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Prepared by Janice Godfrey

Development of 2014 Default Onroad VMT Activity Data for the National Emissions Inventory

The default 2014 National Emissions Inventory (NEI) vehicle miles traveled (VMT) activity data are developed primarily from information provided directly by the Federal Highway Administration (FHWA), along with the FHWA's published *Highway Statistics 2014*, data from the Bureau of Census, and data from the Polk/IHS state vehicle registration database. Default VMT was developed at the county, road type, vehicle type, and fuel type level of detail, to be used in the 2014 NEI in areas for which no state or local agency provided VMT data. The vehicle types used were the thirteen MOVES2014 source types (see Table 1). The road types included were the four MOVES2014 roadway types (see Table 3). The fuel types were the four onroad MOVES2014 fuel types (see Table 4). This produced a total of 208 records per county. Since FHWA does not report VMT for the US Virgin Islands (USVI), the EPA utilized data obtained from the National Renewable Energy Lab (NREL) that surveyed VMT in the USVI in 2010. VMT data are provided in annual units of millions of vehicle miles traveled.

1.0 Data Sources Used to Develop VMT

The 2014 VMT were developed using data supplied directly by FHWA as well as publicly available data from the 2014 version of FHWA's *Highway Statistics* data series, which can be found at the following Web site: http://www.fhwa.dot.gov/policyinformation/statistics/2014/

The *Highway Statistics* data used in the VMT development include:

- Table VM-2, "Functional System Travel - Annual Vehicle-Miles," and
- Table VM-4, "Distribution of Annual Vehicle Distance Traveled."

The publically available VM-2 table contains state-level summaries of 2014 miles of annual travel in each state by HPMS road type. VM-2 road types include interstate, other freeways/expressways, other principal arterial, minor arterial, major/minor collector, and local for both urban and rural areas. The US DOT was able to provide HPMS VM-2 data at the county level directly to the EPA for most road types. However, not all road types were available at the county level from the US DOT. The road types not available at the county level were rural minor collector, rural local, and urban local. Additionally, county-level data was not available for any road type for the state of Massachusetts.

Table VM-4 contains state-level distribution of annual vehicle distance traveled, expressed by the percentage of vehicle miles traveled by vehicle type for both rural and urban road type groupings. These grouping fractions were applied to all counties in their respective state.

US Census population estimates were also used in developing the VMT. This included estimates of 2014 population by county. A ratio of county population to state population was developed for each county in the US to distribute state-level VM-2 VMT data to a county level where the US DOT county-level data was not available. US Census data is available from the following Web site:

http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

Additionally, the EPA utilized state vehicle registration datasets purchased from IHS, a private company that provides automotive information services. The company maintained two databases relevant for MOVES: the National Vehicle Population Profile (NVPP®) and the Trucking Industry Profile (TIP®Net) Vehicles in Operation database. The first focused on light-duty cars and trucks, the second focused on medium and heavy-duty trucks. The IHS data can be found in CRC Report No. A-88, MOVES INPUT IMPROVEMENTS FOR THE 2011 NEI, Final Report, October 2014, found at the following Web site:

http://www.crcao.org/reports/recentstudies2014/A-88/CRC%20A88%20Final%20Report%20102114.pdf

To assign VMT to fuel types, the EPA used fractions from the national scale MOVES2014a run results to calculate VMT by fuel type for each source type.

Finally, since FHWA does not provide VMT data for the US Virgin Islands (USVI), the EPA utilized transportation data from the National Renewable Energy Lab (NREL) that surveyed VMT in the USVI in 2010. The 2010 VMT was distributed to the MOVES source types, fuel types, road types in accordance with fractions developed from the 2011 NEI. The 2010 VMT was then grown to 2014 using growth factors derived from US Census data. For more information see: U.S. Virgin Islands Transportation Petroleum Reduction Plan, Technical Report, NREL/TP-7A40-52565, September 2011, at the following Web site: http://www.nrel.gov/docs/fy11osti/52565.pdf.

