

## **Appendix C.3**

# **On-Road Mobile Source Emission Inventory Documentation**

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## 1.0 INTRODUCTION AND SCOPE

This fine particulate matter (PM<sub>2.5</sub>) on-road mobile source documentation covers the Hickory PM<sub>2.5</sub> nonattainment area (Catawba County) and the Greensboro/Winston Salem/High Point PM<sub>2.5</sub> nonattainment area (referred to as the Triad area and consisting of Davidson and Guilford Counties). On-road mobile sources produce nitrogen oxides (NO<sub>x</sub>), particles less than 2.5 micrometers in diameter (PM<sub>2.5</sub>), and sulfur dioxide (SO<sub>2</sub>), along with a host of other pollutants. Emissions of these pollutants are estimated in the mobile source inventory required for the maintenance plan. Mobile sources comprise about 74% of the NO<sub>x</sub> emissions in the Hickory and Triad fine particulate matter nonattainment areas. The scope of this document covers only the procedures associated with on-road mobile sources.

## 2.0 OVERALL METHODOLOGY

### 2.1 Emission Estimation Approach

Mobile source emissions are estimated by the methodologies suggested in the United States Environmental Protection Agency (USEPA) documents Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations, Policy Guidance on the Use of MOVES2010 for State Implementation Plan Development, Transportation Conformity, and Other Purposes (EPA-420-B-09-046, December 2009), and Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity (EPA-420-B-10-023, April 2010).

In December 2009, the USEPA released a new model for mobile sources. MOVES (MOtor Vehicle Emissions Simulator) is a computer program designed by the USEPA to estimate air pollution emissions from mobile sources. MOVES2010 (hereafter referred to as MOVES) replaces the USEPA's previous emissions model for on-road mobile sources, MOBILE6.2. MOVES is used to estimate exhaust and evaporative emissions as well as brake and tire wear emissions from all types of on-road vehicles.

Compared to MOBILE6.2, MOVES incorporates substantial new emissions test data and accounts for changes in vehicle technology and regulations as well as improved understanding of in-use emission levels and the factors that influence them. Also, MOVES has a completely new database-centered software framework.

There is currently a two year grace period for transportation conformity purposes for use of MOVES as the new regulatory model. However, the North Carolina Division of Air Quality (NCDAQ) committed to provide supplemental data to the Annual PM<sub>2.5</sub> Redesignation Demonstration and Maintenance Plan when MOVES was released and approved for regulatory purposes.

The estimation of emissions from mobile sources involves multiplying an activity level by an emission factor. Previously this was done using MOBILE6.2 to calculate an emissions factor and multiplying it by the vehicle miles travelled (VMT). One important new feature of MOVES is the option to calculate emissions either as inventory estimates (total emissions in units of mass) or, emission rates (emissions per unit of distance for running emissions or per vehicle for starts, extended idle and resting evaporative emissions) in a look-up table format.

Use of the inventory option simplifies the post-processing of MOVES output compared to MOBILE6.2, but it requires VMT and vehicle population data as an input to MOVES. When using the emission rates option, VMT and vehicle population are applied during post-processing external to MOVES. Either approach can be used to develop emissions estimates for state implementation plans (SIPs) and regional conformity analyses. If inventory option is selected, MOVES provides emissions estimates as mass, using VMT and vehicle population entered by the user. If emission rate option is selected, MOVES provides emission rates as mass per unit of activity. The emission rates option produces a look-up table of emission rates that must be post-processed to produce an inventory. The NCDAQ is electing to run the model in the inventory mode due to faster model run times and fewer post-processing requirements.

The USEPA has performed preliminary comparison of MOVES2010 to MOBILE6.2 using local data for several different urban areas, varying the local data used by fleet distribution, fraction of light- and heavy-duty VMT, local fuel specifications, meteorology, and other input factors. In general, volatile organic carbon (VOC) emissions are lower when using MOVES2010 when compared to MOBILE6.2, while NO<sub>x</sub> and particulate matter (PM) emissions are higher.

### **3.0 QUALITY ASSURANCE MEASURES**

The quality assurance (QA) for the highway mobile source category can be broken into two components: 1) input files and 2) MOVES outputs/summaries. Each of these components is detailed in the paragraphs below.

After the speed and VMT information is acquired from the North Carolina Department of Transportation (NCDOT), the speed information is checked for reasonableness against previous

sets of speeds for the areas. Once the speeds are deemed reasonable, the NCDAQ enters the speed information into MOVES input files. In addition to the speed information, the user enters data to characterize local meteorology, fleet and activity information. All input files are checked against a “key” with the original source of the information. This QA step is always performed by a person other than the one who generated the input files. If any discrepancies are found, they are noted back to the person who generated the input files for correction.

Once the input files have passed through the QA procedure, MOVES is run to generate emissions.

## **4.0 DISCUSSION OF ON-ROAD MOBILE SOURCES**

On-road mobile sources produce NO<sub>x</sub>, PM<sub>2.5</sub>, and SO<sub>2</sub>, along with a host of other pollutants. Emissions of these three pollutants are estimated in the on-road mobile source inventory for the maintenance plan. The objective of the following section is to describe the source category, the input files, and the emissions estimation procedures. This section also includes tables summarizing the estimated emissions for the projection years by county.

### **4.1 Introduction and Scope**

On-road mobile sources are considered as those vehicles that travel on the roadways. On-road mobile sources are a major contributor to NO<sub>x</sub> emissions in North Carolina and a less significant contributor to primary PM<sub>2.5</sub> and SO<sub>2</sub>. Emissions from motor vehicles occur throughout the day while the vehicle is in motion, at idle, parked, and during refueling. All of these emissions processes need to be estimated in order to properly reflect the total emissions from this source category.

On-road mobile source emissions comprise a small percentage of the total fine particulate matter emissions for all of North Carolina. Particulate emissions from motor vehicles only occur while the vehicle is moving or idling. These emissions are direct tailpipe (from both gas and diesel fuel vehicles), sulfate, tire wear, and brake wear. Only direct particulate emissions processes will be estimated in order to properly reflect the total fine particulate matter emissions from this source category.

A very important component of the highway mobile emission estimation process is interagency consultation. The primary transportation partners involved in the Hickory and Triad redesignation interagency consultation process included: NCDOT, USEPA, Federal Highway Administration (FHWA), Greensboro Urban Area Municipal Planning Organization (MPO),

High Point Urban Area MPO, Piedmont Triad Rural Planning Organization (RPO), and Greater Hickory MPO. Specifically the NCDOT was consulted for input data such as speeds and VMT for the rural counties where the Hickory and Triad Urban Travel Demand Models (TDMs) did not cover. An interagency call was held April 19, 2010 to discuss the need to update the motor vehicle emission budgets (MVEBs) for the Greater Hickory and Triad areas. The NCDAQ had the data originally provided for the redesignation for the years 2008, 2011, 2014, 2017, and 2021. The NCDAQ received updated speeds and VMT for the Triad (Davidson and Guilford Counties), in February 2009, as well as, updated speeds and VMT for Catawba County from NCDOT in April 2009. The NCDAQ discussed the differences anticipated in the emissions by running the MOVES model and the possible necessity to update the MVEBs in the Redesignation Package before the MOVES model would be required to be used for conformity purposes. The interagency partners agreed that the activity data that the NCDAQ had were the latest and should be used as inputs to the MOVES model.

## **4.2 MOVES Input Assumptions**

Due to the size and the complexity of the MOVES input and output files, the MOVES input files and output files will be provided electronically.

### **4.2.1 Speed Assumptions**

Vehicle power, speed, and acceleration have a significant effect on vehicle emissions. MOVES models those emission effects by assigning activity to specific drive cycles or operating mode distributions. The distribution of vehicle hours traveled (VHT) by average speed is used to determine an appropriate operating mode distribution. The Average Speed Distribution importer in MOVES calls for a speed distribution in VHT in 16 speed bins, by each road type, source type, and hour of the day included in the analysis. The methodology used to develop the average speed distribution inputs is documented below.

The speeds for the urban areas covered by a TDM were provided by the MPOs. Piedmont Authority for Regional Transportation (PART) provided modeled speeds for the entire county of Guilford and the modeled portion of Davidson County for the desired maintenance plan years. Speeds for rural areas in Davidson and the urban and rural areas in Catawba were generated by NCDOT. Modeled speeds for urban areas of Catawba County were received for the years 2007, 2015, 2025, and 2035, and interpolated to the years needed. Tables 4.2.1-1 through 4.2.1-5 provide a summary of the average speeds in miles per hour (mph).



**Table 4.2.1-1 Modeled Area Speeds for Davidson County (miles/hour)**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	68	68	68	68	67
Urban Freeway or Expressway	57	57	56	56	55
Urban Other Principal Arterial	39	39	38	38	39
Urban Minor Arterial	40	40	40	40	39
Urban Collector	42	41	42	42	41
Urban Local	46	45	45	45	44
Rural Interstate	69	68	68	68	68
Rural Other Principal Arterial	---	---	---	35	35
Rural Minor Arterial	51	51	51	51	50
Rural Major Collector	43	43	42	42	41
Rural Minor Collector	49	48	48	48	48
Rural Local	49	49	48	48	48

**Table 4.2.1-2 Rural Area Speeds for Davidson County (miles/hour)**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	62	63	62	62	62
Urban Freeway or Expressway	56	56	56	56	56
Urban Other Principal Arterial	28	29	28	28	29
Urban Minor Arterial	32	32	32	32	32
Urban Collector	31	31	31	31	31
Urban Local	31	31	31	31	31
Rural Interstate	65	66	65	65	65
Rural Other Principal Arterial	45	46	45	45	45
Rural Minor Arterial	44	44	44	44	44
Rural Major Collector	43	43	43	43	43
Rural Minor Collector	42	42	42	42	42
Rural Local	42	42	42	42	42

**Table 4.2.1-3 Modeled Area Speeds for Guilford County (miles/hour)**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	55	55	56	56	55
Urban Freeway or Expressway	51	51	50	50	51
Urban Other Principal Arterial	39	39	39	39	39
Urban Minor Arterial	37	37	38	38	38
Urban Collector	37	37	37	37	37
Urban Local	34	34	34	34	34
Rural Interstate	60	59	58	58	57
Rural Other Principal Arterial	47	48	50	50	49
Rural Minor Arterial	43	42	44	44	46
Rural Major Collector	46	46	46	46	45
Rural Minor Collector	47	47	47	47	46
Rural Local	43	42	46	46	45

**Table 4.2.1-4 Modeled Area Speeds for Catawba County (miles/hour)**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	60	59	57	55	52
Urban Freeway or Expressway	46	46	45	45	44
Urban Other Principal Arterial	34	33	32	31	30
Urban Minor Arterial	34	33	32	31	30
Urban Collector	36	35	34	33	32
Urban Local	38	37	36	35	33
Rural Interstate	64	63	62	60	56
Rural Other Principal Arterial	59	59	58	58	57
Rural Minor Arterial	42	41	40	39	38
Rural Major Collector	43	43	42	42	41
Rural Minor Collector	37	36	35	35	34
Rural Local	42	42	41	41	40

**Table 4.2.1-5 Rural Area Speeds for Catawba County (miles/hour)**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	63	63	63	63	63
Urban Freeway or Expressway	56	56	56	56	56
Urban Other Principal Arterial	29	29	29	29	29
Urban Minor Arterial	32	32	32	32	32
Urban Collector	31	31	31	31	31
Urban Local	31	31	31	31	31
Rural Interstate	63	63	63	63	63
Rural Other Principal Arterial	46	46	46	46	46
Rural Minor Arterial	44	44	44	44	44
Rural Major Collector	43	43	43	43	43
Rural Minor Collector	42	42	42	42	42
Rural Local	42	42	42	42	42

MOVES uses four different roadway type categories that are affected by the average speed distribution input: rural restricted access, rural unrestricted access, urban restricted access, and urban unrestricted access (these road types are discussed in more detail in Section 4.2.6). In MOVES, local roadways are included with arterials and collectors in the urban and rural unrestricted access roads category. In MOBILE6.2, local roadways were a separate category with a fixed speed of 12.9 mph. For MOVES, the USEPA recommends that the average speed distribution for local roadway activity be included as part of a weighted distribution of average speed across all unrestricted roads along with the distribution of average speeds for arterials and connectors.

When only a single average speed is available for a specific road type and that average speed is not identical to the average speed in a particular speed bin, MOVES guidance stipulates that users should apply the following formula for creating the appropriate speed distribution among two adjacent speed bins.

The general formula is:

VHT Fraction A in Speed Bin with closest average speed lower than observed average speed +  
VHT Fraction B in Speed Bin with closest average speed higher than observed average speed = 1

VHT Fraction  $A_{(\text{low bin})} = 1 - [(\text{observed average speed} - \text{average speed of lower speed bin}) / (\text{average speed of higher speed bin} - \text{average speed of lower speed bin})]$

VHT Fraction  $B_{(\text{high bin})} = 1 - [(\text{average speed of higher speed bin} - \text{observed average speed}) / (\text{average speed of higher speed bin} - \text{average speed of lower speed bin})]$

Or more simply: VHT Fraction  $B = 1 - \text{VHT fraction } A$

The following is an example of applying the above equations. If the single average speed for a roadway is 58 miles per hour, the average speed distribution will be split between the 55 and 60 mph speed bins. The appropriate VHT fractions are found with the following equations:

VHT fraction  $A_{(\text{low bin})} = 1 - [(58 \text{ mph Avg. Speed} - 55 \text{ mph (Bin Speed)}) / (60 \text{ mph (Bin Speed)} - 55 \text{ mph (Bin Speed)})] = 0.4$

VHT fraction  $B_{(\text{high bin})} = 1 - [(60 \text{ mph (Bin Speed)} - 58 \text{ mph Avg. Speed}) / (60 \text{ mph (Bin Speed)} - 55 \text{ mph (Bin Speed)})] = 0.6$

VHT Fraction  $A_{(\text{low bin})} + \text{VHT Fraction } B_{(\text{high bin})} = 1$   
 $0.4 + 0.6 = 1$

As stated above, MOVES uses only four different roadway types: rural restricted access, rural unrestricted access, urban restricted access and urban unrestricted access. This means that the speeds for multiple roadway types need to be combined into the appropriate speed bins. To create the speed bin fractions for combined roadways the VMT for each road way is used to weight the speed bin fraction. For example, below are speeds and VMT for urban restricted access road types:

Road type	Speed (miles/hour)	VMT (hourly miles)
Urban Interstate	63	250,000
Urban Freeway	56	100,000

The first step is to determine the speed bin fractions for each road type separately. For the urban interstate road type, the speed 63 is split between the MOVES speed bins of 60 and 65 as described above, which results in the VHT fractions of 0.4 and 0.6 for speed bins 60 and 65, respectively. Similarly, the speed for the urban freeway road type (56 miles/hour) is split

between the MOVES speed bins of 55 and 60 and results in the VHT fractions of 0.8 and 0.2, respectively.

