Appendix B

Emission Inventory Documentation

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Appendix B.1
Point Source Emissions
Inventory Documentation

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1.0 INTRODUCTION AND SCOPE

The point source inventory consists of emissions from individual facilities. Primarily, these are industrial or commercial facilities that require permits issued by the North Carolina Division of Air Quality (NCDAQ), the Forsyth County Environmental Affairs Department and Mecklenburg Air Quality Section under the Land Use & Environmental Services Agency (LUESA) to emit air pollutants.

The emissions in this report are based on the 2010 National Emissions Inventory (NEI) for Durham and Wake Counties while Forsyth and Mecklenburg provided emissions to NCDAQ for this report. Most point source emissions of carbon monoxide (CO) are associated with industrial, utility or large institutional boilers. Other CO sources which may be treated as point sources are industrial process combustion (such as kilns) and large stationary internal combustion engines.

2.0 OVERALL METHODOLOGY

All permitted sources are required to report emissions annually in the case of larger sources while every five years in the case of smaller sources. The emissions data obtained for this report were pulled from files maintained by the NCDAQ, Forsyth County Environmental Affairs Department and Mecklenburg County Air Quality. This 2010 data also represents submissions to the U. S. Environmental Protection Agency (USEPA).

2.1 Source Identification

All facilities required to have permits to operate sources of air pollution are known and are required to submit emission inventories. The local programs in Forsyth and Mecklenburg counties provided the NCDAQ with county specific point source CO inventory data for 2010.

2.2 Emission Estimation Approach

The emission inventory information reported to the State was transferred to the Integrated Build Environment for Application Management (IBEAM) program by both State employees. This program helps assure that certain required data elements are not omitted. It also performs calculations, thereby minimizing the occurrence of errors. Depending on the particular process and facility, emissions may be calculated by various methods. In many cases, emissions are estimated using emission factors published in USEPA's AP-42, Compilation of Air Pollutant Emission Factors. For some processes, a mass balance calculation can be employed to estimate emissions or direct continuous emissions monitoring (CEM) data can be reported. In a relatively few cases, locally produced emission factors may be used. For any particular case, it is possible to determine how emissions were calculated by going to the NEI. This material may be downloaded from the following USEPA website:
http://www.epa.gov/ttn/chief/net/2008inventory.html.

Annual emissions are reported in the NEI and maintained by NCDAQ, Mecklenburg County Air Quality, and Forsyth County Environmental Affairs Department. There is also data for operating hours per day and per year, days per week, and the percentage of emissions occurring in the winter quarter. Using this information, peak CO season daily emissions were calculated. Mecklenburg County and Forsyth County Air Quality provided NCDAQ with 2010 annual emissions. For Durham and Wake Counties, the 2010 inventory was obtained from the NCDAQ database.

3.0 QUALITY ASSURANCE

The 2010 emission inventory has undergone a number of quality assurance checks to meet the standards for the National Emissions Inventory. The IBEAM program helps insure that important data elements are present and calculates some of the data fields, which reduces the number of errors in the data. In addition, since the State began collecting annual fees for emissions from Title V sources, both the State and the facilities ensure that the emissions that are reported annually are accurate.

Calculations of emissions from publicly-owned treatment works (POTWs) and landfills were carefully checked for accuracy. Segment level emissions were totaled to ensure they equaled the totals for plant level emissions.

4.0 TOTAL POINT SOURCES EMISSIONS

Summaries of the point source emissions data are listed in the following tables. All emissions are in tons per winter day.

4.1 Summary of Point Source Emissions

Table 4.1 Summary of Point Source CO Emissions

COUNTY	2010
Raleigh/Durham Maintenance Area	
Durham	0.97
Wake	1.17
TOTAL	2.14
Winston-Salem Maintenance Area	
Forsyth	2.22
Charlotte Maintenance Area	
Mecklenburg	2.39

4.2 Durham County Plant Emissions

Table 4.2 Summary of Plant CO Emissions for Durham County (tons/day)

Facility ID	Location Name	NAICS/SIC	2010
3200308	AW North Carolina, Inc.	33635	0.03
3200270	Carolina Sunrock LLC - Muirhead Distribution Center	32732	0.10
3200296	City of Durham Sanitary Landfill	562212	0.07
3200299	Cree Inc - Silicon Dr	334413	0.09
3200144	Duke University	61131	0.36
3200143	Durham Regional Hospital	62211	0.01
3200289	Eisai Inc	325412	0.02
3200295	Federal Medical Center	62211	0.01
3200214	Freudenberg Nonwovens Group	31323	0.03
3200041	G E Aviation - Durham Engine Facility	336412	0.01
3200017	GlaxoSmithKline	325412	0.06
3200055	IBM Corporation	541512	0.02
3200375	MP Durham, LLC	221119	0.02
3200158	NIEHS	92119	0.05
3200251	North Carolina Central University	61131	0.01
3200257	PBM Graphics - A Consolidated Graphics Company	323110	0.01
3200189	SCM Metal Products, Inc.	331423	0.01
3200234	South Durham Water Reclamation Facility	92411	0.03
3200184	The Hamner Institutes for Health Sciences	54171	0.01
3200215	Valassis Communications	323111	0.01
3200154	Veterans Affairs Medical Hospital	62211	0.01
	Plant Total		**0.97**

4.3 Wake County Plant Emissions

Table 4.3 Summary of Plant CO Emissions for Wake County (tons/day)

Facility ID	Location Name	NAICS/SIC	2010
9200408	Ajinomoto AminoScience, LLC	325414	0.05
9200504	Austin Quality Foods, Inc.	311821	0.02
9200398	Barnhill Contracting Company	324121	0.02
9200566	Biogen Idec US Limited Partnership	325414	0.02
9200208	Cargill Inc - Raleigh	311222	0.06
9200457	Carolina Sunrock, LLC - RDU Distribution Center	324121	0.06
9200599	CP&L - Harris Nuclear Plant	221113	0.01
9200333	Dorothea Dix Campus	62221	0.05
9200550	Fred Smith Company - Holly Springs Asphalt Plant	324121	0.01
9200752	Fred Smith Company - Knightdale Asphalt Plant	324121	0.05
9200259	Fred Smith Company - Westgate plant	324121	0.04
9200570	FUJIFILM Diosynth Biotechnologies U.S.A., Inc.	325414	0.01
9200314	Gelder & Associates Incorporated	324121	0.05
9200443	GSK, Inc.	325412	0.02
9200349	Mallinckrodt LLC	325411	0.04
9200266	Meredith College	61131	0.01
9200592	Metokote Corporation Plant 23	332812	0.01
9200378	Motiva Enterprises LLC	42471	0.01
9200291	NC DOA Central Heating Plant	22133	0.03
9200003	NC DOC - Central Prison	92214	0.01
9200290	NCSU Central Heat Plant	61131	0.14
9200593	North Wake County Landfill Facility	562212	0.06
9200639	PNG Clayton Compressor Station	22121	0.03
9200377	Potters Industries L.L.C.	327215	0.09
9200620	Public Service Company of NC Inc	221119	0.01
9200621	Raleigh-Durham Airport Authority	488119	0.01
9200338	Rea Contracting (Garner)	324121	0.03
9200339	Rea Contracting (Gresham Lake)	324121	0.07
9200341	Rea Contracting (West Raleigh)	324121	0.06
9200343	Rex Healthcare	62211	0.02
9200761	T R Vernal Paving, Inc.	324121	0.02
9200230	WakeMed	62211	0.03
9200617	WakeMed Cary Hospital	62211	0.01
	Plant Total		**1.17**