2.0 VMT Development Procedures

The procedures used in the development of the 2014 NEI default VMT are broken down into six parts (see Figure 1):

1. Using *Highway Statistics* VM-2 state-level VMT along with county population data from US Census to fill gaps in FHWA county-level data to develop VMT by county and HPMS road type for all counties in the US, including Puerto Rico;

2. Further allocating county-level VMT by HPMS road type to HMPS vehicle type using *Highway Statistics* Table VM-4 to develop VMT by county, HPMS road type, and HPMS vehicle type;

3. Distributing certain VMT to MOVES vehicle types using CRC/IHS vehicle population data and 2011 NEI activity data to develop VMT by county, HPMS road type, and MOVES vehicle type;
4. Distributing VMT to MOVES fuel types using a national MOVES2014a run to derive fuel fractions to develop VMT by county, HPMS road type, MOVES vehicle type, and MOVES fuel type;
5. Combining HPMS road types to the four MOVES2014 road types to develop VMT by county, MOVES road type, MOVES vehicle type, and MOVES fuel type; and
6. Develop VMT for the USVI using data from the NREL report; source, road, and fuel type fractions obtained for the 2011 NEI; and growth factors derived from US Census data.

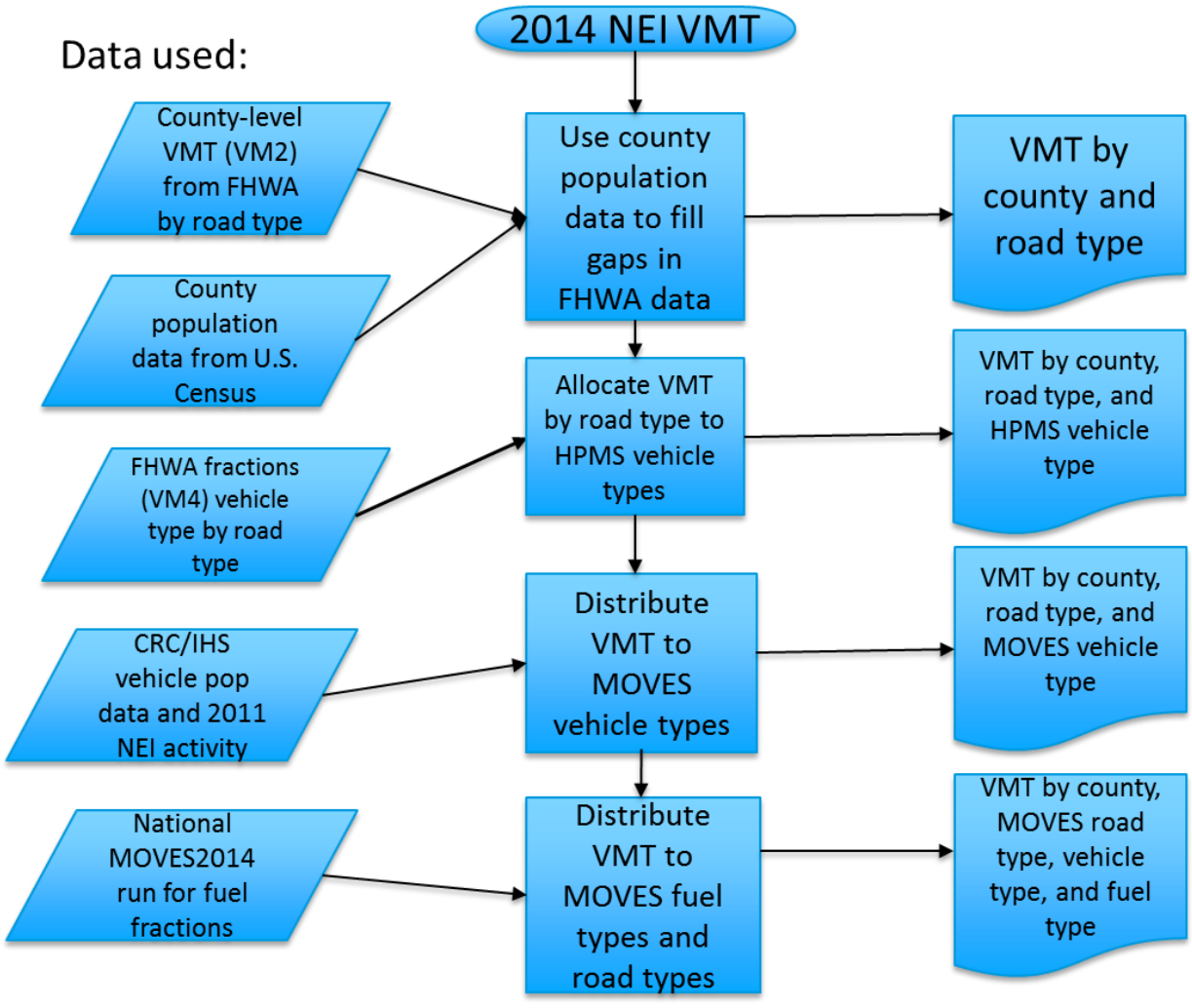

Figure 1. Overview of VMT development

Each of these steps in the development of the 2014 VMT is discussed separately below.

2.1 2014 County-level VMT by HPMS Road Type

The EPA received the HPMS VM-2 data by county from the US DOT. The file had most road types, however, rural minor collectors and locals (HPMS types RminCOLL, RLOC, and ULOC) were not available at the county level. Additionally no county-level data was available for Massachusetts.

In order to create a complete set of VMT by county and HPMS road type, the Table VM-2 (state-level), Functional System Travel - Annual Vehicle-Miles, was downloaded from:

http://www.fhwa.dot.gov/policyinformation/statistics/2014/, along with 2014 census data by county, downloaded from:

http://factfinder.census.gov/faces/tableservices/jsf/pages/.