The next step requires road type VMT to weigh the VHT Fractions so that the final MOVES speed bin fractions can be developed. The VHT Fraction, specific to the road type and speed bin, are multiplied by the corresponding hourly VMT. These hourly totals are divided by the total VMT for that hour for the road type category (in this example, urban restricted access includes urban interstate and urban freeway). The following equation is used to calculate the combined speed bin fractions:

$$VHT_{(Speed\ Bin\ X)} = \frac{[\sum (VHT\ Fraction_{(RT)} \times hourly\ VMT_{(RT)})]}{[\sum hourly\ VMT_{(RT)}]}$$

Where:

RT = the HPMS road type

In this example, the HPMS road types are urban interstate (UI) and urban freeway (UF) and the speed bins are 55, 60 and 65. The table below summarizes the speed bin fractions for this example.

HPMS Road Type	Speed Bin 55	Speed Bin 60	Speed Bin 65
Urban Interstate	0.0	0.4	0.6
Urban Freeway	0.8	0.2	0.0

Using the equation below, the final MOVES speed bin fractions are calculated for the urban restricted access road type.

$$VHT_{(Speed\ Bin\ X)} = \frac{[(VHT\ Fraction_{(UI)} * hourly\ VMT_{(UI)}) + (VHT\ Fraction_{(UF)} * hourly\ VMT_{(UF)})]}{(hourly\ VMT_{(UI)} + hourly\ VMT_{(UF)})}$$

$$VHT_{(Speed\ Bin\ 55)} = \frac{[(0.0 * 250,000) + (0.8 * 100,000)]}{(250,000 + 100,000)}$$

$$VHT_{(Speed\ Bin\ 55)} = 0.2286$$

$$VHT_{(Speed\ Bin\ 60)} = \frac{[(0.4 * 250,000) + (0.2 * 100,000)]}{(250,000 + 100,000)}$$

$$VHT_{(Speed\ Bin\ 60)} = 0.3428$$

$$VHT_{(\text{Speed Bin 65})} = \frac{[(0.6 * 250,000) + (0.0 * 100,000)]}{(250,000 + 100,000)}$$

$$VHT_{(\text{Speed Bin 65})} = 0.4286$$

The sum of the VHT fractions for all speed bins within a road type category must add up to 1.0. The hourly VHT fractions by speed bin and road type are then processed through a MOVES supplied converter to develop the speed distribution file by hour and road type.

#### 4.2.2 Vehicle Age Distribution

The age distribution of vehicle fleets can vary significantly from area to area. Fleets with a higher percentage of older vehicles will have higher emissions for two reasons. Older vehicles have typically been driven more miles and have experienced more deterioration in emission control systems. Additionally, a higher percentage of older vehicles also implies that there are more vehicles in the fleet that do not meet newer, more stringent emissions standards. Surveys of registration data indicate considerable local variability in vehicle age distributions.

For SIP and conformity purposes, the USEPA recommends and encourages states to develop local age distributions. The MOVES model categorizes the vehicle fleet into different vehicle classes and more model years than MOBILE6.2. A typical vehicle fleet includes a mix of vehicles of different ages. MOVES covers a 31 year range of vehicle ages, with vehicles 30 years and older grouped together. MOVES allows the user to specify the fraction of vehicles in each of 30 vehicle ages for each of the 13 source types in the model.

Local age distributions can be estimated from local vehicle registration data. The vehicle age distribution comes from annual registration data for North Carolina from the NCDOT. For this analysis, the age distribution was generated based on 2008 data, the latest available count data at the time. The NCDOT provided the data based on the number of vehicle types per year from 1975 through 2008. The data obtained from the NCDOT has the vehicles greater than 25 years old combined and included as the 25<sup>th</sup> model year. Additionally, the NCDOT data has the vehicle count information provided for nine vehicle types; light duty gas vehicles (LDGV), light duty diesel vehicles (LDDV), light duty gas trucks 1 (LDGT1), light duty gas trucks 2 (LDGT2), light duty diesel trucks 1 (LDDT1), light duty diesel trucks 2 (LDDT2), heavy duty gas vehicles (HDGV), heavy duty diesel vehicles (HDDV) and motorcycles (MC). LDDT1 and LDDT2 are combined and labeled as light duty diesel trucks (LDDT). Since MOVES categorizes the vehicle fleet into different vehicle classes and more model years, the USEPA has created data converters

that take registration distribution input files created for MOBILE6.2 and converts them to the appropriate age distribution input tables for MOVES.

### 4.2.3 Vehicle Mix Assumptions

Vehicle mix or VMT mix is used by MOVES to convert annual VMT to VMT by HPMS class, VMT fractions by hour, and VMT by road type distribution. The vehicle mix is developed by the same method used in MOBILE6.2, as outlined below. The resulting file is then used in a MOVES supplied converter to develop the VMT by HPMS class, VMT fractions by hour, and VMT by road type distribution.

The vehicle mix refers to the percentage of different vehicle types on each of the 12 FHWA road types. These road types are listed above in the speed assumptions section. It is critical for estimating on-road mobile source emissions in an area to use data that accurately reflects the vehicles types traveling on each of these different road types.

In August 2004, the USEPA released the guidance document EPA420-R-04-013, Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation, which outlines how to convert the Highway Performance Monitoring System (HPMS) traffic count data to MOBILE6.2 vehicle mix data. Outlined below is the methodology used to convert the 13 HPMS vehicle types count data reported to FHWA and generate a state specific vehicle mix.

The North Carolina HPMS data used to generate the new statewide vehicle mix was based on 2008 data counts. This is the latest available statewide count information at the time of the modeling. Table 4.2.3-1 shows the percent of vehicles per vehicle type for each of the 12 road classes.

**Table 4.2.3-1 2008 North Carolina HPMS Data**

FC	Functional Classification	Samples	MC	Cars	2A4T	Bus	2ASU	3ASU	4ASU	4AST	5AST	6AST	5AMT	6AMT	7AMT
1	Rural Principal Arterial - Interstate	17	0.0038	0.6013	0.1372	0.0104	0.0286	0.0075	0.0005	0.0186	0.1765	0.0066	0.0051	0.0023	0.0015
2	Rural Principal Arterial - Other	69	0.0075	0.6682	0.1880	0.0078	0.0346	0.0118	0.0011	0.0134	0.0621	0.0029	0.0016	0.0006	0.0004
6	Rural Minor Arterial	32	0.0058	0.6678	0.2031	0.0090	0.0398	0.0122	0.0012	0.0132	0.0454	0.0020	0.0002	0.0001	0.0003
7	Rural Major Collector	20	0.0060	0.7232	0.1949	0.0054	0.0321	0.0105	0.0010	0.0076	0.0179	0.0010	0.0000	0.0000	0.0001
8	Rural Minor Collector	25	0.0072	0.7027	0.2082	0.0069	0.0421	0.0114	0.0007	0.0082	0.0114	0.0009	0.0000	0.0000	0.0002
9	Rural Local System	27	0.0113	0.6512	0.2273	0.0190	0.0568	0.0139	0.0012	0.0100	0.0077	0.0012	0.0000	0.0000	0.0003
11	Urban Principal Arterial - Interstate	21	0.0054	0.6678	0.1375	0.0089	0.0282	0.0105	0.0005	0.0147	0.1184	0.0033	0.0031	0.0012	0.0006
12	Urban Principal Arterial - Other Freeways or Expressways	13	0.0034	0.7132	0.1600	0.0068	0.0278	0.0090	0.0008	0.0130	0.0618	0.0022	0.0013	0.0004	0.0004
14	Urban Principal Arterial - Other	24	0.0056	0.7449	0.1701	0.0053	0.0292	0.0088	0.0012	0.0086	0.0242	0.0016	0.0002	0.0001	0.0003
16	Urban Minor Arterial	21	0.0061	0.7821	0.1575	0.0053	0.0280	0.0069	0.0006	0.0057	0.0064	0.0012	0.0000	0.0000	0.0002
17	Urban Collector	14	0.0077	0.7830	0.1620	0.0048	0.0262	0.0088	0.0002	0.0043	0.0025	0.0004	0.0000	0.0000	0.0001
19	Urban Local System	14	0.0104	0.7244	0.1839	0.0230	0.0364	0.0090	0.0003	0.0051	0.0065	0.0009	0.0000	0.0001	0.0000

#### 4.2.4 Disaggregating State Specific Information

Section 4.1.5 of Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation, illustrates how to map the HPMS statewide vehicle data to general MOBILE6.2 vehicle categories. This mapping is outlined in Table 4.2.4-1 below:

**Table 4.2.4-1 Mapping of HPMS data to MOBILE6.2 Categories**

HPMS Category	General Category
Motorcycle	Motorcycle (MC)
Passenger Car	Passenger Car (LDV)
Other 2-Axel, 4-Tire Vehicles	Light Truck (LDT)
Busses	Bus (HDB)
All Other Trucks: Single unit, 2-axel, 6-tire Single unit, 3-axel Single unit, 4 or more axel Single trailer, 4 or fewer axel Single trailer, 5-axel Single trailer, 6 or more axel Multi-trailer, 5 or fewer axel Multi-trailer, 6-axel Multi-trailer, 7 or more axel	Heavy Duty Truck (HDV)

The HPMS data in Table 4.2.3-1 was grouped into these five general categories for each road type. In order to expand the five general categories to the 16 vehicle types used in MOBILE6.2, the national average VMT fractions by each vehicle class were used. The 2008 fractions were used since the state specific data is from 2008. The national average data was obtained from Table 4.1.2 in Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation. An example for rural interstates is illustrated below:

From Table 4.2.3-1 above:

Passenger Cars	=	60.13%	5 axel Trailer	=	17.65%
Pickup Trucks	=	13.72%	6 axel Trailer	=	0.66%
Bus	=	1.04%	5 axel Multi Trailer	=	0.51%
2 axel Trucks	=	2.86%	6 axel Multi Trailer	=	0.23%
3 axel Trucks	=	0.75%	7 axel Multi Trailer	=	0.15%
4 axel Trucks	=	0.05%	Motorcycles	=	0.38%
4 axel Trailer	=	1.86%			



Therefore, the five general categories are:

Motorcycles	=	0.38%
Light Duty Vehicles	=	60.13%
Light Duty Trucks	=	13.72%
Heavy Duty Buses	=	1.04%
Heavy Duty Vehicles	=	24.73%

From Table 4.1.2 in Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation, the 2008 national average vehicle mix for light duty trucks, buses and heavy duty trucks are:

Light Duty Trucks			Heavy Duty Trucks		
LDT1	=	0.0846	HDV2B	=	0.0388
LDT2	=	0.2817	HDV3	=	0.0038
LDT3	=	0.0868	HDV4	=	0.0031
LDT4	=	0.0399	HDV5	=	0.0024
<hr/>			HDV6	=	0.0087
<b>Total</b>	=	<b>0.4930</b>	HDV7	=	0.0102
			HDV8A	=	0.0111
Buses			HDV8B	=	0.0397
HDBS	=	0.0020	<hr/>		
HDBT	=	0.0009	<b>Total</b>	=	<b>0.1178</b>
<hr/>					
<b>Total</b>	=	<b>0.0029</b>			

Using the methodology described in Section 4.1.5 in Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation the new 2008 North Carolina statewide mix was developed. The basic formula for developing the mix is shown below,

$$\text{Vehicle Type} = (\text{2008 M6.2 fraction for vehicle}) \times \frac{(\text{2008 State total for group})}{(\text{2008 M6.2 total for subcategory})}$$

Table 4.2.4-2 displays the calculation for each vehicle type for the 2008 rural interstate vehicle mix.

**Table 4.2.4-2 Calculation of New 2008 Statewide Rural Interstate Vehicle Mix**

Vehicle Type		Calculation		New 2008 Mix
LDV	=	LDV	=	0.6013
MC	=	MC	=	0.0038
Light Duty Trucks				
LDT1	=	$0.0846 \times (0.1372/0.4930)$	=	0.0235
LDT2	=	$0.2817 \times (0.1372/0.4930)$	=	0.0784
LDT3	=	$0.0868 \times (0.1372/0.4930)$	=	0.0242
LDT4	=	$0.0399 \times (0.1372/0.4930)$	=	0.0111
Heavy Duty Vehicles				
HDV2B	=	$0.0388 \times (0.2473/0.1178)$	=	0.0815
HDV3	=	$0.0038 \times (0.2473/0.1178)$	=	0.0080
HDV4	=	$0.0031 \times (0.2473/0.1178)$	=	0.0065
HDV5	=	$0.0024 \times (0.2473/0.1178)$	=	0.0050
HDV6	=	$0.0087 \times (0.2473/0.1178)$	=	0.0183
HDV7	=	$0.0102 \times (0.2473/0.1178)$	=	0.0214
HDV8A	=	$0.0111 \times (0.2473/0.1178)$	=	0.0233
HDV8B	=	$0.0397 \times (0.2473/0.1178)$	=	0.0833
Buses				
HDBS	=	$0.0020 \times (0.0104/0.0029)$	=	0.0072
HDBT	=	$0.0009 \times (0.0104/0.0029)$	=	0.0032

2008, 2011, 2014, 2017 and 2021 Statewide Vehicle Mix

Once the 2008 new vehicle mix was generated, the other years were created using the methodology described in Section 4.1.4 in Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation. This method grouped light duty vehicles, light duty trucks and motorcycles together and heavy duty buses, heavy duty trucks and heavy duty vehicles together. The combined percentages for these groupings are listed below.