4.4 Forsyth County Plant Emissions

Table 4.4 Summary of Plant CO Emissions for Forsyth County (tons/day)

Facility ID	Location Name	NAICS/SIC	2010
00003	Wake Forest University	61131	0.02
00082	Microfibres, Inc.	3133	0.02
00131	HANES DYE AND FINISHING CO.	313311	0.04
00201	North Carolina Baptist Hospitals, Inc.	6221	0.05
00339	R.J. Reynolds Tobacco Company (Whitaker Park)	31222	0.12
00363	Hanesbrands, Inc.	315111	0.01
00449	Smurfit-Stone Container Corporation	322211	0.01
00460	HIGHLANDS INDUSTRIES	3133	0.01
00464	Larco Construction	324121	0.09
00465	Oracle Flexible Packaging-Phoenix (200)	331315	0.04
00466	Oracle Flexible Packaging-Liberty (604)	322225	0.02
00473	Winston-Salem State University	611310	0.01
00682	Rexam Beverage Can Company	332431	0.02
00732	Corn Products International, Inc.	311221	1.04
00735	Vulcan Materials - East Forsyth Quarry	21239	0.01
00745	R.J. Reynolds Tobacco Co. (Tobaccoville)	31222	0.08
00755	FORSYTH MEMORIAL HOSPITAL	622110	0.03
00784	Deere-Hitachi Construction Machinery Corp.	33312	0.01
00817	ARCHIE ELLEDGE WWTP	221320	0.01
00872	CRES TOBACCO COMPANY	312210	0.01
00884	Salem Energy Systems, L.L.C.	22111	0.12
00910	Cloverleaf Mixing, Inc.	324121	0.02
00914	Piedmont Landfill and Recycling Center	562212	0.30
00990	ARTISTREE	321999	0.01
01062	APAC-Atlantic, Inc., Thompson-Arthur Division, Plant #5 Winston Salem	324121	0.02
00878	Muddy Creek Wastewater Treatment Plant	221320	0.08
	Plant Total		**2.22**

4.5 Mecklenburg County Plant Emissions

Table 4.5 Summary of Plant CO Emissions for Mecklenburg County (tons/day)

Facility ID	Location Name	NAICS/SIC	2010
0756	ALSCO, Inc.	7213	0.01
0322	Associated Asphalt Charlotte, LLC	5032	0.01
0067	Barnhardt Manufacturing Company	2269	0.01
0909	Barrday Corporation	2221	0.17
0710	C & M Recycling, Inc.	3272	0.08
0069	Cargill, Inc.	2079	0.01
0289	Carolinas Medical Center	8062	0.05
0109	Carolinas Medical Center - Pineville	8062	0.01
0626	Charlotte Pipe & Foundry Company, Inc.	3321	0.01
0020	C-MUD: Franklin Water Treatment Plant	4941	0.01
0937	C-MUD: Lee S. Dukes, Jr. Water Plant	4941	0.02
0764	C-MUD: McAlpine Creek Wastewater Treatment Plant	4953	0.03
0222	D.H. Griffin Infrastructure, LLC	3295	0.02
0004	Davidson College	8221	0.01
0595	Emerald Carolina Chemical, LLC	2821	0.02
0054	General Steel Drum, LLC	3412	0.01
0058	Huntersville Hardwoods	2426	0.02
0590	IGM Resins Charlotte, Inc	2869	0.01
0588	Industrial Container Services - NC, LLC (Matthews)	7699	0.01
0381	International Paper Company	2653	1.62
0999	J.T. Russell & Sons, Inc.	2951	0.01
0087	Lincoln Harris, LLC	6099	0.01
0148	Mallard Creek Polymers, Inc.	2821	0.01
0132	Metrolina Greenhouses, Inc.	0181	0.03
0201	Novant Healthcare's Presbyterian Hospital	8062	0.04
0936	Presbyterian Hospital - Matthews	8069	0.03
0785	Presbyterian Hospital Huntersville	8062	0.01
0134	Rea Contracting (069 Arrowood)	2951	0.02
0668	Red Clay Industries	1499	0.01
0108	RR Donnelley	2752	0.01
0003	SteelFab, Inc.	3441	0.01
0215	University of North Carolina at Charlotte	8221	0.03
0216	US Airways, Four (4) Site Locations	4581	0.03
	Plant Total		**2.39**

Appendix B.2
Area Source Emissions
Inventory Documentation

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List of Acronyms

Acronym	Definition
CO	Carbon Monoxide
EIIP	Emissions Inventory Improvement Program
ERTAC	Eastern Regional Technical Advisory Group
LPG	Liquid Petroleum Gas
NAICS	North American Industry Classification System
NCDAQ	North Carolina Division of Air Quality
NCDFR	North Carolina Division of Forest Resources
NCDOT	North Carolina Department of Transportation
NCOSBM	North Carolina Office of State and Budget Management
NCSU	North Carolina State University
NG	Natural Gas
QAPP	Quality Assurance Project Plan
SIC	Standard Industrial Classification
USCBP	U.S Census Bureau, County Business Patterns
USEPA	U.S. Environmental Protection Agency
USFA	U.S. Fire Administration
VMT	Vehicle Miles Traveled

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1.0 INTRODUCTION AND SCOPE

Area sources represent a collection of many small, unidentified points of air pollution emissions within a specified geographical area, emitting less than the minimum level prescribed for point sources. Because these sources are too small and/or too numerous to be surveyed and characterized individually, all area source activities are collectively estimated. The county is the geographic area for which emissions from area sources are compiled, primarily because counties are the smallest areas for which data used for estimating emissions is readily available.

The area source emissions inventory has been developed in order to meet the requirement of the carbon monoxide (CO) National Ambient Air Quality Standard, as part of the process of demonstrating continued maintenance for the CO National Ambient Air Quality Standard.

The North Carolina maintenance areas for CO are comprised of Durham, Forsyth, Mecklenburg and Wake Counties. Most of the activity data needed to estimate 2010 emissions was not available, therefore, the 2007 emissions inventory that has been developed for other purposes was grown to the 2010 base year. All emissions are calculated on a ton per winter day basis.