County- and state-level population data was used to create ratios of county population to state population. State-level VMT was then multiplied by the county-level ratios to develop a set of annual VMT for all counties based on population as follows:

$$state\ VMT * (county\ population)/(state\ population) = county\ VMT$$

These were only used to fill in VMT for road types that were missing from the county data sent to the EPA by the US DOT, as well as, for the state of Massachusetts.

2.2 2014 County-level VMT by HPMS Road Type and Vehicle Type

In order to allocate the county-level VMT by Highway Performance Maintenance System (HPMS) road type to HPMS vehicle type, the Table VM-4, Distribution of Annual Vehicle Distance Traveled, was downloaded from:

http://www.fhwa.dot.gov/policyinformation/statistics/2014/,

These distributions were used to apportion county-level VMT by HPMS road type to HPMS vehicle type as follows:

$$HPMS\ vehicle\ type\ fraction * county\text{-}level\ VMT = county\ VMT\ by\ HPMS\ road\ type\ and\ vehicle\ type$$

2.3 2014 County-level VMT by HPMS Road Type and MOVES2014 Source Type

In this step the HPMS vehicle types are translated to the MOVES2014 source types. The table below maps the HPMS vehicle types to the MOVES2014 source types:

Table 1. MOVES2014 onroad source types

MOVES sourceType ID	MOVES Source Type Name	HPMSVTypeID	Description
11	Motorcycles	10	Motorcycles
21	Passenger Cars	25	Light-Duty Vehicles
31	Passenger Trucks	25	Light-Duty Vehicles
32	Light Commercial Trucks	25	Light-Duty Vehicles
41	Intercity Buses	40	Buses
42	Transit Buses	40	Buses
43	School Buses	40	Buses
51	Refuse Trucks	50	Single Unit Trucks
52	Single Unit Short-Haul Trucks	50	Single Unit Trucks
53	Single Unit Long-Haul Trucks	50	Single Unit Trucks
54	Motor Homes	50	Single Unit Trucks
61	Combination Short-Haul Trucks	60	Combination Trucks
62	Combination Long-Haul Trucks	60	Combination Trucks

As you can see, there is a one-to-many relationship between some HPMS vehicle types and the source types we use in MOVES2014.