Light Duty Vehicles = 74.23%

Heavy Duty Vehicles = 25.77%

The MOBILE6.2 vehicle mix fractions for the year being developed were obtained from Table 4.1.2 in Technical Guidance on the Use of MOBILE6.2 for Emission Inventory Preparation. The MOBILE6.2 vehicle fractions for 2008 are listed below.

Light Duty Vehicles			Heavy Duty Vehicles		
LDV	=	0.3807	HDV2B	=	0.0388
LDT1	=	0.0846	HDV3	=	0.0038
LDT2	=	0.2817	HDV4	=	0.0031
LDT3	=	0.0868	HDV5	=	0.0024
LDT4	=	0.0399	HDV6	=	0.0087
MC	=	0.0056	HDV7	=	0.0102
<b>Total</b>	=	<b>0.8793</b>	HDV8A	=	0.0111
			HDV8B	=	0.0397
			HDBS	=	0.0020
			HDBT	=	0.0009
			<b>Total</b>	=	<b>0.1207</b>

The North Carolina 2008 vehicle mix was normalized to the MOBILE6.2 fractions using the following formula:

$$\text{Vehicle Type} = (\text{2008 M6 fraction for vehicle}) \times \frac{(\text{2008 State total for group})}{(\text{2008 M6 total for group})}$$

Table 4.2.4-3 below displays the calculations used to generate the 2008 North Carolina vehicle mix for rural interstate.

**Table 4.2.4-3 Calculation of 2008 Statewide Rural Interstate Vehicle Mix**

Vehicle Type		Calculation		2008 State Mix
Light Duty Vehicles				
LDV	=	$0.3807 \times (0.7386/0.8737)$	=	0.3219
LDT1	=	$0.0846 \times (0.7386/0.8737)$	=	0.0715
LDT2	=	$0.2817 \times (0.7386/0.8737)$	=	0.2381
LDT3	=	$0.0868 \times (0.7386/0.8737)$	=	0.0734
LDT4	=	$0.0399 \times (0.7386/0.8737)$	=	0.0337
MC	=			0.0038
Heavy Duty Vehicles				
HDV2B	=	$0.0388 \times (0.2472/0.1178)$	=	0.0814
HDV3	=	$0.0038 \times (0.2472/0.1178)$	=	0.0080
HDV4	=	$0.0031 \times (0.2472/0.1178)$	=	0.0065
HDV5	=	$0.0024 \times (0.2472/0.1178)$	=	0.0050
HDV6	=	$0.0087 \times (0.2472/0.1178)$	=	0.0183
HDV7	=	$0.0102 \times (0.2472/0.1178)$	=	0.0214
HDV8A	=	$0.0111 \times (0.2472/0.1178)$	=	0.0233
HDV8B	=	$0.0397 \times (0.2472/0.1178)$	=	0.0833
HDBS	=	$0.0020 \times (0.0104/0.0029)$	=	0.0072
HDBT	=	$0.0009 \times (0.0104/0.0029)$	=	0.0032

This method was used to generate all of the future year vehicle mixes that were needed to compute the emission factors. The North Carolina transportation partners consider the statewide vehicle mix to be the best representation of the vehicle population in the Hickory and Triad nonattainment area. The vehicle mixes for all years can be found in Section 5.1 of this appendix.

As stated earlier in this section, vehicle mix or VMT mix is used in MOVES converters to develop VMT by HPMS class, VMT fractions by hour, and VMT by road type distribution, which are inputs to the model.

#### **4.2.5 Vehicles/Equipment: On-Road Vehicle Equipment**

The Vehicles/Equipment menu item and panel is used to specify the vehicle types that are included in the MOVES run. MOVES allows the user to select from among 13 “source use

types” (the terminology that MOVES uses to describe vehicle types), and four different fuel types (gasoline, diesel, compressed natural gas (CNG), and electricity).

For SIP and regional conformity analyses, users must select the appropriate fuel and vehicle type combinations in the On Road Vehicle Equipment panel to reflect the full range of vehicles that will operate in the county. For this analysis all valid diesel, gasoline, and CNG (only transit buses) vehicle and fuel combinations were selected.

#### **4.2.6 Road Type**

The Road Type Panel is used to define the types of roads that are included in the run. MOVES defines five different Road Types:

- Off-Network (roadtype 1) – all locations where the predominant activity is vehicle starts, parking and idling (parking lots, truck stops, rest areas, freight or bus terminals)
- Rural Restricted Access (2) – rural highways that can only be accessed by an on-ramp
- Rural Unrestricted Access (3) – all other rural roads (arterials, connectors, and local streets)
- Urban Restricted Access (4) – urban highways or freeways that can only be accessed by an on-ramp
- Urban Unrestricted Access (5) – all other urban roads (arterials, connectors, and local streets)

Users should select the road types present in the area being analyzed. The determination of rural or urban road types should be based on the HPMS classification of the roads in the county being analyzed.

The NCDAQ followed the USEPA guidance that states that all SIP and regional conformity analyses must include the Off-Network road type in order to account for emissions from vehicle starts, extended idle activity, and evaporative emissions (for hydrocarbons). The Off-Network road type is automatically selected when start or extended idle pollutant processes are chosen and must be selected for all evaporative emissions to be quantified. Off-Network activity in MOVES is primarily determined by the Source Type Population input, which is described in Section 4.2.9 of this document. Some evaporative emissions are estimated on roadways (i.e., roadtypes 2, 3, 4, and 5) to account for evaporative emissions that occur when vehicles are driving. All roads types are automatically selected when Refueling emission processes are selected.

MOVES uses Road Type to assign default drive cycles to activity on road types 2, 3, 4, and 5. For example, for unrestricted access road types, MOVES uses drive cycles that assume stop and go driving, including multiple accelerations, decelerations, and short periods of idling. For restricted access road types, MOVES uses drive cycles that include a higher fraction of cruise activity with less time spent accelerating or idling, although some ramp activity is also included.

#### **4.2.7 Pollutants and Processes**

In MOVES, pollutant refers to particular types of pollutants or precursors of the pollutant, such as PM or NO<sub>x</sub>, while process refers to the mechanism by which emissions are created, such as running exhaust or start exhaust. Users must select all processes associated with a particular pollutant in order to account for all emissions of that pollutant. For example, there are 11 separate pollutant processes in MOVES for hydrocarbon emissions; all 11 must be selected when estimating hydrocarbon emissions for SIPs or regional conformity analyses. For this maintenance plan, the pollutants under consideration were NO<sub>x</sub>, PM<sub>2.5</sub>, and SO<sub>2</sub>.

#### **4.2.8 Temperature, Relative Humidity and Barometric Pressure Assumptions**

Local temperature and humidity data are required inputs for SIP and regional conformity analyses with MOVES. Ambient temperature is a key factor in estimating emission rates for on-road vehicles with substantial effects on most pollutant processes. Relative humidity is also important for estimating NO<sub>x</sub> emissions from motor vehicles. MOVES requires a temperature (in degrees Fahrenheit) and relative humidity (in percent – 0 to 100 scale) for each hour selected in the Run Spec. For example, MOVES requires a 24-hour temperature and humidity profile to model a full day of emissions on an hourly basis. For mobile source emission estimates, the NCDAQ used 2008 monthly averages for the 24-hour temperature profile from the Hickory Airport for Catawba County and the Triad Regional Airport for Davidson and Guilford Counties. Data were obtained by the NCDAQ meteorologists from North Carolina State Climate Retrieval and Observations Network of the Southeast Database (CRONOS). The temperature and relative humidity profiles as presented in the MOVES input files are listed in Section 5.2 for each month.

#### **4.2.9 Source Type Population**

Source type (i.e., vehicle type) population is used by MOVES to calculate start and evaporative emissions. In MOBILE6.2, starts and evaporative emissions were calculated as emission factors in grams per mile. As a result, start and evaporative emissions were related to VMT. However, the relationship between VMT and vehicle starts or evaporative emissions is not always consistent. Chained trips may involve multiple starts with relatively low VMT. Evaporative emissions depend more on how long a vehicle is parked than how many miles it is driven. In MOVES, start and resting evaporative emissions are related to the population of vehicles in an

area. Since vehicle type population directly determines start and evaporative emission, users must develop local data for this input.

MOVES uses a vehicle classification system based on the way vehicles are classified in the Federal Highway Administration's HPMS rather than on the way they are classified in the USEPA emissions regulations; thus making it easier for users to develop local data for MOVES. MOVES categorizes vehicles into 13 source types, which are subsets of 6 HPMS vehicle types in MOVES, as shown in the crosswalk in Table 4.2.9-1. The USEPA believes that states should be able to develop population data for many of these source type categories from state motor vehicle registration data (e.g., motorcycles, passenger cars, passenger trucks, light commercial trucks) and from local transit agencies, school districts, bus companies, and refuse haulers (intercity, transit, and school buses, and refuse trucks). The NCDOT supplied the NCDAQ with source population data as described in the following section.

Table 4.2.9-1 MOVES Source Types and HPMS Vehicle Types			
Source Type ID	Source Types	HPMS Vehicle Type ID	HPMS Vehicle Type
11	Motorcycle	10	Motorcycles
21	Passenger Car	20	Passenger Cars
31	Passenger Truck	30	Other 2 axle-4 tire vehicles
32	Light Commercial Truck	30	Other 2 axle-4 tire vehicles
41	Intercity Bus	40	Buses
42	Transit Bus	40	Buses
43	School Bus	40	Buses
51	Refuse Truck	50	Single Unit Trucks
52	Single Unit Short-haul Truck	50	Single Unit Trucks
53	Single Unit Long-haul Truck	50	Single Unit Trucks
54	Motor Home	50	Single Unit Trucks
61	Combination Short-haul Truck	60	Combination Trucks
62	Combination Long-haul Truck	60	Combination Trucks

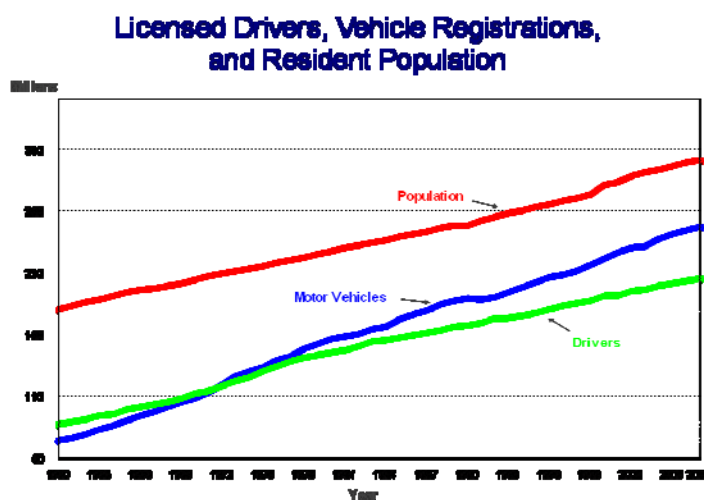
#### Source Type Population – Local Data

MOVES uses allocation factors to distribute emissions and activity (such as vehicle type populations) to individual counties. The NCDAQ is committed to using representative local data which will over ride MOVES default values through the County Data Manager. This decision was based on the fact that default allocation factors used in MOVES are derived from the VMT. Since the allocations are based on VMT, the vehicle populations allocated to counties are proportional to the VMT being allocated to that county. The NCDAQ corresponded with

USEPA Office of Transportation and Air Quality (OTAQ) to arrive at an acceptable method to allocate current year as well as to project future year vehicle populations to source type populations. The NCDAQ believes that using MOVES default vehicle population to estimate a fraction is the best method of taking state specific vehicle registration data and allocating county total vehicles to specific vehicle source types.

MOVES categorize vehicles into 13 source types, which are subsets of 6 HPMS vehicle types. Presently the NCDAQ is unable to develop county source type population data for many of these source type categories based on how the NCDOT collects vehicle registration data. The latest vehicle registration data broken down by county and towns is available by January of each year. Because the vehicle types database available from the NCDOT differs from what MOVES2010 expects, the NCDAQ relies on MOVES default fractions and applies these fractions to the county total vehicle population minus trailers. It is assumed that trailers do not have engines and do not generate VMT.

For future year MOVES runs, the NCDAQ needed to be able to grow the vehicle population reflective of the county of interest. From FHWA Highway Statistics graph of Licensed Drivers, Vehicle Registrations, and Resident Population (Figure 4.2.9-1), the NCDAQ has determined that growth in human population is a better indicator of growth in vehicle ownership as compared to VMT growth.



**Figure 4.2.9-1 Federal Highway Association Statistics Graph**

In order to forecast future year vehicle population and disaggregate to the appropriate source type, a reliable source of county population is needed. The North Carolina Office of State Budget and Management (OSBM) coordinates with the Census Bureau in the Federal State Cooperative



Program for population estimates for all state government data, with special emphasis on a consistent set of population projections. On the OSBM website are annual certified county population estimates which account for births, deaths and natural growth representing a net migration populous on the county level.

Population data is updated annually in May and certified by September for the previous year's data. Projected annual county population estimates are available to adjust future year county vehicle populations as needed. The USEPA has indicated that using human population growth as a surrogate to project vehicle population growth is an acceptable option. An example of how a 2008 vehicle population would be grown to 2011 based on this surrogate of projected county population follows:

$$\text{Vehicle Pop}_{2011} = \text{Vehicle Pop}_{2008} * (\text{Human Pop}_{2011} / \text{Human Pop}_{2008})$$

#### **4.2.10 Vehicle Inspection and Maintenance Program Assumptions**

In 2002, North Carolina implemented a new vehicle emissions inspection program referred to as onboard diagnostics (OBDII). This program covers all light duty gasoline powered vehicles that are model year 1996 and newer. The program was initially implemented in 9 counties and was expanded to include a total of 48 counties between July 2002 and January 2006. Guilford County was phased in July 2002. Davidson and Catawba Counties were phased-in July 1, 2003.