2.0 OVERALL METHODOLOGY

2.1 SOURCE CATEGORY IDENTIFICATION

The area source categories were identified from two US Environmental Protection Agency (USEPA) guidance documents: EPA-450/4-91-016, Procedures for the Preparation of Emission Inventories of Carbon Monoxide and Precursors of Ozone, Vol. 1, from this point on this document will be referred to as the Procedures document, and the Emissions Inventory Improvement Program (EIIP) Technical Reports, Vol. 3, Area Sources, from this point on this document will be referred to as EIIP Tech. Report.

2.2 EMISSION ESTIMATION APPROACH

Area source emissions are estimated by multiplying an emission factor by some known indicator of collective activity for each source category within the inventory area. An indicator is any parameter associated with the activity level of a source that can be correlated with the air pollutant emissions from that source, such as production, number of employees, or population.

In general, one of the following emissions estimation approaches is used to calculate the area source emissions: per capita emission factors, employment-related emission factors, commodity consumption-related emission factors and level of activity based emission factors. The emission factors used were obtained from the EIIP Tech. Report, the USEPA's AP-42 Compilation of Air Pollutant Emission Factors, 5th Edition, referred to as AP-42 or the emissions methods developed by E.H. Pechan & Associates, Inc. (Pechan) for the USEPA for the 2008 National Emissions Inventory. The methods Pechan developed were based upon the emission factor development work conducted by the Eastern Regional Technical Advisory Group (ERTAC) in conjunction with the USEPA and states.

As previously stated, the area source emissions were calculated based on the emissions methods developed by Pechan or the USEPA's EIIP Tech. Report and AP-42. The majority of the area source categories were calculated with the methods outlined by Pechan because they incorporate the most recent emission factors and activity data available. The remaining area source categories were calculated using the USEPA's EIIP Tech. Report and AP-42 because these categories were not included as part of the area source categories Pechan updated. The following outlines the area source categories calculated using the emissions methods developed by Pechan:

- Residential Combustion
- Commercial Combustion
- Industrial Combustion

- Charbroiling
- Open Burning.

The remaining area source categories were calculated using the EIIP Tech. Report and AP-42 are:

- Structure Fires
- Vehicle Fires
- Forest Fires.

There are several methods for estimating the activity level for a specific area source category. Some of these methods include treating area sources as point sources, surveying local activity levels, apportioning national or statewide activity totals to local inventory areas, or using population and employment data. All of these methods were employed to determine the activity data needed for the various area source categories.

For certain categories, there can be overlap between the point sources and the area sources, which can lead to double counting of emissions. To avoid double counting of emissions, point source emissions were identified so they could be subtracted from the applicable area source emissions.

There are a number of categories where emissions were calculated with emission factors based on employment. These emission factors were developed by the USEPA when employment reports were organized by Standard Industrial Classification (SIC) code. Since 1997 employment statistics are organized by the North American Industry Classification System (NAICS).

The employment for the combustion source categories were obtained from the on-line US Census Bureau, County Business Patterns (USCBP) for the various NAICS codes at the county level for North Carolina. In addition to having employment values (or employment ranges due to confidentiality rules) by NAICS, the USCBP breaks down the number of facilities by employment categories. The employment categories are 1 – 4, 5 – 9, 10 – 19, 20 – 49, 50 – 99, 100 – 249, 250 – 499, 500 – 999, >1000 employees. To account for point sources, it was assumed that facilities with 100 employees or greater were point sources and were not considered in the calculations.

When a NAICS category gave a number of employees and there were no establishments with 100 employees or greater, then the value was used, however, in most cases the USCBP gave a range of total employees in the county instead of the actual number. When this occurred, facility sizes were considered and the mid-range of employees was assumed, in accordance with the EIIP

Tech. Report. For example, a NAICS category for a county had a range of employment of 100-249 with two establishments with 1-4 employees, one with 20-49 employees, and one with 100-249 employees. Assuming 3 to be the mid-range of 1-4 and 35 to be the mid-range of 20-49, the employment used for the area source calculation was estimated as:

(2 x 3) + (1 x 35) = 41 employees

The larger establishment was assumed to be a point source and not taken into consideration for the area source calculation.

If a total number of employees was provided and there were establishments with 100 employees or greater, then the mid-range of the smaller facilities were used as described above. The estimated employment was compared to the value given to ensure that remainder would account for the large establishment. In cases where the remainder would not be enough employment to account for the larger establishment, the area source employment was adjusted down. For example, a NAICS category had 250 employees with one establishment with 20–49 employees (mid-range 35), two establishments with 50–99 employees (mid-range 75), and one establishment with 100–249 employees. The employment estimated for the area source and the remainder employment was estimated as:

(1 x 35) + (2 x 75) = 185 employees
250 – 185 = 65 employees

The remainder of 65 employees is not enough to account for an establishment of 100–249 employees. Therefore, the area source employment was adjusted down by 35 so that there were 100 employees remaining to account for the large establishment.

Additionally, many of the categories for the area source emissions use total county population or the rural portion of the county population for the activity data. In order to calculate the emissions for these categories, the 2010 population was obtained from the North Carolina Office of State and Budget Management (NCOSBM). Since the 2010 population was available, categories that have population as the activity data were not grown from 2007 but were calculated for 2010. The rural portion of the total county population was determined by applying a rural percentage to the total county population. The rural percentage was determined from the latest census data available, the 2010 census.

Table 2.2-1 contains the total county population for the CO maintenance areas.

Table 2.2-1 County Population

County	2010 Population
Durham	267,587
Forsyth	350,670
Mecklenburg	919,628
Wake	900,993

Table 2.2-2 shows the rural percentage of each county and the corresponding rural population.

Table 2.2-2 County Rural Population

County	Percentage of Rural Population	2010 Rural Population
Durham	5.63	15,065
Forsyth	7.35	25,774
Mecklenburg	1.07	9,840
Wake	6.10	54,961

Certain emission categories were adjusted for factors such as control efficiency, rule effectiveness and rule penetration. These are discussed in the description of the area source categories where they are applicable.

3.0 QUALITY ASSURANCE MEASURES

The first step in the quality assurance process is to develop a list of area sources in the maintenance areas. The Procedures document and the EIIP Tech. Report were the primary references used in preparing this list for the emissions inventory. To ensure the accuracy of the emissions estimates, the area source emissions inventory team followed the quality assurance measures as outlined in the NCDAQ Emissions Inventory Quality Assurance Project Plan (QAPP).

Under the direction of the quality assurance coordinator, emission sources whose contribution was either at the high or low end of the range of estimates were scrutinized more closely for reasonableness. The accuracy was addressed by performing independent checks of the emissions calculations, verifying the activity data and emission factors as well as plotting all of the area source categories vs. pollutants.