Light Duty Vehicles

In MOVES2014, what we call the HPMS class for light-duty vehicles (25) denotes the sum of the FHWA Table VM-4 values for long wheelbase and short wheelbase light-duty vehicles. HPMSVTypeID 25 is new for MOVES2014 and replaces HPMSVTypeID 20 (passenger cars) and 30 (other two-axle four-tire vehicles) in MOVES2010. As such, in MOVES2014 any VMT input by HPMS class for passenger cars and light-duty trucks must be entered as a combined value in the new HPMSVTypeID 25. This change in HPMS classes has come about as passenger vehicles have evolved over time with the physical characteristics of "cars" and "trucks" becoming less distinct. In response, the US DOT changed the organization of HPMS classifications and MOVES has evolved to reflect this change. In order to further refine HPMSVType 25, the EPA used data compiled from 2011 state vehicle registration data from IHS to develop county-level fractions to break down HPMSVTypeID 25 into the three light-duty source types needed for MOVES2014 (passenger cars (21), passenger trucks (31), and light commercial trucks (32)) as follows:

HPMSVTypeID 25 VMT∗county-level IHS fraction=county VMT by HPMS road type and MOVES2014 source type

This information can be found in the table titled "Population Database" at the following Web site: http://www.crcao.org/publications/atmosphereImpacts/index.html

Buses, Refuse Trucks, and Motor Homes

For the bus, refuse truck, and motor home categories the EPA did not have registration data available to apportion the HPMS categories to the MOVES2014 source categories. For buses, in order to further refine HPMSVType 40, the EPA used activity data from the 2011 NEI modeling platform to develop county-level fractions to break down HPMSVTypeID 40 into the three bus source types needed for MOVES2014 (intercity buses (41), transit buses (42), and school buses (43)) as follows:

HPMSVTypeID 40 VMT∗county-level fraction=county VMT by HPMS road type and MOVES2014 source type

The 2011 NEI contains state supplied activity data for many states, therefore this is reasoned to be the best data available at the time of the first draft to apportion VMT for these categories.

Long-haul and Short-haul Trucks

In an analogous approach for HPMSVType 50, single-unit trucks, the EPA again used activity data from the 2011 NEI modeling platform to develop county-level fractions to break out the MOVES2014 refuse trucks (51) and motor homes (54) from the total HPMS single unit truck VMT. After the refuse trucks and motor homes were split out, the remainder was assumed to be the total for single unit long-haul (52) and short-haul (53) trucks.

To determine long-haul vs. short-haul for single unit and combination trucks, the EPA used VMT fractions derived from the 2007 Freight Analysis Framework (FAF), which produced unique allocations by region of the country, urban vs. rural, and interstate vs. non-interstate. Sixteen groupings, covering each combination of: major census region (Midwest, Northeast, South and West), interstate/non-interstate (translated to restricted and unrestricted to match MOVES road types), and urban/rural as depicted in the following figure:

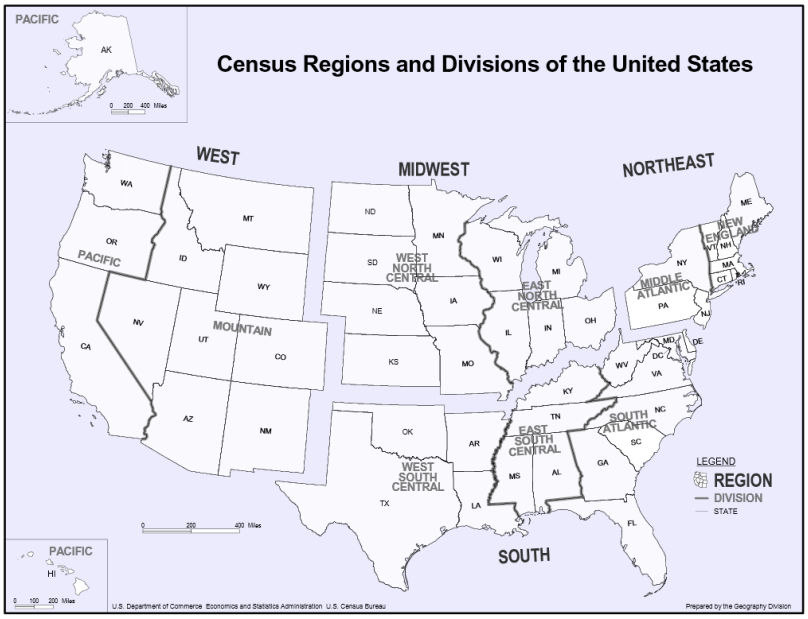

Figure 2. U.S. Census Regions

The updated long-haul fractions for combination trucks varied by region of the country, road type and urban/rural area, ranging from around 30 percent on urban unrestricted roads, to up to 90 percent for some rural restricted roads, in comparison to a static MOVES default of 59 percent as follows:

Table 2. Long-haul fractions by U.S. Census Region

Region	Roadtype	Long Haul Fraction Calculations		MOVES Defaults	
		Combo LH Fraction	Single LH Fraction	Combo LH Fraction	Single LH Fraction
Midwest Urban	Noninterstate (Unrestricted)	0.27	0.04	0.59	0.12
Northeast Urban	Noninterstate (Unrestricted)	0.29	0.02	0.59	0.12
South Urban	Noninterstate (Unrestricted)	0.27	0.04	0.59	0.12
West Urban	Noninterstate (Unrestricted)	0.28	0.03	0.59	0.12
Midwest Rural	Noninterstate (Unrestricted)	0.48	0.16	0.59	0.12
Northeast Rural	Noninterstate (Unrestricted)	0.44	0.05	0.59	0.12
South Rural	Noninterstate (Unrestricted)	0.35	0.08	0.59	0.12
West Rural	Noninterstate (Unrestricted)	0.39	0.06	0.59	0.12
Midwest Urban	Interstate (Restricted)	0.57	0.21	0.59	0.12
Northeast Urban	Interstate (Restricted)	0.59	0.11	0.59	0.12
South Urban	Interstate (Restricted)	0.53	0.16	0.59	0.12
West Urban	Interstate (Restricted)	0.62	0.12	0.59	0.12
Midwest Rural	Interstate (Restricted)	0.90	0.50	0.59	0.12
Northeast Rural	Interstate (Restricted)	0.88	0.22	0.59	0.12
South Rural	Interstate (Restricted)	0.70	0.39	0.59	0.12
West Rural	Interstate (Restricted)	0.84	0.38	0.59	0.12

Fractions from the FAF analysis are considered to be an improvement over simply using the MOVES2014 default splits for long-haul vs. short-haul. For more information on FAF long-haul truck VMT estimates see CRC Report No. A-88, MOVES INPUT IMPROVEMENTS FOR THE 2011 NEI, Final Report, October 2014, available at:

http://www.crcao.org/reports/recentstudies2014/A-88/CRC%20A88%20Final%20Report%20102114.pdf

It should be further noted that for Hawaii and Puerto Rico, where there are no roads exceeding 200 miles in continuous length, the long-haul vehicle VMT was lumped in with the short-haul vehicle VMT since long-haul vehicles are those that routinely travel more than 200 miles in one trip.

2.4 2014 County-level VMT by HPMS Road Type, MOVES2014 Source Type and Fuel Type

To further assign VMT to fuel type the EPA used national scale MOVES2014a run results to assign fractions for fuel types for each source type. The following table summarizes the fuel types available for onroad vehicles in MOVES:

Table 3. MOVES2014 fuel types

fuelTypeID	Description
1	Gasoline
2	Diesel Fuel
3	Compressed Natural Gas (CNG)
5	Ethanol (E-85) Capable

2.5 2014 County-level VMT by MOVES2014 Road Type, Source Type, and Fuel Type

To assign VMT from the FHWA functional types to the MOVES2014 road types, VMT was combined by the following table:

Table 4. MOVES2014 road types

roadTypeID	Description	FHWA Functional Types
2	Rural Interstate	Rural Interstate
3	Rural Unrestricted Access	Rural Principal Arterial, Minor Arterial, Major Collector, Minor Collector & Local
4	Urban Restricted Access	Urban Interstate & Urban Freeway/Expressway
5	Urban Unrestricted Access	Urban Principal Arterial, Minor Arterial, Collector & Local

The four MOVES road types (2-5) are thus aggregations of FHWA functional types.