Inspection and maintenance programs continue to be important local control programs in many nonattainment areas. MOVES has simplified I/M program inputs compared to MOBILE6.2, but it includes the capability of modeling all the aspects of an I/M program that have a significant impact on vehicle emissions. The USEPA recommends that users modeling an existing I/M program in MOVES begin by examining the default I/M program description included in MOVES for the particular county in question. The NCDAQ modified the default data in MOVES to reflect county specific compliance factors.

#### **4.2.11 Reid Vapor Pressure (RVP) Assumptions**

RVP reflects a gasoline's volatility. During the winter months an RVP of 15.0 pounds per square inch (psi) is allowable. As ambient air temperatures increase, so does the volatility of gasoline. Lower RVP leads to lower VOC emissions from gasoline handling and lowers vapor losses from motor vehicles. An RVP of 9.0 psi is required during May through September for Catawba County. An RVP of 9.0 psi is required for Davidson and Guilford Counties in May, but further reduces to an RVP of 7.8 psi for June through September.

#### **4.2.12 Diesel Sulfur Content Assumptions**

The diesel fuel sulfur content is required in MOVES to generate PM<sub>2.5</sub> emissions because the amount of sulfur in diesel fuel directly correlates to sulfate particulate emissions. For the MVEBs calculation, the USEPA recommends a diesel fuel sulfur content of 43 parts per million (ppm) for the period June 2006 through May 2010 and 11 ppm for June 2010 and beyond, for all of the nonattainment counties. The USEPA's OTAQ was contacted at the time of this submission to verify that there was no update to this guidance.

#### **4.2.13 Fuel (Formulation and Supply)**

In general, users should first review the MOVES default fuel formulation and fuel supply data, and then make changes only where local volumetric fuel property information is available. The lone exception to this guidance is in the case of RVP where a user should change the value to reflect the regulatory requirements and differences between ethanol- and non-ethanol blended gasolines. The current version of MOVES does not allow the user to create new fuel identification numbers. Thus, per current The USEPA guidance, the NCDAQ edited the default fuel supply tables for the individual counties to reflect the county-specific RVP data.

#### **4.3 VMT Assumptions**

As input, MOVES requires *annual* VMT by HPMS vehicle class. The USEPA has created a tool that allows users to input average annual VMT as well as monthly and weekend day adjustment factors to create the annual VMT by HPMS class and appropriate monthly and daily adjustments needed by MOVES. The USEPA has also created a set of software tools that can import VMT tables by MOBILE6.2 vehicle types (either 8, 12, 16, or 28 MOBILE6.2 vehicle types) and facility types, as well as MOBILE6.2 hourly VMT fractions, VMT mix, and ramp fractions and convert these to the equivalent MOVES tables of VMT by HPMS class, VMT fractions by hour, and road type distribution.

Mapping MOBILE6.2 vehicle types to their equivalent MOVES source types is a complex process. The USEPA strongly encourages states to use the converter tools to create the appropriate MOVES input tables from MOBILE6.2 data to avoid errors.

The modeled and non-modeled VMT for the Triad nonattainment area was provided by PART on February 11, 2009 for the years 2008, 2011, 2014, 2017, and in September 2009 for the year 2021. The non-modeled VMT for the Hickory nonattainment area was provided by the NCDOT in September 2009 for the years 2008, 2011, 2015, 2020, and 2025, which were interpolated to the required years. The modeled VMT for Catawba County were received for the years 2007,

2015, 2020, and 2025 and interpolated to the years needed. Tables 4.3-1 through 4.3-5 list the VMT used in the MVEBs calculations.

**Table 4.3-1 Modeled Vehicle Miles Traveled for Davidson County**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	395,808	427,523	454,579	482,342	520,791
Urban Freeway or Expressway	410,216	436,626	489,844	529,960	566,161
Urban Other Principal Arterial	400,851	417,566	424,786	445,799	485,302
Urban Minor Arterial	313,228	333,766	349,383	369,146	399,106
Urban Collector	174,365	188,452	204,905	216,695	228,296
Urban Local	263,573	282,255	299,328	314,619	334,105
Rural Interstate	205,714	221,276	236,619	251,896	272,214
Rural Other Principal Arterial	0	0	0	301	350
Rural Minor Arterial	210,241	224,000	239,192	266,365	310,129
Rural Major Collector	164,069	175,155	185,178	195,299	209,788
Rural Minor Collector	134,626	144,647	154,644	161,725	169,253
Rural Local	278,885	301,554	319,434	331,683	346,180

**Table 4.3-2 Vehicle Miles Traveled for Davidson County Rural Donut Area**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	342,756	364,745	374,943	385,141	398,738
Urban Freeway or Expressway	195,218	205,614	211,362	217,111	224,776
Urban Other Principal Arterial	271,728	284,492	292,446	300,400	311,005
Urban Minor Arterial	246,395	254,965	262,094	269,222	278,727
Urban Collector	94,146	107,235	110,233	113,232	117,229
Urban Local	96,153	98,562	101,318	104,074	107,748
Rural Interstate	255,299	251,587	258,621	265,655	275,034
Rural Other Principal Arterial	152,576	149,062	153,229	157,397	162,954
Rural Minor Arterial	198,073	198,673	204,228	209,783	217,189
Rural Major Collector	241,204	238,551	245,220	251,890	260,783
Rural Minor Collector	160,589	165,660	170,292	174,924	181,099
Rural Local	98,912	98,757	101,518	104,280	107,961

**Table 4.3-3 Vehicle Miles Traveled for Guilford County**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	3,985,564	4,419,157	4,865,961	5,227,576	5,686,133
Urban Freeway or Expressway	2,251,352	2,452,593	2,613,197	2,905,078	3,399,412
Urban Other Principal Arterial	2,368,151	2,477,254	2,591,662	2,679,083	2,770,030
Urban Minor Arterial	2,727,044	2,837,423	3,012,805	3,147,788	3,280,571
Urban Collector	1,368,123	1,452,017	1,570,260	1,645,148	1,700,307
Urban Local	780,183	815,646	847,770	878,533	917,755
Rural Interstate	989,050	1,090,492	1,229,196	1,351,896	1,492,538
Rural Other Principal Arterial	513,834	545,289	546,548	567,373	605,086
Rural Minor Arterial	244,663	273,514	278,683	287,233	304,790
Rural Major Collector	776,249	838,619	898,783	941,639	993,028
Rural Minor Collector	360,879	393,534	420,122	448,880	491,674
Rural Local	411,379	435,206	655,193	721,391	643,883

**Table 4.3-4 Vehicle Miles Traveled for Catawba County Modeled Portion**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	1,082,650	1,173,558	1,264,465	1,343,145	1,439,900
Urban Freeway or Expressway	326,299	355,400	384,500	413,800	453,001
Urban Other Principal Arterial	875,547	924,218	972,889	1,020,227	1,082,454
Urban Minor Arterial	922,232	978,471	1,034,710	1,084,007	1,145,109
Urban Collector	296,562	321,947	347,332	369,591	397,186
Urban Local	249,239	279,431	309,622	335,319	366,584
Rural Interstate	55,519	60,555	65,591	70,918	78,214
Rural Other Principal Arterial	203,044	223,934	244,824	266,142	294,853
Rural Minor Arterial	116,496	127,525	138,554	151,696	170,628
Rural Major Collector	97,859	108,994	120,128	130,182	142,869
Rural Minor Collector	206,017	227,192	248,367	268,052	293,307
Rural Local	83,014	91,622	100,230	108,227	118,484

**Table 4.3-5 Vehicle Miles Traveled for Catawba County Rural Donut Area**

Functional Class	2008	2011	2014	2017	2021
Urban Interstate	121,399	130,012	135,296	140,580	147,625
Urban Freeway or Expressway	48,073	51,483	53,576	55,668	58,458
Urban Other Principal Arterial	134,146	143,663	149,502	155,341	163,126
Urban Minor Arterial	103,768	111,130	115,647	120,163	126,185
Urban Collector	28,738	30,777	32,027	33,278	34,946
Urban Local	93,964	100,630	104,720	108,810	114,263
Rural Interstate	16,696	17,880	18,607	19,334	20,303
Rural Other Principal Arterial	35,762	38,299	39,855	41,412	43,487
Rural Minor Arterial	53,291	57,072	75,073	82,619	85,712
Rural Major Collector	26,637	28,527	29,686	30,846	32,392
Rural Minor Collector	49,311	52,810	54,956	57,102	59,964
Rural Local	27,521	29,474	30,671	31,869	33,466

#### 4.4 Estimated Emissions From Mobile Sources

Using the inventory approach in the MOVES model gives a summary of emissions in tons per year, by county. Table 4.4-1 summarizes NO<sub>x</sub>, PM<sub>2.5</sub>, and SO<sub>2</sub> emissions, respectively.

**Table 4.4-1 Emissions by County and year**

County\Year	2008	2011	2014	2017	2021
<b>NO<sub>x</sub> Emissions (tons per year)</b>					
<b>Hickory Area</b>					
Catawba	4,982	4,005	3,240	2,591	2,054
<b>Triad Area</b>					
Davidson	5,267	4,095	3,227	2,536	1,974
Guilford	14,499	11,157	8,882	7,143	5,796
Triad Total	19,766	15,252	12,109	9,679	7,770

**Table 4.4-1 Emissions by County and year (Continued)**

<b>County\Year</b>	<b>2008</b>	<b>2011</b>	<b>2014</b>	<b>2017</b>	<b>2021</b>
<b>SO2 Emissions (tons per year)</b>					
Hickory Area					
Catawba	35	20	18	19	20
Triad Area					
Davidson	36	19	17	18	18
Guilford	111	62	55	59	63
Triad Total	147	81	72	77	81
<b>PM2.5 Emissions (tons per year)</b>					
Hickory Area					
Catawba	166	127	107	89	73
Triad Area					
Davidson	169	121	97	77	60
Guilford	465	330	272	221	183
Triad Total	634	451	369	298	243

## 4.5 Motor Vehicle Emissions Budget for Conformity

### 4.5.1 Transportation Conformity

The purpose of transportation conformity is to ensure that Federal transportation actions occurring in a nonattainment area do not hinder the area from attaining and/or maintaining the annual PM<sub>2.5</sub> standard. This means that the level of emissions estimated by the NCDOT or the MPOs for the Transportation Improvement Program and Long Range Transportation Plan must not exceed the MVEBs as defined in this maintenance plan.

### 4.5.2 Pollutants to be Considered

40 CFR 93.119(f)(7) through (10) identifies the pollutants for PM<sub>2.5</sub> that regional emissions analysis needs to be performed for transportation conformity purposes. These parts of the rule are listed below:

*§119(f)(7) – PM<sub>2.5</sub> in PM<sub>2.5</sub> areas;*

*§119(f)(8) – Reentrained road dust in PM<sub>2.5</sub> areas only if the EPA [Environmental Protection Agency] Regional Administrator or the director of the State air agency has made a finding that emissions from reentrained road dust within the area are a significant contributor to the PM<sub>2.5</sub> nonattainment problem and has so notified the MPO and DOT [Department of Transportation];*

*§119(f)(9) – NO<sub>x</sub> [nitrogen oxides] in PM<sub>2.5</sub> areas, unless the EPA Regional Administrator and the director of the State air agency have made a finding that emissions of NO<sub>x</sub> from within the area are not a significant contributor to the PM<sub>2.5</sub> nonattainment problem and has so notified the MPO and DOT; and*

*§119(f)(10) – VOC, SO<sub>2</sub> and/or ammonia in PM<sub>2.5</sub> areas if the EPA Regional Administrator or the director of the State air agency has made a finding that any of such precursor emissions from within the area are a significant contributor to the PM<sub>2.5</sub> nonattainment problem and has so notified the MPO and DOT.*

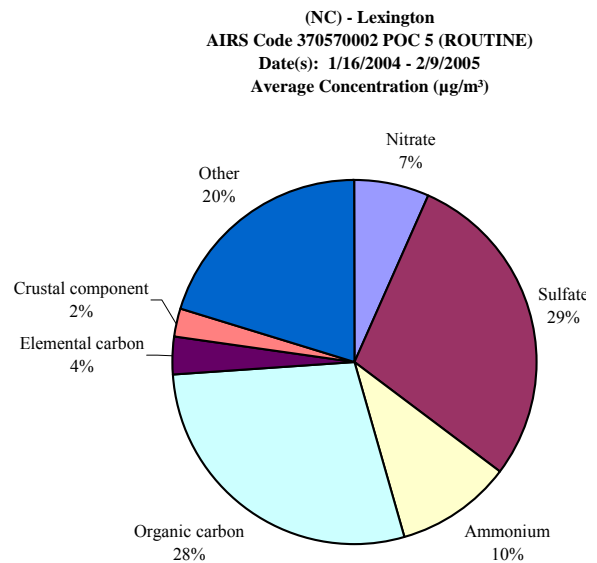
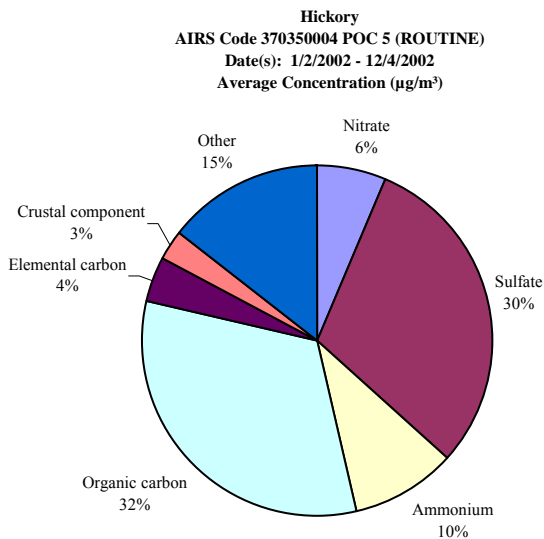
Only primary, or direct PM<sub>2.5</sub>, tailpipe emissions must be considered for transportation conformity regional emissions analysis. The other precursor pollutants and reentrained road dust only need to be considered if the State air agency and/or the USEPA has deemed the pollutant as a significant contributor to the PM<sub>2.5</sub> nonattainment problem. The following sections discuss the significance of the precursor pollutants and reentrained road dust to the PM<sub>2.5</sub> nonattainment problem.