4.0 DISCUSSION OF AREA SOURCE CATEGORIES

There are two major area source categories, man made area sources and small stationary combustion sources, that produce CO emissions. Sections 4.1 and 4.2 address each of these categories and include subsections that correspond to the category. The objective of each subsection is to describe the emission estimation and projection procedures.

4.1 MAN MADE AREA SOURCES

Man made area sources include forest fires, which encompasses wildfires and prescribed burns, structure fires, vehicle fires, charbroiling and open burning. The methodology used to calculate the emissions from these sources are described in detail in each subsection.

4.1.1 Forest Fires

There are two types of forest fires; wild fires, which are accidental or felonious fires and prescribed burns, which are intentionally set for the purpose of forest and/or grassland management practice. The number of acres burned in 2007 for each of these categories was obtained from the North Carolina Division of Forest Resources (NCDFR) and are listed in Table 4.1.1-1. The U.S. Forest Service and U.S. Fish and Wildlife Service also perform prescribed burns in North Carolina but none are in the CO maintenance areas.

Table 4.1.1-1 2007 Acres of Land Burned by Fires

County	Wildfires Acres	Prescribed Fires Acres	Total Acres Burned
Durham	83	531	614
Forsyth	28	0	28
Mecklenburg	62	24	86
Wake	121	665	786

The makeup of the plant life burned in each fire can vary from woodland to brush to grassland. The emission factors for the southern region of the United States were obtained from AP-42, Table 13.1-2, were used to estimate the emissions from forest burns. The fuel loading was also obtained from the AP-42. The emission factors are 67 tons CO per acre burned for prescribed fires and 140 tons of CO per acre burned for wildfires.

The NCDFR was not able to provide seasonal numbers, so the daily emissions are estimated by dividing by 365 days per year. It is assumed that the number of acres burned remains relatively constant; therefore, the 2007 acres will be used to determine the 2010 fire emissions. The emissions were calculated using equation 4.1.1-1.

$$EM = \text{no. acres burned} * \text{fuel loading} * EF * (1\ \text{year}/365\ \text{days}) \qquad 4.1.1\text{-}1$$

where:

EM = total daily emissions in tons/day
Fuel loading = 9 tons/acre
EF = emission factors, $EF_{Prescribed\ Fires}$ = 67 tons/acre burned and $EF_{Wildfires}$ = 140 tons/acres burned

The CO emission estimates, in tons/day (tpd), from forest fires for the CO maintenance areas are listed in Table 4.1.1-2.

Table 4.1.1-2 CO Emissions (tpd) from Forest Fires

County	Prescribed Fires Emissions	Wildfires Emissions	Total Forest Fires CO Emissions
Durham	0.44	0.14	0.58
Forsyth	0.00	0.05	0.05
Mecklenburg	0.02	0.11	0.13
Wake	0.55	0.21	0.76

4.1.2 Structure Fires

The U.S. Fire Administration (USFA) maintains statistics on the number of fires per county. The number of fires per county for 2009 was obtained from the USFA fire statistics website. The structure fires category is based on both residential and non-residential structures. A fires per person factor was calculated for the residential structures based on the national number of residential fires divided by the national population for 2009. The fires per person factor for residential structures 0.0012 fires/person. A fires per person factor was also calculated for the non-residential structures based on the national number of non-residential fires divided by the national employment for 2009. The fires per employee factor for non-residential structures 0.00078 fires/employee.

The 2010 county population was obtained from the North Carolina State Demographics and the 2009 county employment was obtained from the US Census Bureau, County Business Patterns. The 2009 county employment is the latest data available. The 2009 employment data is not expected to be significantly different from 2010. The fires per person factor was applied to the 2010 county population to determine the number of residential structure fires per county.

Additionally, the fires per employee factor was applied to the 2009 total county employment to determine the non-residential structure fires per county. To determine the total emissions from structure fires, the sum of the residential and non-residential structure fires were totaled for each county.

The 2010 county population, shown in Table 2.2-1, was used to estimate the emissions for the residential portion and the 2009 county employment, shown in Table 4.3.2-1, was used to estimate the emissions for the non-residential portion. The estimates of the residential and nonresidential portions were summed to obtain the total emissions for the structure fires.

Table 4.1.2-1 2009 County Employment

	County Employment
Durham	163,018
Forsyth	163,419
Mecklenburg	531,089
Wake	375,345

The fuel loading factor, 1.15 tons of material burned per structural fire, was obtained from the EIIP Tech. Report, Chapter 18. The CO emission factor was also obtained from the EIIP Tech. Report, Table 18.4-1. The emission factor is 60 lbs of CO per ton burned.

According to the EIIP Tech. Report emissions from this source category occur 365 days per year and there is no seasonal adjustment required.

The structure fires emissions were calculated using equation 4.1.2-1.

$$EM = \frac{[(\text{cnty pop} * FPP) + (\text{cnty empl} * FPE)]}{2{,}000 \text{ lbs/tons}} * CF * EF * (1 \text{ year}/365 \text{ days}) \qquad 4.1.2\text{-}1$$

where:

EM = total daily emissions in tons/day
FPP = fires per person, 0.0012 fires/person
FPE = fires per employee, 0.00078 fires/employee
CF = conversion factor, 1.15 tons burned/structure fire
EF = emission factors, CO = 60 lbs/ton burned/year

The CO emission estimates, in tons/day, from structure fires are listed in Tables 4.1.2-2.

Table 4.1.2-2 CO Emissions (tpd) from Structure Fires

County	CO Emissions
Durham	0.01
Forsyth	0.01
Mecklenburg	0.04
Wake	0.03

4.1.3 Vehicle Fires

Vehicle fire emissions within the maintenance areas are estimated by considering the estimated number vehicles burned in the maintenance counties, the amount of material burned (the fuel loading) in a vehicle fire, and the emission factors for the open burning of automobile components. The method used to calculate the CO emissions from vehicle fires was obtained from the EIIP Tech. Report, Vehicle Fires.

The estimated number of vehicle fires per county was determined by apportioning a national fire statistic to the county level using vehicle miles traveled (VMT). The USFA maintains national-level fire statistics. The latest available data for vehicle fires are for the year 2007. The number of vehicle fires nationwide in 2007 was 258,000. The number of national vehicle fires was apportioned to a state-level using a ratio of the 2007 NC VMT to 2007 U.S. VMT (249,698,650 miles/3,029,822 x 10^6 miles). The number of statewide vehicle fires was then apportioned to a county level based on the ratio of the 2010 county-level VMT to the 2010 NC VMT. The nationwide VMT was obtained from the U.S. Department of Transportation, Federal Highway Administration website. The statewide and county VMT is Highway Performance Monitoring System data that was received from the NCDOT.

The CO emission factor was also obtained from the EIIP Tech. Report, Vehicle Fires. The CO emission factor is 125 lbs of CO per ton burned. This source category can occur 365 days per year and there is no seasonal adjustment required.