2.6 2014 County-level VMT by MOVES2014 Road Type, Source Type, and Fuel Type for the USVI

Since FHWA does not provide VMT data for the US Virgin Islands (USVI), EPA utilized transportation data from the National Renewable Energy Lab (NREL) that surveyed VMT in the USVI in 2010. Table 1 of NERL's Technical Report NREL/TP-7A40-52565, September 2011, shows average VMT in miles/year for light-duty and heavy-duty vehicles. This data was used to calculate adjustment factors for light-duty and heavy-duty vehicles that were used to adjust the EPA's 2011 VMT to create a complete set of county-level VMT by MOVES2014 road type, source type, and fuel type for 2010. This data set was then grown from 2010 to 2014 using growth factors derived from US Census data. Since the VMT data from NERL was from an actual survey the EPA determined it was appropriate to adjust what the EPA had developed for 2011, which resulted in a higher VMT for light-duty vehicles (32% higher than what was previously determined for 2011) and a much higher VMT for heavy-duty vehicles (nearly 5 times higher). The statistics provided in NERL's USVI road transportation statistics had previously been dispersed among multiple agencies and reports, but were compiled for the first

time in this report. More information on the compilation of these statistics can be found in: U.S. Virgin Islands Transportation Petroleum Reduction Plan, Technical Report, NREL/TP-7A40-52565, September 2011, at the following Web site: http://www.nrel.gov/docs/fy11osti/52565.pdf

It should be further noted that since there are no roads in the USVI that exceed 200 miles in continuous length, the long-haul vehicle VMT was lumped in with the short-haul vehicle VMT since long-haul vehicles are those that routinely travel more than 200 miles in one trip.

Development of 2014 Default VPOP Activity Data and Hotelling Hours for the National Emissions Inventory

MOVES uses vehicle population (VPOP) to characterize emissions activity that is not directly dependent on VMT. The default 2014 NEI vehicle population and hotelling hours activity data are developed primarily from FHWA's published *Highway Statistics 2014*, data from the US Bureau of Census, and transportation data from the US Virgin Islands compiled by the National Renewable Energy Lab (NREL), that surveyed VMT in the USVI in 2010. Default VPOP and hotelling hours were developed at the county, source type, and fuel type level of detail, to be used in the 2014 NEI in areas for which no state or local agency provided VPOP or hotelling hours data.

1.0 Data Sources Used to Develop VPOP and Hotelling Hours

MOVES2014 VPOP and hotelling hours are derived top-down from registration data in Table MV-1 of the Federal Highway Administration's annual Highway Statistics report: http://www.fhwa.dot.gov/policyinformation/statistics/2014/

The *Highway Statistics* data used in the VPOP and hotelling hours development include:

- Table MV-1, "State motor-vehicle registrations"

In this table, vehicles are separated into four general vehicle categories: motorcycles, passenger cars, trucks, and buses. Table MV-1 includes vehicles in the 50 United States and Puerto Rico, but does not account for vehicles in the US Virgin Islands. For the USVI the EPA utilized transportation data from the National Renewable Energy Lab (NREL) survey of VMT in the USVI conducted in 2010.

Additionally, the EPA used fractions derived from the national scale MOVES2014a run results to calculate a national rate of hotelling hours per mile of travel by long-haul combination trucks as well as the hours of extended idle versus auxiliary power unit (APU) use.

2.0 VPOP Development Procedures

Registrations by state are broken down into four HPMS groupings, "automobiles, buses, trucks, and motorcycles" in the *Highway Statistics* Table MV-1. The EPA broke these categories down further to the MOVES source types as follows: "Motorcycles" were assigned to source type 11. "Automobiles" were assigned to MOVES source type 21. "Buses" were assigned to MOVES source types 41, 42, and 43. Trucks were assigned to MOVES source types 31, 32, 51, 52, 53,

54, 61, and 62. The EPA then used national scale MOVES2014a run results to further allocate the MV-1 state-level population data to the MOVES2014 source types and fuel types.

To allocate the short-haul VPOP to the county level we used fractions derived from US Census data for human population. The reasoning for using US Census data for all short-haul VPOP is that most vehicle starts (one of the more important events that is derived from VPOP activity data) will occur in the county in which one lives, or close by. Short-haul vehicles are distinguished from long-haul vehicles in that they routinely travel less than 200 miles in one trip. The following were considered short-haul vehicles: motorcycles (11), automobiles (21), passenger trucks (31), light commercial trucks (32), transit buses (42), school buses (43), refuse trucks (51), single unit short-haul trucks (52), and combination short-haul trucks (61).