#### Precursor Pollutants NO<sub>x</sub>, VOC, and Ammonia

The PM<sub>2.5</sub> precursor NO<sub>x</sub> is presumed to be a significant contributor to the PM<sub>2.5</sub> nonattainment problem by the USEPA. The NCDAQ has determined that NO<sub>x</sub> is a relatively minor contributor to the PM<sub>2.5</sub> concentrations in North Carolina. However, the NCDAQ is not asserting that NO<sub>x</sub> is an insignificant precursor for the 1997 PM<sub>2.5</sub> standard. Therefore, the NCDAQ will establish county level MVEBs for NO<sub>x</sub> for all three PM<sub>2.5</sub> nonattainment counties.

For the purpose of this attainment demonstration, VOC and ammonia are presumed to be insignificant contributors to the PM<sub>2.5</sub> nonattainment problem by the USEPA. The NCDAQ agrees with the USEPA that both VOC and ammonia are insignificant contributors to the PM<sub>2.5</sub> nonattainment problem in North Carolina. Since these precursors have been deemed insignificant, no MVEBs are being established for VOC or ammonia.

An affirmative insignificance finding from the USEPA only relieves the transportation partners from a regional emissions analysis for PM<sub>2.5</sub> emissions for these areas and does not relieve them



**Figure 4.5.2-1. Speciated Data for the Hickory area (left) and the Triad area (right)**

of the other transportation conformity requirements. The transportation partners will need to note the  $\text{PM}_{2.5}$  insignificance finding (if found adequate and approved by the USEPA) in future conformity determinations.

#### Reentrained Road Dust

The majority of the roads in North Carolina are paved so there is minimum road dust due to the paved roads. The factor to calculate reentrained road dust on paved roads is very small. What dust is generated, has been shown in the literature, *Methodology to Estimate the Transportable Fraction (TF) of Fugitive Dust Emissions for Regional and Urban Scale Air Quality Analyses*, *US EPA, August 3, 2005*, to be inconsequential.

This fact is affirmed by the small crustal component in the  $\text{PM}_{2.5}$  speciated data which measures only 3% at Hickory monitoring site (Catawba County) in 2002 and only 2% at Lexington monitoring site (Davidson County) in 2004 (see Figure 4.5.2-1 below).

Since the reentrained road dust is not a significant contributor to the  $\text{PM}_{2.5}$  nonattainment problem, the NCDAQ will not be establishing MVEBs for this source category. An affirmative insignificance finding from the USEPA only relieves the transportation partners from a regional emissions analysis for reentrained road dust emissions for these areas and does not relieve them of the other transportation conformity requirements. The transportation partners will need to note the reentrained road dust insignificance finding (if found adequate and approved by the USEPA) in future conformity determinations.



## Precursor Pollutant SO<sub>2</sub>

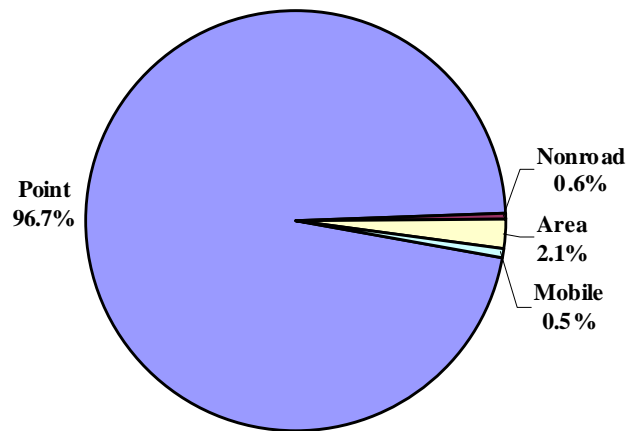
The PM<sub>2.5</sub> precursor SO<sub>2</sub> could not be deemed insignificant to the PM<sub>2.5</sub> nonattainment problem. However, the NCDAQ has determined that SO<sub>2</sub> emitted by the mobile source sector is insignificant. The USEPA in its Federal Register (FR) notice for PM<sub>2.5</sub> does not address the mobile sector in its listing of significant emissions. North Carolina agrees with the following statements addressing SO<sub>2</sub> from on-road mobile emissions as published in the May 6, 2005 Federal Register, (70 FR 24283):

*“While speciated air quality data show that sulfate is a relatively significant component (e.g., ranging from nine to 40 percent) of PM<sub>2.5</sub> mass in all regions of the country, emissions inventory data and projections show that on-road emissions of SO<sub>x</sub> constitute a “de minimis” (i.e., extremely small) portion of total SO<sub>x</sub> emissions. Emissions inventory data for 1999 for the 372 potential PM<sub>2.5</sub> nonattainment counties for PM<sub>2.5</sub> (based on 1999–2001 air quality data) show that on-road sources were responsible for only two percent of total SO<sub>x</sub> emissions.*

*Furthermore, EPA has already adopted two regulations that will greatly reduce emissions of SO<sub>x</sub> from on-road sources by the time such regulations are both in full effect in 2009. First, in 2004 the low sulfur gasoline program began to be phased in and will be fully effective in 2007 (February 10, 2000, 65 FR 6697). This regulation will reduce the sulfur content of gasoline by approximately 90 percent when fully effective. Second, in 2006 the low sulfur diesel program will begin to be phased in and will be fully effective by 2009 (January 18, 2001, 66 FR 5001). This regulation will reduce the sulfur content of diesel fuel by approximately 97 percent nationally when fully effective.*

*Projections of on-road emissions of SO<sub>2</sub> in 2020 indicate that on-road sources will be responsible for less than one percent of the total SO<sub>2</sub> emissions in 2020 in the 372 potential PM<sub>2.5</sub> nonattainment counties (based on 1999–2001 air quality data). These projections confirm that the implementation of the fuel regulations discussed above will ensure that as a general matter of SO<sub>2</sub> emissions from on-road sources remain at insignificant levels in all areas.”*

Although sulfate is a significant component to the PM<sub>2.5</sub> nonattainment problem in North Carolina, the majority of the SO<sub>2</sub> emissions (which can be oxidized to form SO<sub>4</sub>) in 2009 come from the stationary point source sector (see Figure 4.5.2-2). The mobile source sector only contributes one half of one percent (0.5 %) of the 2009 statewide SO<sub>2</sub> emissions. This is consistent with what the USEPA stated above.



**Figure 4.5.2-2. North Carolina's 2009 Statewide SO<sub>2</sub> Emissions**

Since the mobile source SO<sub>2</sub> contribution is insignificant, the NCDAQ is not establishing MVEBs for this precursor. An affirmative insignificance finding from the USEPA only relieves the transportation partners from a regional emissions analysis for SO<sub>2</sub> emissions for these areas and does not relieve them of the other transportation conformity requirements. The transportation partners will need to note the SO<sub>2</sub> insignificance finding (if found adequate and approved by the USEPA) in future conformity determinations.

#### Direct PM<sub>2.5</sub> Emissions

The NCDAQ believes strongly that the primary PM<sub>2.5</sub> emissions from mobile sources do not contribute significantly to the PM<sub>2.5</sub> nonattainment problem. However, the USEPA has indicated they will not approve a SIP that does not set MVEBs for primary PM<sub>2.5</sub> for the Triad. Therefore, the NCDAQ will establish county level MVEBs for primary PM<sub>2.5</sub> for the Triad. The sections that follow discuss the insignificance of PM<sub>2.5</sub> emissions for the Hickory area.

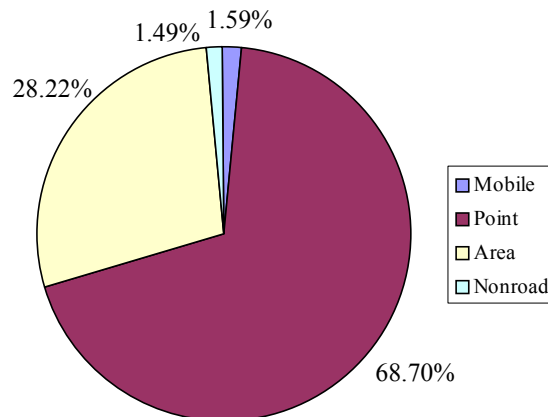
40 CFR 93.109(k) in the Transportation Conformity Rule Amendments for the new 8-hour ozone and fine particulate matter National Ambient Air Quality Standards (NAAQSs) addresses areas with insignificant motor vehicle emissions as follows,

*“Notwithstanding the other paragraphs in this section, an area is not required to satisfy a regional emissions analysis for §93.118 and/or §93.119 for a given pollutant/precursor and NAAQS, if EPA finds through the adequacy or approval process that a SIP demonstrates that regional motor vehicle emissions are an insignificant contributor to the air quality problem for that pollutant/precursor and NAAQS. The SIP would have to demonstrate that it would be unreasonable to expect that such an area would experience*

*enough motor vehicle emissions growth in that pollutant/precursor for a NAAQS violation to occur.”*

The rule suggests that such a finding would be based on a number of factors, including the percentage of motor vehicle emissions in the context of the total SIP inventory, the current state of air quality as determined by monitoring data for that NAAQS, the absence of SIP motor vehicle control measures, and historical trends and future projections of the growth of motor vehicle emissions. Although there is an inspection and maintenance program in the nonattainment areas, this control measure does not control primary PM<sub>2.5</sub>, but rather is in place to reduce the ozone precursors.

The attainment modeling for the Hickory (Catawba County) and the Triad (Davidson and Guilford Counties) PM<sub>2.5</sub> nonattainment areas was performed in conjunction with the regional haze modeling being done by the Southeast Regional Planning Organization, Visibility Improvement State and Tribal Association of the Southeast (VISTAS) and the fine particulate matter and ozone modeling being done by the Association of Southeastern Integrated Planning (ASIP). VISTAS and ASIP were run by the ten southeast states (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and West Virginia). In conjunction with that modeling the NCDAQ examined the sources of PM<sub>2.5</sub> emissions and their contribution to PM<sub>2.5</sub> formation in the nonattainment counties. This was accomplished using the 2009 emissions inventories developed for the VISTAS/ASIP modeling. Figure 4.5.2-3 provides the percent contributions from point, area, nonroad mobile and on-road mobile source sectors for the Hickory nonattainment area.

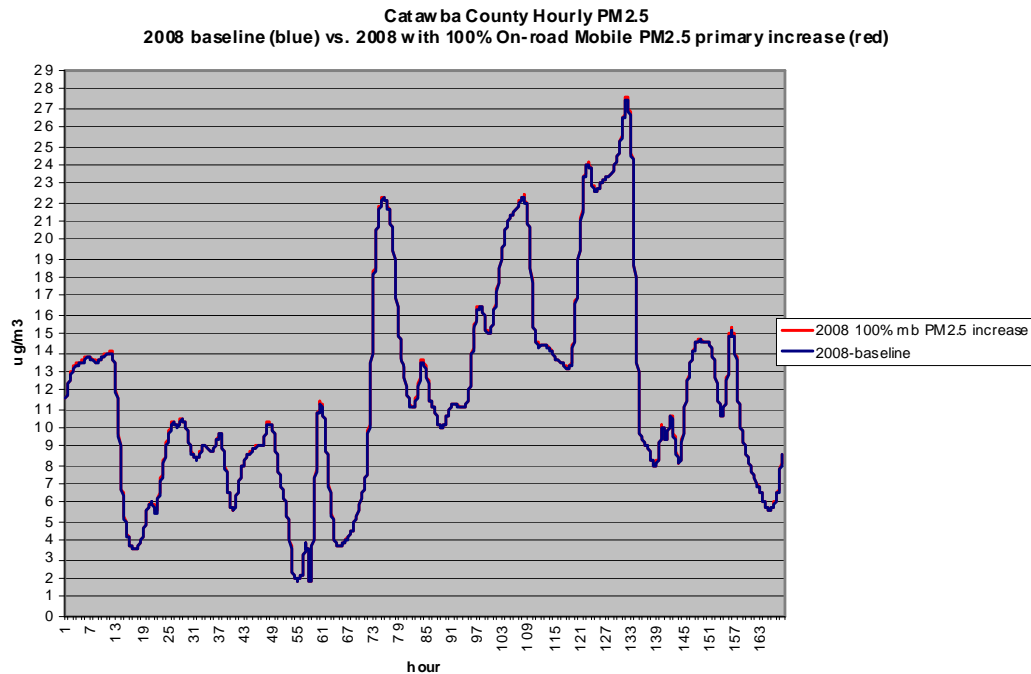


**Figure 4.5.2-3. Hickory Area 2009 Primary PM<sub>2.5</sub> Emissions**

The 2009 on-road mobile PM<sub>2.5</sub> emissions contributed only 1.6% of the total PM<sub>2.5</sub> emissions for the Hickory area. Therefore, it is demonstrated, that the PM<sub>2.5</sub> emissions compared to the total PM<sub>2.5</sub> emissions are insignificant. It should be noted that the mobile source PM<sub>2.5</sub> emissions slightly decrease from 2002 to 2009 despite an increase in VMT. The Hickory PM<sub>2.5</sub> emissions go from 100 tons/year in 2002 to 75 tons/year in 2009. Meanwhile, there is an increase in VMT in the Hickory area from 4,444,280 miles/day in 2002 to 5,081,590 miles/day in 2009. Further justification for the case insignificance of direct PM<sub>2.5</sub> emission follows.

The NCDAQ performed sensitivity modeling using 2008 emissions modeling in order to address the challenge of Section 93.109(k) in the Transportation Conformity Rule Amendments, “*The SIP would have to demonstrate that it would be unreasonable to expect enough motor vehicle emissions growth in that pollutant/precursor for a NAAQS violation to occur*”. The modeling system used was the same as the VISTAS/ASIP modeling and consisted of three components: 1) the Penn State University/National Center for Atmospheric Research Mesoscale Model (MM5 version 3.6.1+), 2) the Sparse Matrix Operator Kernel Emissions Modeling System (SMOKE version 2.1), and 3) the Community Multiscale Air Quality (CMAQ version 4.4) model. Model configurations, input data, and modeling methods are consistent with those suggested by the USEPA in Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS.