The above methodology was employed to calculate the vehicle fire emissions per county. For 2010, the VMT for the CO maintenance areas are listed in Table 4.1.3-1.

Table 4.1.3-1 2010 Vehicle Miles Traveled

County	Vehicle Miles Traveled
Durham	3,290,264,636
Forsyth	3,916,801,397
Mecklenburg	11,820,712,140
Wake	10,469,417,080
Statewide	102,384,967,632

The amount of vehicle material burned in a vehicle fire was estimated by assuming that an average vehicle has 500 lbs. of components (0.25 tons) that can burn in a fire, based on a 3,700 lbs. average vehicle weight (CARB, 1995).

The emissions for 2010 were calculated using equation 4.1.3-1.

$$EM = \frac{\text{US veh fires} * CF * EF}{2{,}000\ \text{lbs/tons}} * (\text{NC VMT}_{2007}/\text{US VMT}_{2007})*(\text{cnty VMT}_{2010}/\text{NC VMT}_{2010})*(1\ \text{yr}/365\ \text{dys}) \qquad 4.1.3\text{-}1$$

where:

EM = total daily emissions in tons/day
CF = conversion factor, 0.25 tons burned/vehicle fire
EF = emission factors, CO = 125 lbs/ton burned year

The CO emission estimates from vehicle fires are listed in Table 4.1.3-2.

Table 4.1.3-2 CO Emissions (tpd) from Vehicle Fires

County	CO Emissions
Durham	0.01
Forsyth	0.01
Mecklenburg	0.04
Wake	0.04

4.1.4 Charbroiling

Charbroiling is one of the categories the USEPA revised for the 2008 National Emissions Inventory (NEI). The emission factors were developed and reviewed by an ERTAC advisory panel composed of state and USEPA personnel. The emission factors were generated by taking the 2002 NEI emissions and dividing by the 2002 population to develop per capita emission factors. The charbroiling emission factors are shown in Table 4.1.4-1

Table 4.1.4-1 Charbroiling Emission Factors

Subcategory	CO Emission Factors (lb CO/person/year)
Conveyorized Charbroiling	0.043
Under-fired Charbroiling	0.135
Deep Fat Frying	0.000
Flat Griddle Frying	0.013
Clamshell Griddle Frying	0.000

The 2010 emissions were calculated using equation 4.1.4-1.

$$EM = \frac{\text{county population} * EF}{2{,}000 \text{ lbs/tons}} * (1 \text{ year}/365 \text{ days}) \qquad 4.3.4\text{-}1$$

where:

EM = total daily emissions in tons/day
EF = emission factor per charbroiling subcategory

The CO emission estimates, in tons/day, from charbroiling for the CO maintenance areas are listed in Tables 4.1.4-2.

Table 4.1.4-2 CO Emissions (tpd) from Charbroiling

County	Conveyorized Charbroiling Emissions	Under-fired Charbroiling	Flat Griddle Frying	Total Charbroiling CO Emissions
Durham	0.01	0.03	0.00	0.04
Forsyth	0.01	0.03	0.00	0.04
Mecklenburg	0.03	0.10	0.01	0.14
Wake	0.02	0.07	0.01	0.10

4.1.5 Open Burning – Municipal Solid Waste and Yard Waste

It was assumed that all municipal solid waste (MSW) and yard waste were burned in the open for solid waste generated outside the municipal corporate limits. Since it is illegal to burn within the corporate limits, only the rural percentage of the total population was used. The rural population was calculated by applying the 2010 census rural population percentage to the total 2010 county population as shown in Table 2.2-2. The 2010 total population for each county was obtained from the North Carolina Office of State Budget and Management, State Data Center. The emission factors were developed by the USEPA in consultation with the ERTAC based primarily on AP-42. The fraction of leaf yard waste burned, the fraction of waste generated that is burned and the per capita waste generated was estimated using data from a report by the USEPA on municipal solid waste.

The 2010 emissions were calculated using equations 4.1.5-1 and 4.1.5-2.

$$EM_{MSW} = \frac{\text{county rural pop} * 0.28 * PC_{MSW} * EF}{2{,}000 \text{ lb/tons}} \qquad 4.1.5\text{-}1$$

$$EM_{Yard} = \frac{\text{county rural pop} * 0.25 * 0.28 * PC_{Yard} * EF}{2{,}000 \text{ lb/tons}} \qquad 4.1.5\text{-}2$$

where:

EM = total daily emissions in tons/day
fraction of waste generated that is burned = 0.28
leaf fraction of yard waste = 0.25
PC_{MSW} = per capita MSW generated = 0.000993 ton MSW/person/year
PC_{Yard} = per capita yard waste generated = 0.000295 ton yard waste/person/year
EF = CO emission factor for MSW = 85 lbs MSW/ton burned/year and for
yard waste = 112 lbs yard waste/ton burned/year

Since the NCDAQ has an open burning regulation that prohibits the burning of man-made materials, the emissions estimated for MSW were reduced to account for this rule. The control efficiency is 100% since no burning yields no emissions. The rule penetration is also 100% since the regulation prohibits the burning of man-made materials statewide. Finally the rule effectiveness was set to a conservative 56% for 2010 since the NCDAQ knows that burning of man-made materials does occur. The NCDAQ has started an aggressive campaign to make the public aware that it is illegal to burn man-made materials. The NCDAQ has sponsored radio ads as well as billboard signs in an effort to educate the public. Additionally, the NCDAQ has developed an educational video discussing open burning and the State’s regulation. This video has been distributed to the fire departments across the State. Finally, at the 2009 and 2010 North

Carolina State Fair, the NCDAQ had a booth that allowed staff to talk with the general public about the open burning regulations and provide hand outs that discussed what was legal to burn.

The formula used to apply these controls to the emissions estimates is shown below in equation 4.1.5-3.

$$EM_{MSW,Controlled} = EM_{MSW} \times [1 - (CE \times RP \times RE)] \qquad 4.1.5\text{-}3$$

where:

$EM_{MSW,Controlled}$ = controlled emissions from burning MSW
EM_{MSW} = emissions from burning MSW
CE = control efficiency
RP = rule penetration
RE = rule effectiveness

The CO emission estimates, in tons/day, from the open burning of MSW and yard waste are listed in Table 4.1.5-1.

Table 4.1.5-1 CO Emissions (tpd) from Open Burning

County	2010 MSW Emissions	2010 Yard Waste Emissions	Total Open Burning CO Emissions
Durham	0.08	0.02	0.10
Forsyth	0.13	0.03	0.16
Mecklenburg	0.05	0.01	0.06
Wake	0.29	0.06	0.35

4.2 SMALL STATIONARY COMBUSTION AREA SOURCES

Combustion sources are comprised of the small stationary combustion sources that are not included in the point source emissions inventory. This source category covers emissions from natural gas (NG), liquid petroleum gas (LPG), fuel oil, coal and wood combustion in the residential, commercial/institutional (referred to as commercial) and industrial sectors. The methodology used to calculate the emissions from these sources are described in detail in each subsection.

