a relatively simple procedure.* The procedure is straightforward and uses readily available data.

- *VMT fractions estimated using the proposed methodology vary according to regions and showed significant differences compared to fractions used by VDOT in previous air quality analyses.* VMT fractions estimated in this study showed differences by region and had distinctive differences compared to volume fractions previously used by VDOT. Judging from the research team's expectations and the rationality of a methodology and data sources, VMT fractions derived by the proposed methodology are more reasonable. Field validation of VMT fractions generated by the methodology is required, however.

RECOMMENDATION

1. *VDOT's Environmental Division should use the VMT fraction estimation methodology proposed in this report to generate input to the MOBLE model for mobile source emission estimates.* VMT fractions estimated in this study showed differences by region and had distinctive deviations compared to volume fractions currently used by VDOT. The proposed methodology is regionally representative because of the use of three local data sets—vehicle registration data from the DMV, VIUS data prepared by the U.S. Census Bureau, and TMS data—in estimating VMT fractions for each non-attainment area. By using this new methodology, VDOT can expect to generate more reliable and accurate estimates of mobile source emissions.

BENEFITS AND COSTS ASSESSMENT

By carrying out the recommendation of this study, VDOT will realize the following benefits:

- The method constitutes an improved methodology for the estimation of VMT fractions to support mobile source emission estimates. The methodology was demonstrated to reflect local conditions better than do currently used and/or available methods.

- The additional cost of implementing the recommendation would be minimal. Estimation of VMT fractions is a current activity, and the new methodology requires equivalent or less effort to the existing approach. In addition, required data for the proposed methodology can be obtained at no additional cost.

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