The primary PM<sub>2.5</sub> emissions from on-road mobile sources were doubled in Catawba, Davidson and Guilford Counties, therefore, simulating a doubling of the VMT during a 7-day summer time simulation. The results of the emissions sensitivities showed such similar results that looking at just the difference between two air quality model simulations, one with base case emissions and another with increased emissions inputs, showed no change. To show what the differences were between the two runs, line graphs of the hourly emissions for the time period modeled for Catawba County is displayed in Figures 4.5.2-3. The sensitivity modeling design value (DV) increased by 0.04 µg/m<sup>3</sup> in Catawba County. The difference is barely visible as seen in the figure below.



**Figure 4.5.2-4. Catawba County Hourly PM<sub>2.5</sub> Emissions**

Based on the information discussed above, the NCDAQ believes that the on-road mobile PM<sub>2.5</sub> emissions are insignificant contributors to the PM<sub>2.5</sub> nonattainment problem in Catawba County. Emission estimates indicate that the on-road mobile PM<sub>2.5</sub> emissions are a small percentage of the total PM<sub>2.5</sub> emissions in the Hickory nonattainment area. On-road mobile PM<sub>2.5</sub> emissions are projected to decrease into the future notwithstanding VMT increases. Air quality modeling sensitivities show that doubling the mobile source PM<sub>2.5</sub> emissions has very little effect on the future design values. The NCDAQ considers it unreasonable to expect that the Hickory PM<sub>2.5</sub> nonattainment area will experience enough motor vehicle PM<sub>2.5</sub> emissions growth for a future PM<sub>2.5</sub> violation to occur due to mobile sources.

Due to above analysis and agreement from the USEPA, budgets for direct PM<sub>2.5</sub> will not be set for the Hickory nonattainment area. An affirmative insignificance finding from the USEPA only relieves the transportation partners from a regional emissions analysis for PM<sub>2.5</sub> emissions for this area and does not relieve them of the other transportation conformity requirements. The transportation partners will need to note the PM<sub>2.5</sub> insignificance finding (if found adequate and approved by the USEPA) in future conformity determinations.

### 4.5.3 Safety Margin

A safety margin is the difference between the attainment level of emissions from all source categories (i.e., point, area, and mobile) and the projected level of emissions from all source

categories. The State may choose to allocate some of the safety margin to the MVEBs, for transportation conformity purposes, so long as the total level of emissions from all source categories remains below the attainment level of emissions. In this maintenance plan, the safety margin is the difference between the attainment level of emissions (2008) from all man-made sources and the projected level of emissions from all man-made sources in the nonattainment area. The safety margin for each projected year is listed below in Table 4.5.3-1 and 4.5.3-2.

**Table 4.5.3-1 Safety Margin for Hickory PM<sub>2.5</sub> Nonattainment Area**

Year	NOx		PM <sub>2.5</sub>	
	(tons/year)	(kilograms per year)	(tons/year)	(kilograms per year)
2011	-4,037	-3,662,304	-67	-60,781
2014	-5,073	-4,602,148	-126	-114,305
2017	-5,917	-5,367,811	-180	-163,293
2021	-6,618	-6,003,748	-253	-229,518

**Table 4.5.3-2 Safety Margin for Triad PM<sub>2.5</sub> Nonattainment Area**

Year	NOx		PM <sub>2.5</sub>	
	(tons/year)	(kilograms per year)	(tons/year)	(kilograms per year)
2011	-5,247	-4,759,998	-277	-251,290
2014	-9,150	-8,300,739	-490	-444,520
2017	-12,270	-11,131,155	-682	-618,700
2021	-14,759	-13,389,138	-919	-833,703

There are significant safety margins for both nonattainment areas for 2011 and 2021. The NCDAQ has decided to allocate a portion of the safety margin to the MVEBs to allow for unanticipated growth in VMT, changes to vehicle mix assumptions, etc. that will influence the emission estimations. However, since NOx is a precursor to ozone, we need to limit how much safety margin is added to the MVEBs. In 2008 the USEPA lowered the National Ambient Air Quality Standard for ozone to 0.075 ppm. The NCDAQ believes adding an additional 10% to the 2011 NOx emissions is appropriate for the 2011 NOx MVEBs and adding an additional 20% to the 2021 NOx emissions is appropriate for the 2021 NOx MVEBs to account for potential changes in VMT, vehicle mix and vehicle age distribution for Catawba, Davidson, and Guilford Counties. The NCDAQ believes that setting the 2011 and 2021 PM<sub>2.5</sub> MVEBs to the level of

PM<sub>2.5</sub> emissions present in 2008 is a sufficient safety margin for Davidson and Guilford Counties.

#### 4.5.4 Motor Vehicle Emission Budgets

As part of the consultation process on setting MVEBs, the NCDAQ sent out a request for comment on setting the geographic extent of the MVEBs to all of the transportation partners. A copy of the letter can be found in Appendix B. In the letter, the NCDAQ expressed its preference for setting county level budgets and the reasons why the NCDAQ believed county level budgets were appropriate. With respect to the PM<sub>2.5</sub> nonattainment areas, the NCDAQ received comments from the Greensboro MPO regarding the geographic extent of the MVEBs. The Greensboro MPO agreed with the NCDAQ that MVEBs should be set at the county level. A copy of the letter received that relates to the PM<sub>2.5</sub> nonattainment areas can be found in Appendix B. Therefore MVEBs will be set at the county level.

According to Section 93.118 of the transportation conformity rule, a maintenance plan must establish a MVEB for the last year of the maintenance plan (in this case, 2021). Through the interagency consultation process, it was decided that an interim MVEB would be set for the year 2011 for the Hickory and Triad maintenance plan.

Tables 4.5.3-1 and 4.5.3-2 below display the PM<sub>2.5</sub> and NO<sub>x</sub> emissions, respectively expressed in kilograms per year and the corresponding tons per year for the years MVEBs are being established. These two tables are for reference purposes only and are not the tables presenting the MVEBs.

**Table 4.5.4-1 On-Road Mobile Source PM<sub>2.5</sub> Emissions**

County	Kilograms/year		Tons/year	
	2011	2021	2011	2021
Davidson	109,769	54,431	121	60
Guilford	299,371	166,015	330	183
Triad Total	409,140	220,446	451	243

**Table 4.5.4-2 On-Road Mobile Source NOx Emissions**

County	Kilograms/year		Tons/year	
	2011	2021	2011	2021
Catawba	3,633,274	1,863,357	4,005	2,054
Davidson	3,714,921	1,790,782	4,095	1,974
Guilford	10,121,459	5,258,042	11,157	5,796
Triad Total	13,836,380	7,048,824	15,252	7,770

Although the emissions are usually expressed in terms of tons, the MVEBs will be set in terms of kilograms (kg). The NCDAQ will set MVEB, for transportation conformity purposes, as county budgets within the Hickory and Triad maintenance areas for 2011 and 2021. Tables 4.6.4-3 through 4.6.4-5 below list out the MVEBs in kilograms per year, for transportation conformity purposes, by county for the years 2011 and 2021. Upon the USEPA's affirmative adequacy finding for these county level sub-area MVEBs, these MVEBs will become the applicable MVEBs for each county.

**Table 4.5.4-3 Catawba County MVEB**

	2011	2021
<i>NO<sub>x</sub> Emissions (kg/year)</i>		
Base Emissions	3,633,274	1,863,357
Safety Margin Allocated to MVEB	363,327	372,671
<b>NO<sub>x</sub> Conformity MVEB</b>	<b>3,996,601</b>	<b>2,236,028</b>

**Table 4.5.4-4 Davidson County MVEB**

	2011	2021
<i>NO<sub>x</sub> Emissions (kg/year)</i>		
Base Emissions	3,714,921	1,790,782
Safety Margin Allocated to MVEB	371,492	358,156
<b>NO<sub>x</sub> Conformity MVEB</b>	<b>4,086,413</b>	<b>2,148,938</b>
<i>PM<sub>2.5</sub> Emissions (kg/year)</i>		
Base Emissions	109,769	54,431
Safety Margin Allocated to MVEB	43,544	98,882
<b>PM<sub>2.5</sub> Conformity MVEB</b>	<b>153,313</b>	<b>153,313</b>



**Table 4.5.4-5 Guilford County MVEB**

	2011	2021
<i>NO<sub>x</sub> Emissions (kg/year)</i>		
Base Emissions	10,121,459	5,258,042
Safety Margin Allocated to MVEB	1,012,146	1,051,608
<b>NO<sub>x</sub> Conformity MVEB</b>	<b>11,133,605</b>	<b>6,309,650</b>
<i>PM<sub>2.5</sub> Emissions (kg/year)</i>		
Base Emissions	299,371	166,015
Safety Margin Allocated to MVEB	122,470	255,826
<b>PM<sub>2.5</sub> Conformity MVEB</b>	<b>421,841</b>	<b>421,841</b>

Tables 4.5.4-6 and 4.5.4-7 list that portion of the safety margin that was added to the mobile source emissions to develop the MVEBs. These values can be compared to those in Tables 4.5.4-1 and 4.5.4-2 to see that NCDAQ added only a small fraction of that which was available. With these safety margins, it is projected that emissions from all source categories will remain below the attainment level emissions.

**Table 4.5.4-6 County Level PM<sub>2.5</sub> MVEB Safety Margin for 2011 and 2021**

County	2011 MVEB Safety Margin (Kilograms/year)	2021 MVEB Safety Margin (Kilograms/year)
Triad Total	166,014	354,708

**Table 4.5.4-7 County Level NO<sub>x</sub> MVEB Safety Margin for 2011 and 2021**

County	2011 MVEB Safety Margin (Kilograms/year)	2021 MVEB Safety Margin (Kilograms/year)
Catawba	363,327	372,671
Triad Total	1,383,638	1,409,764

For the Hickory nonattainment area, a total of 363,327 kg/year (400 tons/year) and 372,671 kg/year (411 tons/year) of the 2011 and 2021 NO<sub>x</sub> safety margins, respectively, were added to the NO<sub>x</sub> MVEBs.

For the Triad nonattainment area, a total of 1,383,638 kg/year (1,525 tons/year) and 1,409,764 kg/year 1,554 tons/year) of the 2011 and 2021 NO<sub>x</sub> safety margins, respectively, were added to the Triad NO<sub>x</sub> MVEBs. For PM<sub>2.5</sub>, a total of 166,014 kg/year (183 tons/year) and 354,708 kg/year (391 tons/year) of the 2011 and 2021 PM<sub>2.5</sub> safety margins, respectively, were added to the Triad PM<sub>2.5</sub> MVEBs. Tables 4.5.4-8 and 4.5.4-9 reflect the remaining safety margins.

**Table 4.5.4-8 New Safety Margins for the Hickory PM<sub>2.5</sub> nonattainment area**

Year	NO <sub>x</sub> TPY	PM <sub>2.5</sub> TPY
2011	-3,637	-67
2014	-5,073	-126
2017	-5,917	-180
2021	-6,207	-253

**Table 4.5.4-9 New Safety Margins for the Triad PM<sub>2.5</sub> nonattainment area**

Year	NO <sub>x</sub> TPY	PM <sub>2.5</sub> TPY
2011	-3,722	-94
2014	-9,150	-490
2017	-12,270	-682
2021	-13,205	-528

## 5.0 DATA USED

### 5.1 North Carolina's Vehicle Mix

#### 5.1.1 2008 State Vehicle Mix

2008 State Vehicle Mix							
Rural	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
LDV	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.3219	0.0715	0.2381	0.0734	0.0337	0.0814	0.0080	0.0065
0.0050	0.0183	0.0214	0.0233	0.0833	0.0072	0.0032	0.0038
Princ. Art.							
0.3731	0.0829	0.2761	0.0851	0.0391	0.0423	0.0041	0.0034
0.0026	0.0095	0.0111	0.0121	0.0433	0.0054	0.0024	0.0075
Minor Art.							
0.3796	0.0843	0.2808	0.0865	0.0398	0.0376	0.0037	0.0030
0.0023	0.0084	0.0099	0.0108	0.0385	0.0062	0.0028	0.0058
Major Collector							
0.4002	0.0889	0.2960	0.0912	0.0419	0.0232	0.0023	0.0019
0.0014	0.0052	0.0061	0.0066	0.0237	0.0037	0.0017	0.0060
Minor Collector							
0.3969	0.0882	0.2937	0.0905	0.0416	0.0247	0.0024	0.0020
0.0015	0.0055	0.0065	0.0071	0.0253	0.0048	0.0021	0.0072
Local							
0.3829	0.0851	0.2832	0.0873	0.0401	0.0300	0.0029	0.0024
0.0019	0.0067	0.0079	0.0086	0.0307	0.0131	0.0059	0.0113
Urban							
LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.3510	0.0780	0.2596	0.0800	0.0368	0.0594	0.0058	0.0047
0.0037	0.0133	0.0156	0.0170	0.0608	0.0061	0.0028	0.0054
Freeway							
0.3805	0.0845	0.2815	0.0867	0.0399	0.0384	0.0038	0.0031
0.0024	0.0086	0.0101	0.0110	0.0393	0.0047	0.0021	0.0034
Princ. Art.							
0.3987	0.0886	0.2950	0.0909	0.0418	0.0244	0.0024	0.0020
0.0015	0.0055	0.0064	0.0070	0.0250	0.0036	0.0016	0.0056
Minor Art							
0.4095	0.0910	0.3029	0.0933	0.0429	0.0161	0.0016	0.0013
0.0010	0.0036	0.0042	0.0046	0.0165	0.0037	0.0017	0.0061
Coll							
0.4117	0.0915	0.3047	0.0939	0.0432	0.0140	0.0014	0.0011
0.0009	0.0031	0.0037	0.0040	0.0143	0.0033	0.0015	0.0077
Local							
0.3957	0.0880	0.2929	0.0902	0.0415	0.0192	0.0019	0.0015
0.0012	0.0043	0.0050	0.0055	0.0196	0.0159	0.0072	0.0104