The 2010 emissions were developed by applying a growth factor to the 2007 emissions for these subcategories.

The 2007 fuel usage data for North Carolina was obtained from the U.S. Department of Energy, Energy Information Administration (EIA) website for fuel consumption.

The following table shows the fuel usage for the residential, commercial and industrial sectors.

Table 4.2-1 2007 Fuel Use in North Carolina

Fuel	Units	Residential	Commercial	Industrial
Natural Gas	10^6 ft^3	58,909	45,861	89,289
LPG	gallons	239,256,678	41,811,847	184,668,990
Oil	gallons	117,527,897	66,949,824	295,999,749
Coal	tons	4,447	40,020	0
Wood	tons	1,466,667		
Wood	10^6 BTU		1,641	75,691

The emission factors used to estimate the emissions, except residential wood, were obtained from E.H. Pechan & Associates, Inc. based on the ongoing emission factor development work conducted by the Eastern Regional Technical Advisory Group in conjunction with the USEPA. The residential wood emission factors were obtained from a tool developed by the USEPA to calculate the emissions generated from residential wood combustion.

The emission factors used are shown in Table 4.2-2 below.

Table 4.2-2 Residential Combustion CO Emission Factors

Fuel	Units	CO Emission Factors
Residential		
NG	lb/10^6 ft^3	40
LPG	lb/10^3 gal	159.6
Fuel Oil	lb/10^3 gal	5
Coal	lb/ton	275
Wood	lb/ton	149

4.2.1 Residential Combustion Sources

The residential category for the fuel oil, coal, NG and LPG sources fuel usage for the CO maintenance areas were calculated by apportioning the State total fuel usage to a county level. Fuel usage was apportioned by applying the ratio of the number of households heated with the appropriate fuel type in a county to the total households in the State heated with the appropriate fuel type, see equation 4.2.1-1.

$$\text{no. gal. fuel per cnty} = (\text{no. gal. fuel for State}) * \frac{(\text{no. housing units heated by fuel per county})}{(\text{no. housing units heated by fuel in State})} \qquad 4.2.1\text{-}1$$

The number of households heated with fuel oil, coal, NG and LPG was obtained from the U.S. Census Bureau based on the latest census data which is 2000. The number of households heated per fuel type is shown in Table 4.2.1-1.

Table 4.2.1-1 Residential Fuel Type

	Number of Households per Fuel Type				
County	Fuel Oil	Coal	NG	LPG	Wood
Durham	4,231	6	35,446	4,569	14
Forsyth	22,223	39	32,646	3,763	18
Mecklenburg	6,568	29	142,812	4,009	0
Wake	4,265	17	100,902	17,686	43
Statewide	368,279	464	757,777	394,275	65,657

For the residential wood combustion emissions, the USEPA developed a tool to generate the emissions for this subcategory. The emissions for this subcategory are for housing units with fireplaces as their main source of heating. The activity data used in the calculation was also obtained from the tool the USEPA developed to calculate residential wood combustion emissions.

For the residential source sectors, the growth factors are based on the population for each county. The population growth factors were developed based on the ratio of the 2010 population to the 2007 population, see equation 4.2.1-2.

$$\text{Population Growth Factors} = \frac{FY_{pop}}{BY_{pop}} \qquad 4.2.1\text{-}2$$

where:

BY_{pop} = 2007 population per county
FY_{pop} = 2010 population per county

The population growth factors are in Table 4.2.1-2.

Table 4.2.1-2 Population Growth Factors for Residential Combustion

County	Growth Factors
Durham	1.0621
Forsyth	1.0401
Mecklenburg	1.0566
Wake	1.0939

The emissions calculation is shown in equation 4.2.1-3.

$$EM_{2007} = \frac{\text{activity data} * EF}{2{,}000 \text{ lbs/ton}} * (1 \text{ year}/365 \text{ days}) \qquad 4.2.1\text{-}3$$

where:

EM_{2007} = 2007 daily emissions in tons/day
EF = emission factors for CO are shown in Table 4.2-2
activity data = number of households per fuel type.

The 2010 emissions for residential combustion were calculated using equation 4.2.1-4

$$EM_{2010} = EM_{2007} * POP_{GF} \qquad 4.2.1\text{-}4$$

where:

EM_{2010} = 2010 emissions in tons/day
EM_{2007} = 2007 emissions in tons/day
POP_{GF} = population growth factors.

The CO emissions estimates for each residential fuel combustion source, in tons/day, for the residential source sector are listed in Table 4.2.1-3.

Table 4.2.1-3 CO Emissions (tpd) for Residential Combustion

County	Coal	Fuel Oil	NG	LPG	Wood	Total Residential Combustion CO Emissions
Durham	0.02	0.01	0.16	0.01	0.19	0.39
Forsyth	0.15	0.04	0.15	0.01	0.20	0.55
Mecklenburg	0.11	0.01	0.64	0.01	1.04	1.81
Wake	0.07	0.01	0.45	0.05	0.53	1.11

4.2.2 Commercial and Industrial Combustion Sources

Commercial and industrial fuel usage was apportioned according to the number of employees in the commercial/industrial business establishments in the State and the CO maintenance counties. Fuel usage was apportioned to the county level by applying the ratio of county employment to the total State employment, see equation 4.2.2-1.

$$\text{no. gal. fuel per county} = (\text{no. gal. fuel for State}) * \frac{(\text{commercial/industrial employment per county})}{(\text{commercial/industrial employment in State})} \quad 4.2.2\text{-}1$$

The commercial employment data was obtained from the County Business Patterns for NAICS codes 42 (wholesale trade) through 81 (other services - except public administration). For industrial combustion, the employment data was also obtained from the County Business Patterns for NAICS codes 31-33 (manufacturing). The total number of employees for these establishments was used to allocate emissions to the county level. The 2007 commercial and industrial employment for each county are shown in Table 4.2.2-1.