To allocate the long-haul VPOP to the county level we used fractions from the EPA-derived 2014 default onroad VMT. The EPA reasoned that heavy-duty traffic population tracks more with VMT growth due to economic conditions and the need for heavy-duty transportation of goods. The following vehicles were considered long-haul vehicles: intercity buses (41), single unit long-haul trucks (53), motor homes (54), and combination long-haul trucks (62).

Since FHWA does not provide vehicle population data for the US Virgin Islands (USVI), EPA utilized transportation data from the National Renewable Energy Lab (NREL) that surveyed vehicle population in the USVI in 2010. Table 1 of NERL's Technical Report NREL/TP-7A40-52565, September 2011, shows population data for motorcycles, cars, light trucks, and heavy-duty vehicles. This data was used to calculate adjustment factors for light-duty and heavy-duty vehicles that were applied to the EPA's 2011 VPOP to create a complete set of county-level VPOP by MOVES2014 road type, vehicle type, and fuel type for 2010. This data set was then grown from 2010 to 2014 using growth factors derived from US Census data. Since the vehicle population data from NERL was from an actual survey the EPA determined it was appropriate to adjust what the EPA had developed for 2011. The statistics provided in NERL's USVI road transportation statistics had previously been dispersed among multiple agencies and reports, but were compiled for the first time in this report. More information on the compilation of these statistics can be found in: U.S. Virgin Islands Transportation Petroleum Reduction Plan, Technical Report, NREL/TP-7A40-52565, September 2011, at the following Web site: http://www.nrel.gov/docs/fy11osti/52565.pdf.

It should be further noted that since there are no roads in the USVI that exceed 200 miles in continuous length, the long-haul VPOP was lumped in with the short-haul VPOP since long-haul vehicles are those that routinely travel more than 200 miles in one trip.

3.0 Hotelling Hours Development Procedures for Long-Haul Trucks

An analogous approach was used to develop hotelling hours for the long-haul trucks. Default hotelling hours for the 2014 estimates based solely on VMT from 2014 were derived as follows:

*2014 hours = (2014 long-haul comb restricted (urban+rural) VMT) **
(2014 National hotelling hours / 2014 National long haul comb restricted (urban+rural) VMT)

The method starts by calculating a national rate of hotelling hours per mile of travel by long-haul combination trucks for both rural and urban restricted roads using the national MOVES2014a run. This rate is applied to the restricted access VMT (both urban and rural) in each county to calculate the total hotelling hours. The hours of extended idle versus auxiliary power unit (APU) use are calculated using the fraction calculated from the results of the national MOVES2014a run. Example data is available from:
ftp://ftp.epa.gov/EmisInventory/2014/doc/onroad/draft2014activity/

Data Sources

Highway Statistics Table VM-1 "Annual Vehicle Distance Traveled in Miles and Related Data – 2014; by Highway Category and Vehicle Type", http://www.fhwa.dot.gov/policyinformation/statistics/2014/

Highway Statistics Table VM-2 "Functional System Travel – 2014; Annual Vehicle-Miles", http://www.fhwa.dot.gov/policyinformation/statistics/2014/

Highway Statistics Table MV-1 "State Motor-Vehicle Registrations – 2014", http://www.fhwa.dot.gov/policyinformation/statistics/2014/

United States Census Bureau, "County population, population change and estimated components of population change: April 1, 2013 to July 1, 2014," http://www.census.gov/popest/data/counties/totals/2014/files/CO-EST2014-Alldata.csv, downloaded June 7, 2013.

CRC Report No. A-88 MOVES INPUT IMPROVEMENTS FOR THE 2011 NEI Final Report October 2014, http://www.crcao.org/publications/atmosphereImpacts/index.html

National Renewable Energy Laboratory, U.S. Virgin Islands Transportation Petroleum Reduction Plan, Technical Report NREL/TP-7A40-52565, September 2011, http://www.nrel.gov/docs/fy11osti/52565.pdf