## 5.1.2 2011 State Vehicle Mix

2011 State Vehicle Mix							
Rural	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
LDV	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2894	0.0770	0.2561	0.0789	0.0363	0.0828	0.0081	0.0068
0.0051	0.0185	0.0219	0.0238	0.0845	0.0042	0.0021	0.0045
Princ. Art.							
0.3367	0.0896	0.2980	0.0918	0.0423	0.0438	0.0043	0.0036
0.0027	0.0098	0.0116	0.0126	0.0447	0.0022	0.0011	0.0052
Minor Art.							
0.3421	0.0909	0.3024	0.0932	0.0429	0.0396	0.0039	0.0032
0.0024	0.0088	0.0105	0.0114	0.0404	0.0020	0.0010	0.0053
Major Collector							
0.3606	0.0958	0.3188	0.0982	0.0452	0.0244	0.0024	0.0020
0.0015	0.0054	0.0064	0.0070	0.0249	0.0012	0.0006	0.0056
Minor Collector							
0.3581	0.0952	0.3167	0.0976	0.0449	0.0263	0.0026	0.0022
0.0016	0.0059	0.0069	0.0076	0.0269	0.0013	0.0007	0.0055
Local							
0.3471	0.0923	0.3070	0.0946	0.0435	0.0354	0.0034	0.0029
0.0022	0.0079	0.0093	0.0102	0.0361	0.0018	0.0009	0.0054
Urban							
LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.3161	0.0841	0.2797	0.0862	0.0397	0.0608	0.0059	0.0050
0.0037	0.0136	0.0161	0.0175	0.0620	0.0031	0.0016	0.0049
Freeway							
0.3418	0.0909	0.3023	0.0932	0.0429	0.0397	0.0039	0.0033
0.0024	0.0089	0.0105	0.0114	0.0405	0.0020	0.0010	0.0053
Princ. Art.							
0.3590	0.0954	0.3176	0.0979	0.0451	0.0255	0.0025	0.0021
0.0016	0.0057	0.0067	0.0073	0.0260	0.0013	0.0007	0.0056
Minor Art							
0.3691	0.0980	0.3262	0.1005	0.0463	0.0174	0.0017	0.0014
0.0011	0.0039	0.0046	0.0050	0.0178	0.0009	0.0004	0.0057
Coll							
0.3717	0.0988	0.3286	0.1013	0.0466	0.0152	0.0015	0.0012
0.0009	0.0034	0.0040	0.0044	0.0155	0.0008	0.0004	0.0057
Local							
0.3585	0.0952	0.3169	0.0977	0.0450	0.0261	0.0025	0.0021
0.0016	0.0058	0.0069	0.0075	0.0267	0.0013	0.0007	0.0055

### 5.1.3 2014 State Vehicle Mix

2014 State Vehicle Mix							
Rural	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
LDV	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2658	0.0811	0.2698	0.0831	0.0382	0.0827	0.0080	0.0068
0.0051	0.0186	0.0218	0.0237	0.0846	0.0042	0.0021	0.0044
Princ. Art.							
0.3095	0.0943	0.3139	0.0967	0.0445	0.0437	0.0042	0.0036
0.0027	0.0098	0.0115	0.0125	0.0447	0.0022	0.0011	0.0051
Minor Art.							
0.3143	0.0957	0.3186	0.0981	0.0451	0.0395	0.0038	0.0032
0.0024	0.0089	0.0104	0.0113	0.0405	0.0020	0.0010	0.0052
Major Collector							
0.3310	0.1009	0.3358	0.1034	0.0476	0.0243	0.0024	0.0020
0.0015	0.0055	0.0064	0.0070	0.0249	0.0012	0.0006	0.0055
Minor Collector							
0.3287	0.1003	0.3336	0.1028	0.0473	0.0263	0.0026	0.0022
0.0016	0.0059	0.0069	0.0075	0.0269	0.0013	0.0007	0.0054
Local							
0.3186	0.0972	0.3234	0.0996	0.0458	0.0353	0.0034	0.0029
0.0022	0.0080	0.0093	0.0101	0.0362	0.0018	0.0009	0.0053
Urban							
LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2904	0.0885	0.2946	0.0908	0.0417	0.0607	0.0059	0.0050
0.0037	0.0137	0.0160	0.0174	0.0621	0.0031	0.0016	0.0048
Freeway							
0.3140	0.0957	0.3185	0.0981	0.0451	0.0396	0.0039	0.0032
0.0024	0.0089	0.0104	0.0114	0.0406	0.0020	0.0010	0.0052
Princ. Art.							
0.3296	0.1005	0.3345	0.1030	0.0474	0.0255	0.0025	0.0021
0.0016	0.0057	0.0067	0.0073	0.0261	0.0013	0.0007	0.0055
Minor Art							
0.3387	0.1033	0.3436	0.1059	0.0487	0.0174	0.0017	0.0014
0.0011	0.0039	0.0046	0.0050	0.0178	0.0009	0.0004	0.0056
Coll							
0.3414	0.1040	0.3462	0.1066	0.0490	0.0152	0.0015	0.0012
0.0009	0.0034	0.0040	0.0043	0.0155	0.0008	0.0004	0.0056
Local							
0.3291	0.1003	0.3338	0.1028	0.0473	0.0261	0.0025	0.0021
0.0016	0.0059	0.0069	0.0075	0.0267	0.0013	0.0007	0.0054

### 5.1.4 2017 State Vehicle Mix

2017 State Vehicle Mix							
Rural	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
LDV	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2490	0.0839	0.2795	0.0861	0.0396	0.0825	0.0082	0.0069
0.0051	0.0185	0.0219	0.0238	0.0844	0.0042	0.0021	0.0043
Princ. Art.							
0.2897	0.0976	0.3252	0.1002	0.0461	0.0436	0.0043	0.0037
0.0027	0.0098	0.0116	0.0126	0.0446	0.0022	0.0011	0.0050
Minor Art.							
0.2939	0.0991	0.3301	0.1017	0.0468	0.0395	0.0039	0.0033
0.0024	0.0089	0.0105	0.0114	0.0404	0.0020	0.0010	0.0051
Major Collector							
0.3101	0.1045	0.3479	0.1072	0.0493	0.0243	0.0024	0.0020
0.0015	0.0054	0.0064	0.0070	0.0248	0.0012	0.0006	0.0054
Minor Collector							
0.3079	0.1038	0.3456	0.1065	0.0490	0.0262	0.0026	0.0022
0.0016	0.0059	0.0070	0.0076	0.0268	0.0013	0.0007	0.0053
Local							
0.2982	0.1006	0.3350	0.1032	0.0475	0.0353	0.0035	0.0030
0.0022	0.0079	0.0094	0.0102	0.0361	0.0018	0.0009	0.0052
Urban							
LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2721	0.0916	0.3052	0.0940	0.0432	0.0606	0.0060	0.0051
0.0037	0.0136	0.0161	0.0175	0.0620	0.0031	0.0015	0.0047
Freeway							
0.2940	0.0991	0.3299	0.1017	0.0467	0.0396	0.0039	0.0033
0.0024	0.0089	0.0105	0.0114	0.0405	0.0020	0.0010	0.0051
Princ. Art.							
0.3091	0.1040	0.3465	0.1068	0.0491	0.0254	0.0025	0.0021
0.0016	0.0057	0.0067	0.0073	0.0260	0.0013	0.0006	0.0053
Minor Art							
0.3172	0.1069	0.3560	0.1097	0.0504	0.0174	0.0017	0.0015
0.0011	0.0039	0.0046	0.0050	0.0178	0.0009	0.0004	0.0055
Coll							
0.3196	0.1077	0.3586	0.1105	0.0508	0.0151	0.0015	0.0013
0.0009	0.0034	0.0040	0.0044	0.0155	0.0008	0.0004	0.0055
Local							
0.3083	0.1038	0.3458	0.1066	0.0490	0.0260	0.0026	0.0022
0.0016	0.0058	0.0069	0.0075	0.0266	0.0013	0.0007	0.0053

### 5.1.5 2021 State Vehicle Mix

2020+ State Vehicle Mix							
Rural	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
LDV	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2366	0.0861	0.2865	0.0883	0.0406	0.0825	0.0081	0.0069
0.0052	0.0185	0.0219	0.0238	0.0844	0.0042	0.0021	0.0043
Princ. Art.							
0.2751	0.1002	0.3334	0.1028	0.0473	0.0436	0.0043	0.0036
0.0028	0.0098	0.0116	0.0126	0.0446	0.0022	0.0011	0.0050
Minor Art.							
0.2791	0.1017	0.3384	0.1043	0.0480	0.0395	0.0039	0.0033
0.0025	0.0089	0.0105	0.0114	0.0404	0.0020	0.0010	0.0051
Major Collector							
0.2945	0.1072	0.3567	0.1099	0.0506	0.0243	0.0024	0.0020
0.0015	0.0055	0.0064	0.0070	0.0248	0.0012	0.0006	0.0054
Minor Collector							
0.2924	0.1065	0.3543	0.1092	0.0503	0.0262	0.0026	0.0022
0.0017	0.0059	0.0070	0.0076	0.0268	0.0013	0.0007	0.0053
Local							
0.2833	0.1032	0.3435	0.1059	0.0487	0.0353	0.0035	0.0029
0.0022	0.0079	0.0094	0.0102	0.0361	0.0018	0.0009	0.0052
Urban							
LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4
HDV5	HDV6	HDV7	HDV8a	HDV8b	HDBS	HDBT	MC
Interstate							
0.2583	0.0940	0.3129	0.0964	0.0444	0.0606	0.0060	0.0051
0.0038	0.0136	0.0161	0.0175	0.0620	0.0031	0.0015	0.0047
Freeway							
0.2790	0.1017	0.3383	0.1043	0.0480	0.0396	0.0039	0.0033
0.0025	0.0089	0.0105	0.0114	0.0405	0.0020	0.0010	0.0051
Princ. Art.							
0.2934	0.1068	0.3553	0.1095	0.0504	0.0254	0.0025	0.0021
0.0016	0.0057	0.0067	0.0073	0.0260	0.0013	0.0006	0.0054
Minor Art							
0.3013	0.1097	0.3650	0.1125	0.0518	0.0174	0.0017	0.0014
0.0011	0.0039	0.0046	0.0050	0.0178	0.0009	0.0004	0.0055
Coll							
0.3033	0.1105	0.3677	0.1133	0.0522	0.0152	0.0015	0.0013
0.0010	0.0034	0.0040	0.0044	0.0155	0.0008	0.0004	0.0055
Local							
0.2926	0.1066	0.3546	0.1093	0.0503	0.0260	0.0026	0.0022
0.0016	0.0059	0.0069	0.0075	0.0266	0.0013	0.0007	0.0053

## 5.2 Meteorology

### 5.2.1 Catawba County Temperature and Relative Humidity

STATE CLIMATE OFFICE OF NORTH CAROLINA

NC CRONOS Database

2008 data retrieval from Hickory Airport (KHKY)

Hickory, Burke County

Latitude: 35.7411464 Longitude: -81.3895489

Elevation: 1189 ft.

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
1	0	31	35.9	67
1	1	31	34.5	71
1	2	31	34.2	72
1	3	31	33.7	74
1	4	31	33	76
1	5	31	32.5	75
1	6	31	32.3	75
1	7	31	32.3	75
1	8	31	34.7	70
1	9	31	37.6	63
1	10	31	40.7	54
1	11	31	42.9	50
1	12	31	44.9	46
1	13	31	46.3	45
1	14	31	46.9	44
1	15	31	46.5	45
1	16	31	45.4	46
1	17	31	42.8	51
1	18	31	40.9	56
1	19	31	40	58
1	20	30	38.8	62
1	21	31	37.9	62
1	22	31	37.1	65
1	23	31	36.6	67
2	0	29	40.1	72
2	1	29	39.5	73
2	2	29	38.7	75
2	3	29	38.1	75
2	4	29	37	78
2	5	29	36.7	79
2	6	29	36.5	79
2	7	29	36.8	78
2	8	29	39.4	74
2	9	29	42.8	68
2	10	29	45.8	62
2	11	29	48.5	58



Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
2	12	29	50.7	55
2	13	29	52	53
2	14	29	52.5	52
2	15	29	53.1	50
2	16	29	52.3	51
2	17	29	49.8	55
2	18	29	47.5	57
2	19	29	45.6	61
2	20	29	44.7	62
2	21	29	43.6	64
2	22	29	42.4	66
2	23	29	41.4	68
3	0	31	46.7	63
3	1	31	45.5	65
3	2	31	44.1	68
3	3	31	43.9	68
3	4	31	42.9	70
3	5	31	41.9	73
3	6	31	41.9	74
3	7	31	44.2	72
3	8	31	47.7	63
3	9	31	51.4	56
3	10	31	54.1	50
3	11	31	56.2	48
3	12	31	57.1	49
3	13	31	58.2	48
3	14	31	58.5	46
3	15	31	58.7	46
3	16	31	58.4	46
3	17	31	57.2	48
3	18	31	54.8	52
3	19	31	52.7	55
3	20	31	51.6	57
3	21	31	50.4	58
3	22	31	49.2	61
3	23	31	47.6	64
4	0	30	53.6	76
4	1	30	53.2	78
4	2	30	51.9	80
4	3	30	51.3	80
4	4	30	50.6	82
4	5	30	50	82
4	6	30	51.4	81
4	7	30	53.9	76
4	8	30	56.8	69
4	9	30	59.8	63
4	10	30	61.4	61
4	11	30	63.3	57
4	12	30	64.3	54