Table 4.2.2-1 Commercial and Industrial Combustion Employment

County	2007 Commercial Employment	2007 Industrial Employment
Durham	66,296	2,225
Forsyth	81,819	5,932
Mecklenburg	274,725	14,984
Wake	224,283	8,688
Statewide	1,829,856	163,364

The emissions for 2007 for each small stationary combustion source were calculated using equations 4.2.2-2 through 4.2.2-6.

$$EM_{coal} = \frac{\text{no. tons/year coal} * EF_{coal}}{2{,}000\ \text{lb/ton}} * (1\ \text{year}/365\ \text{days}) - pse \qquad 4.2.2\text{-}2$$

$$EM_{NG} = \frac{\text{no. ft}^3\text{/year NG} * EF_{NG}}{2{,}000\ \text{lbs /ton}} * (1\ \text{year}/365\ \text{days}) - pse \qquad 4.2.2\text{-}3$$

$$EM_{LPG} = \frac{\text{no. gal/year LPG} * EF_{LPG}}{2{,}000\ \text{lbs /ton}} * (1\ \text{year}/365\ \text{days}) - pse \qquad 4.2.2\text{-}4$$

$$EM_{fuel\ oil} = \frac{\text{no. gal/year fuel oil} * EF_{oil}}{2{,}000\ \text{lbs /ton}} * (1\ \text{year}/365\ \text{days}) - pse \qquad 4.2.2\text{-}5$$

$$EM_{wood} = \frac{\text{no. ton/year wood} * EF_{wood}}{2{,}000\ \text{lbs /ton}} * (1\ \text{year}/365\ \text{days}) - pse \qquad 4.2.2\text{-}6$$

where:

EM_{coal} = daily total coal emissions in tons/day
EM_{NG} = daily total Ng emissions in tons/day
EM_{LPG} = daily total LPG emissions in tons/day
$EM_{fuel\ oil}$ = daily total fuel oil emissions in tons/day
EM_{wood} = daily total wood emissions in tons/day
EF_{coal} = CO emission factor for coal combustion
EF_{NG} = CO emission factor for NG combustion
EF_{LPG} = CO emission factor for LPG combustion
EF_{oil} = CO emission factor for fuel oil combustion
EF_{wood} = CO emission factor for wood combustion
pse = point source emissions

The CO emission factors used to estimate the emissions for the commercial and industrial stationary sources are shown in Table 4.2.2-2.

Table 4.2.2-2 Commerical/Industrial Combustion CO Emission Factors

Fuel	Units	CO Emission Factors
Commercial		
NG	$lb/10^6\ ft^3$	84
LPG	$lb/10^3$ gal	7.97
Fuel Oil	$lb/10^3$ gal	5
Coal	lb/ton	5
Wood	$lb/10^6$ BTU	0.6
Industrial		
NG	$lb/10^6\ ft^3$	84
LPG	$lb/10^3$ gal	7.97
Fuel Oil	$lb/10^3$ gal	5
Wood	$lb/10^6$ BTU	0.6

The growth factors were developed based on the ratio of the 2010 employment to the 2007 employment, see equation 4.2.2-7.

$$\text{Commercial/Industrial Growth Factors} = \frac{FY_{emp}}{BY_{emp}} \qquad 4.2.2\text{-}7$$

where:

BY_{emp} = 2007 employment per county
FY_{emp} = 2010 employment per county

The commercial combustion growth factors were generated from the statewide employment data for NAICS codes 42 (wholesale trade) through 81 (other services - except public administration). The industrial combustion growth factors were also generated from statewide data using NAICS codes 31-33 (manufacturing). The FORECAST function in Microsoft EXCEL was used to determine the future year employment data based on the past statewide employment data for 2005 - 2009. The FORECAST tool uses linear interpolation to project future values based on the historic data.

Table 4.2.2-3 shows the commercial and industrial combustion growth factors.

Table 4.2.2-3 Growth Factors for Commercial and Industrial Combustion

County	Commercial	Industrial
Durham	0.9792	0.6786
Forsyth	0.9795	0.9167
Mecklenburg	1.0235	0.8717
Wake	1.0430	0.9142

The emissions for 2010 for all of the small stationary combustion sources were calculated using equation 4.2.2-8

$$EM_{2010} = EM_{a,2007} * EMP_{GF} \qquad 4.2.2\text{-}8$$

where:

EM_{2010} = 2010 emissions in tons/day
$EM_{a,2007}$ = 2007 emissions in tons/day per combustion source
EMP_{GF} = employment growth factors.

The commercial and industrial small stationary combustion sources CO emission estimates, in tons/day, are shown in Tables 4.2.2-4 – 4.2.2-5, respectively. There are no coal combustion emissions for the industrial source sector because the emissions generated from coal are accounted for in the point sources inventory.

Table 4.2.2-4 CO Emissions (tpd) for Commercial Combustion

County	Coal	Fuel Oil	NG	LPG	Wood	Total Commercial Combustion CO Emissions
Durham	0.01	0.01	0.13	0.04	0.06	0.25
Forsyth	0.01	0.02	0.16	0.05	0.07	0.31
Mecklenburg	0.04	0.06	0.56	0.19	0.24	1.09
Wake	0.03	0.04	0.61	0.16	0.17	1.01

Table 4.2.2-5 CO Emissions (tpd) for Industrial Combustion

County	Fuel Oil	NG	LPG	Wood	Total Industrial Combustion CO Emissions
Durham	0.00	0.09	0.03	0.04	0.16
Forsyth	0.02	0.15	0.05	0.06	0.28
Mecklenburg	0.05	0.48	0.16	0.21	0.90
Wake	0.04	0.53	0.14	0.15	0.86

Point sources are those stationary sources that require an air permit to operate. In general, these sources have a potential to emit more than 5 tons per year of CO from a single facility. Point sources that meet this criterion are accounted for in the point source emissions inventory. They are subtracted from the area source emissions inventory to prevent double counting of emissions. The 2007 point source emissions data was subtracted from the overall area source emissions calculation. Tables 4.2.2-6 and 4.2.2-7 illustrates the point source emissions that were subtracted from the commercial and industrial fuel oil, NG and wood combustion sources. The coal and LPG commercial and industrial combustion sources do not have point source emissions for the CO maintenance areas.

Table 4.2.2-6 Point Source Commercial Combustion Emissions (tpd)

County	Fuel Oil	NG	Wood
Durham	0.01	0.03	0.00
Forsyth	0.00	0.03	0.01
Mecklenburg	0.00	0.19	0.13
Wake	0.00	0.15	0.00

Table 4.2.2-7 Point Source Industrial Combustion Emissions (tpd)

County	Fuel Oil	NG	Wood
Durham	0.00	0.06	0.00
Forsyth	0.02	0.23	0.56
Mecklenburg	0.02	0.28	0.00
Wake	0.00	0.09	0.00

5.0 SUMMARY OF AREA SOURCE EMISSIONS

The total area source CO emissions for the maintenance areas are summarized in the table below. All of the emissions are in tons per day.