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
4	13	30	65.6	54
4	14	29	66.8	52
4	15	30	66.1	52
4	16	30	65.7	51
4	17	30	64	55
4	18	30	62	58
4	19	30	59.7	63
4	20	30	58.3	65
4	21	30	56.9	68
4	22	30	55.7	71
4	23	30	54.6	73
5	0	31	60.6	73
5	1	31	59.5	76
5	2	31	58.7	78
5	3	31	58.2	78
5	4	31	57.1	81
5	5	31	56.7	84
5	6	31	59.1	80
5	7	30	61.7	73
5	8	31	65.9	64
5	9	31	68.6	59
5	10	31	70.8	55
5	11	31	73.3	50
5	12	31	75.1	47
5	13	31	75.4	45
5	14	31	75.4	45
5	15	31	75.3	46
5	16	31	74.5	46
5	17	31	73.2	49
5	18	31	70.7	52
5	19	31	68	56
5	20	31	66.1	61
5	21	31	64.3	65
5	22	31	63.6	66
5	23	31	62.4	71
6	0	30	70.3	76
6	1	30	69.3	78
6	2	30	67.7	81
6	3	30	66.9	82
6	4	30	66.4	83
6	5	30	66.5	84
6	6	30	69.5	78
6	7	30	73.9	69
6	8	30	78.6	58
6	9	30	82.4	49
6	10	30	84.9	44
6	11	30	86.4	40
6	12	30	87.9	37
6	13	30	89	35

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
6	14	30	88.6	36
6	15	30	87.1	39
6	16	30	85.7	43
6	17	30	83.5	47
6	18	30	81.3	51
6	19	30	77.8	57
6	20	30	75.9	61
6	21	30	74.3	65
6	22	30	73	68
6	23	30	71.4	73
7	0	31	70.7	84
7	1	31	69.3	87
7	2	31	68.9	87
7	3	31	68	90
7	4	31	67.5	90
7	5	31	67.4	90
7	6	31	69	87
7	7	31	71.9	80
7	8	31	75.8	71
7	9	31	78.7	64
7	10	31	81.5	58
7	11	31	83.1	54
7	12	31	84.6	51
7	13	31	83.9	52
7	14	31	83.6	54
7	15	31	82.7	56
7	16	31	83.5	54
7	17	31	82.3	57
7	18	31	79.8	62
7	19	31	76.8	68
7	20	31	75.4	72
7	21	31	73.8	76
7	22	31	72.7	80
7	23	31	71.7	82
8	0	31	70.4	84
8	1	31	69.3	86
8	2	31	68.2	88
8	3	31	67.5	89
8	4	31	66.9	90
8	5	31	66.4	91
8	6	31	67.8	89
8	7	31	70.7	82
8	8	31	74	73
8	9	31	77.4	65
8	10	31	79.2	59
8	11	31	80.8	56
8	12	31	82.1	55
8	13	31	82.7	54
8	14	31	82.9	54

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
8	15	31	82.6	55
8	16	31	82	55
8	17	31	80.8	57
8	18	31	78.6	62
8	19	31	76.2	67
8	20	31	74.8	71
8	21	31	73.7	74
8	22	31	72.2	78
8	23	31	71.1	81
9	0	30	65.3	89
9	1	30	64.6	90
9	2	30	64	92
9	3	30	63.4	93
9	4	30	63	93
9	5	30	62.6	93
9	6	30	63.3	92
9	7	30	65.2	89
9	8	30	68.7	80
9	9	30	71.9	71
9	10	30	74.3	64
9	11	30	75.1	62
9	12	30	76.5	59
9	13	30	77.6	58
9	14	30	77.5	58
9	15	30	77.1	59
9	16	30	76.1	62
9	17	30	73.9	67
9	18	30	70.7	74
9	19	30	69.4	78
9	20	30	68.1	82
9	21	30	67	84
9	22	30	66.2	87
9	23	30	65.3	89
10	0	31	51.7	84
10	1	31	51.1	85
10	2	31	50.8	85
10	3	31	49.9	86
10	4	31	49.1	88
10	5	31	48.8	88
10	6	31	48.4	88
10	7	31	51.6	82
10	8	31	55.7	73
10	9	31	59.6	64
10	10	31	62.6	57
10	11	31	64.8	52
10	12	31	66.1	50
10	13	31	66.7	48
10	14	31	66.7	48
10	15	31	66.2	49

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
10	16	31	64.4	52
10	17	31	60.7	59
10	18	31	58.5	64
10	19	31	56.7	68
10	20	31	55.4	73
10	21	31	53.9	78
10	22	31	52.7	81
10	23	31	52	83
11	0	30	41.9	76
11	1	30	41.1	78
11	2	30	40.8	78
11	3	30	40.6	77
11	4	30	39.9	78
11	5	30	39.6	79
11	6	30	39.6	79
11	7	30	40.3	79
11	8	30	44.5	70
11	9	30	48.1	59
11	10	30	50.9	53
11	11	30	53.2	48
11	12	30	54.6	45
11	13	30	55.5	43
11	14	30	55.5	44
11	15	30	54.8	45
11	16	30	53.1	48
11	17	30	49.8	54
11	18	30	48.2	58
11	19	30	46.8	61
11	20	30	46.1	64
11	21	30	44.8	66
11	22	30	43.8	69
11	23	30	42.4	74
12	0	31	41.2	78
12	1	31	41	78
12	2	31	39.8	80
12	3	31	40	79
12	4	31	39.7	81
12	5	31	39.5	80
12	6	31	39.6	79
12	7	31	39.2	80
12	8	31	41.2	76
12	9	31	43.5	71
12	10	31	45.5	66
12	11	31	47.4	62
12	12	31	48.7	59
12	13	31	49.9	57
12	14	31	50.3	56
12	15	31	50	56
12	16	31	48.5	59

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
12	17	31	46.5	64
12	18	31	45.2	66
12	19	31	44.3	68
12	20	31	43.3	71
12	21	31	42.6	72
12	22	31	42.1	74
12	23	31	41.6	74

### 5.2.2 Davidson and Guilford County Temperature and Relative Humidity

STATE CLIMATE OFFICE OF NORTH CAROLINA

NC CRONOS Database

2008 data retrieval from Greensboro Airport (KGSO)

Greensboro, Guilford County

Latitude: 36.0977469 Longitude: -79.9372975

Elevation: 926 ft.

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
1	0	31	36.2	62
1	1	31	35.8	63
1	2	31	35.9	63
1	3	30	36.5	65
1	4	31	35.8	65
1	5	31	35	66
1	6	31	34.2	66
1	7	31	34.4	65
1	8	31	36.6	62
1	9	31	39.2	55
1	10	31	41.5	49
1	11	31	43.6	45
1	12	31	45.5	42
1	13	31	46.5	41
1	14	30	46.9	40
1	15	30	46.6	41
1	16	30	45.2	43
1	17	31	42.9	46
1	18	31	41.1	50
1	19	31	39.9	52
1	20	31	39	54
1	21	31	38.5	56
1	22	31	37.7	57
1	23	31	36.8	60
2	0	29	40.9	64
2	1	29	39.7	66

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
2	2	29	39.3	66
2	3	29	38.7	67
2	4	29	38.2	68
2	5	29	37.9	68
2	6	29	37.5	69
2	7	29	38.4	69
2	8	29	40.9	65
2	9	29	43.5	59
2	10	29	46.6	55
2	11	29	49.1	50
2	12	29	51.2	47
2	13	29	52.9	45
2	14	29	53.6	45
2	15	29	53.2	46
2	16	29	52.3	47
2	17	29	50.1	50
2	18	29	48.5	53
2	19	29	46.7	55
2	20	29	45.4	57
2	21	29	44.1	59
2	22	29	42.7	62
2	23	29	42	63
3	0	31	47.4	61
3	1	31	46.7	61
3	2	31	45.4	63
3	3	31	44.7	65
3	4	31	44	66
3	5	31	43.4	66
3	6	31	43.1	67
3	7	31	46	62
3	8	31	48.9	56
3	9	31	51.6	51
3	10	31	54.2	47
3	11	31	56.7	42
3	12	31	58.1	40
3	13	31	59	39
3	14	31	59.3	41
3	15	31	59.4	41
3	16	31	58.4	42
3	17	31	56.9	44
3	18	31	55.1	46
3	19	31	53.4	50
3	20	31	52.3	53
3	21	31	50.6	56
3	22	31	49.7	58
3	23	31	48.6	60
4	0	30	53.6	76
4	1	30	53.2	76
4	2	30	52	78

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
4	3	30	51.5	78
4	4	30	50.8	78
4	5	30	50.5	78
4	6	30	52.1	76
4	7	30	55	69
4	8	30	57.7	64
4	9	30	59.9	60
4	10	30	61.7	56
4	11	30	63	53
4	12	30	64.1	53
4	13	30	65.2	51
4	14	30	65.1	51
4	15	30	64.9	53
4	16	30	64.7	53
4	17	30	63.6	54
4	18	30	61.2	59
4	19	30	59.4	62
4	20	30	58.3	64
4	21	30	57.2	67
4	22	30	55.9	69
4	23	30	54.7	72
5	0	31	60.2	69
5	1	31	59.6	70
5	2	31	58.8	73
5	3	31	58.3	74
5	4	31	57.8	75
5	5	31	57.8	75
5	6	31	60.4	71
5	7	31	63.4	65
5	8	31	66.3	59
5	9	31	68.8	55
5	10	31	70.6	51
5	11	31	72.3	48
5	12	31	73.4	46
5	13	31	74.3	44
5	14	31	74.5	45
5	15	31	74.5	44
5	16	31	73.6	45
5	17	31	72.7	46
5	18	31	70.2	51
5	19	31	67.6	55
5	20	31	65.6	59
5	21	31	64.3	62
5	22	31	63	64
5	23	31	61.9	67
6	0	30	72.4	68
6	1	30	71.7	69
6	2	30	70.7	72
6	3	30	69.5	74



Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
6	4	30	68.7	76
6	5	30	69.7	75
6	6	30	72.8	69
6	7	30	76.6	61
6	8	30	79.8	54
6	9	30	82.3	48
6	10	30	85	43
6	11	30	86.3	40
6	12	30	87.8	37
6	13	30	88.4	35
6	14	30	88.6	35
6	15	30	87.5	36
6	16	30	86.4	39
6	17	30	84.1	43
6	18	30	81.4	49
6	19	30	78.9	53
6	20	30	77.2	57
6	21	30	76	59
6	22	30	74.9	61
6	23	30	73.5	64
7	0	31	72.1	74
7	1	31	70.9	78
7	2	31	70.5	78
7	3	31	70.1	79
7	4	31	69.4	81
7	5	31	69.7	80
7	6	31	72.1	76
7	7	31	75	70
7	8	31	78.1	63
7	9	31	81	56
7	10	31	82.7	52
7	11	31	84.1	48
7	12	31	85	46
7	13	31	85.2	46
7	14	31	86	44
7	15	31	85.6	45
7	16	31	84.5	48
7	17	31	83	51
7	18	31	80.5	56
7	19	31	78	61
7	20	31	76.4	66
7	21	31	75	69
7	22	31	74.1	71
7	23	31	73.2	73
8	0	31	70.9	74
8	1	31	70.4	76
8	2	31	69.5	77
8	3	31	69	79
8	4	31	68.5	79

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
8	5	31	67.9	81
8	6	31	69.9	77
8	7	31	72.9	71
8	8	31	75.7	65
8	9	31	78	59
8	10	31	80.3	54
8	11	31	82.1	51
8	12	31	83	48
8	13	31	84	47
8	14	31	83.8	48
8	15	31	83.1	48
8	16	31	82.6	48
8	17	31	81.3	51
8	18	31	79	55
8	19	31	76.9	59
8	20	31	75.3	63
8	21	31	73.9	67
8	22	31	73	69
8	23	31	72	72
9	0	30	66.5	80
9	1	30	65.7	82
9	2	30	65.3	82
9	3	30	65	83
9	4	30	64.2	85
9	5	30	63.9	85
9	6	30	64.8	83
9	7	30	66.9	79
9	8	30	69.8	72
9	9	30	71.9	68
9	10	30	73.7	63
9	11	30	75.3	59
9	12	30	76.3	57
9	13	30	76.9	56
9	14	30	77.1	56
9	15	30	76.7	57
9	16	30	76.1	59
9	17	30	74	64
9	18	30	71.9	69
9	19	30	70.3	73
9	20	30	69	74
9	21	30	68.4	76
9	22	30	67.5	78
9	23	30	66.8	80
10	0	31	52.9	77
10	1	31	52	79
10	2	31	51.1	80
10	3	31	50.4	81
10	4	31	50.2	81
10	5	31	49.4	82

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
10	6	31	49.8	81
10	7	31	53.6	75
10	8	31	57.8	64
10	9	31	60.9	57
10	10	31	62.9	53
10	11	31	64.6	50
10	12	31	65.9	47
10	13	30	67.1	46
10	14	31	67.2	44
10	15	31	66.5	44
10	16	31	64.6	49
10	17	31	61.7	54
10	18	31	59.4	60
10	19	31	57.4	65
10	20	31	55.9	69
10	21	31	55	71
10	22	31	54	73
10	23	31	52.9	75
11	0	30	43	69
11	1	30	42	72
11	2	30	41.4	73
11	3	30	41.2	73
11	4	30	40.8	73
11	5	30	40.4	74
11	6	30	40.2	74
11	7	30	42	72
11	8	30	46.5	63
11	9	30	49.6	56
11	10	30	51.6	53
11	11	30	53.3	49
11	12	30	54.4	47
11	13	30	55.4	44
11	14	30	55.3	43
11	15	30	54.8	44
11	16	30	52.6	48
11	17	30	50.5	51
11	18	30	48.2	56
11	19	30	47	59
11	20	30	45.7	62
11	21	30	44.4	66
11	22	30	44.1	67
11	23	30	43.7	68
12	0	31	43	71
12	1	31	42.2	72
12	2	31	42	71
12	3	31	41.3	72
12	4	31	41	72
12	5	31	40.8	72
12	6	31	40.7	72

Month	Hour	Number of Records Compiled	Average Temperature (F)	Average Relative Humidity (%)
12	7	31	40.7	71
12	8	31	42.9	67
12	9	31	45.1	63
12	10	31	47.1	59
12	11	31	48.7	56
12	12	31	49.8	53
12	13	31	50.6	52
12	14	31	51	52
12	15	31	50.5	52
12	16	31	49	55
12	17	31	47.2	58
12	18	31	46.1	60
12	19	31	45.2	63
12	20	31	44.3	65
12	21	31	43.4	68
12	22	31	43.3	67
12	23	31	42.8	69