Table 5-1 Total Area Source CO Emissions (tpd)

County	2010
Durham	1.54
Forsyth	1.41
Mecklenburg	4.21
Wake	4.26

Appendix B.3

On-road Mobile Source

Emissions Inventory Documentation

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List of Acronyms

Acronym	Definition
AADVMT	Average Annual Daily Vehicle Miles Traveled
CO	Carbon Monoxide
HPMS	Highway Performance Monitoring System
MOVES	Motor Vehicle Emission Simulator
NCDAQ	North Carolina Division of Air Quality
NCDOT	North Carolina Department of Transportation
NCOSBM	North Carolina Office of State and Budget Management
QAPP	Quality Assurance Project Plan
RVP	Reid Vapor Pressure
TDM	Travel Demand Modeling
USEPA	U.S. Environmental Protection Agency
VMT	Vehicle Miles Traveled

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1.0 INTRODUCTION AND SCOPE

Carbon monoxide (CO) emissions from on-road mobile sources comprise a large percentage of the total man-made CO emissions from all sources in the current North Carolina CO attainment/maintenance area. However, on-road mobile source CO emissions have continually decreased over the past two decades due to improved vehicle pollution controls and fuel economy, implementation of inspection and maintenance programs, and effective transportation planning measures. These decreases have been realized in spite of continual increases in vehicle miles traveled (VMT), and have led to ambient CO concentrations well below the CO National Ambient Air Quality Standard (NAAQS) in recent years.

These consistently low CO concentrations allow North Carolina the option of implementing a limited CO maintenance plan for the four affected counties (Forsyth, Durham, Mecklenburg, and Wake Counties). An on-road mobile source CO emissions inventory has been developed as part of the limited maintenance plan requirements. This appendix covers the procedures associated with the emissions inventory development.

The CO emissions inventory data includes 2010 daily on-road mobile source CO emissions (tons/day) for a typical winter (January) day for each of the four affected counties. Emissions data were generated using the United States Environmental Protection Agency (USEPA) Motor Vehicle Emissions Simulator (MOVES) model. Monthly CO inventories for January 2010 were generated for each county and the average daily CO emissions values were calculated from the monthly inventory values. Details of the MOVES modeling process, including input data requirements, input data preparation, and modeling parameters and assumptions, are presented below.

2.0 MODELING METHODOLOGY

2.1 MOVES MODELING SCENARIO AND PARAMETERS

Mobile source emissions are estimated by the methodologies suggested in the 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 is a computer program designed by the USEPA to estimate air pollution emissions from mobile sources. MOVES2010a (hereafter referred to as MOVES) replaces the USEPA's previous emissions model for on-road mobile sources, MOBILE6.2. MOVES can be used to estimate exhaust and evaporative emissions as well as brake and tire wear emissions from all types of on-road vehicles.

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, 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). 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 North Carolina Division of Air Quality (NCDAQ) is electing to run the model in the inventory mode due to faster model run times and fewer post-processing requirements.

To generate the emissions inventory data required for the limited CO maintenance plan, MOVES modeling was performed using the parameters listed ion Table 2.1-1.

Table 2.1-1 MOVES Modeling Parameters

MOVES Model Version	MOVES2010a
Pollutant	Carbon Monoxide (CO)
Modeling Spatial Domains	CO Maintenance counties – Durham, Forsyth, Mecklenburg, Wake
Modeling Year	2010
Required Emissions Time Period	Typical winter day
Vehicle Types	All on-road vehicles
Inspection and Maintenance Program Applicability	As per the North Carolina Inspection and Maintenance SIP (includes OBD-II inspection of light duty gasoline vehicles)

While MOVES can model emissions for a weekday and weekend day in a specified month, it cannot directly model a single day with specified "typical winter day" conditions. Therefore, to calculate emissions for a typical winter day, MOVES was first run to estimate the total on-road CO emissions for the month of January 2010 for each of the listed counties. Each monthly emissions value (tons CO) was then divided by the number of days in the month (31) to give typical winter day emissions (tons CO/day).

3.0 QUALITY ASSURANCE MEASURES

The quality assurance (QA) for the on-road 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 files. If any discrepancies are found, they are noted back to the person who generated the input files for correction. Additionally, a report is kept that identifies the person who produced the input file, the person that QA'd the file, and where the data originated. Once the input files have passed through the QA procedure, MOVES is run to generate emissions.

MOVES output data from each county is also checked for reasonableness by comparison with historical emissions inventory data and by comparison with emissions data from counties with similar transportation activity. As with the MOVES input data, MOVES output data summaries are also reviewed for accuracy by someone other than the preparer of the summary.

4.0 MODELING RESULTS

On-road mobile sources produce emissions of a host of pollutants. For the purpose of this maintenance plan, only the CO emissions were estimated. The objective of this 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 maintenance year 2010 by county.

4.1 INTRODUCTION AND SCOPE

On-road highway mobile sources are considered as those vehicles that travel on public roadways. On-road mobile sources are a major contributor to CO emissions in North Carolina. CO is emitted from motor vehicles primarily while vehicles are in motion or at idle and only minimally while vehicles are parked or during refueling operations. However, emissions from all of these emissions processes were estimated to properly reflect the total emissions from this source category.

A very important component of the highway mobile emission estimation process is interagency consultation among federal, state, regional and local regulatory and planning agencies. For this CO emissions inventory development project, NCDAQ used travel demand modeling data provided by three organizations listed below. These organizations executed the travel demand modeling (TDM) for their respective counties in the CO nonattainment area and provided speeds and vehicle miles traveled (VMT).

Table 4.1-0-1 TDM Data Providers

Organization Providing TDM Data	County VMT and Speed Data Provided
Mecklenburg-Union Metropolitan Planning Organization (MUMPO)	Mecklenburg
Capital Area Metropolitan Planning Organization (CAMPO) in coordination with Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC-MPO)	Durham, Wake
Piedmont Authority for Regional Transportation (PART)	Forsyth

4.2 MOVES INPUT DATA CRITERIA AND ASSUMPTIONS

The following sections describe the input data used for the MOVES CO emissions modeling. 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 Vehicle Miles Traveled and Speeds

The MOVES model calculates emissions based on several mobile source operating parameters, including the number of VMT on specific types of roadways as defined under the Federal Highway Administration's Highway Performance Monitoring System (HPMS). For each of the four affected counties, VMT data were obtained from the municipal planning organization (MPO) representing that county. Each MPO used travel demand modeling (TDM), based on their specific demographic, roadway network, and socioeconomic data and conditions, to estimate the average annual daily VMT (AADVMT) and corresponding average speeds categorized by twelve HPMS roadway functional classes. For three of the four counties, VMT and speed data were furthered categorized by daily travel periods, including morning and afternoon peak periods. Table 4.2-1 shows the travel periods for each county.

Table 4.2-1 Peak and Off-peak Travel Periods

County	AM Peak Period	Midday Period	PM Peak Period	Off-peak Period
Durham, Wake	**06:00-10:00**	**Included as off-peak**	**15:00-18:00**	**10:00-15:00, 18:00-23:59, 00:00-06:00**
Mecklenburg	**06:00-09:00**	**09:00-15:00**	**15:00-18:00**	**18:00-23:59, 00:00-06:00**
Forsyth	**No peak or off-peak travel periods specified – VMT and speeds provided apply to entire day**			

VMT and speed data were processed with converter applications to format the data for input into MOVES. Annual VMT for each of 6 HPMS vehicle types were tabulated, as well as the hourly distribution of VMT for each source type-road type-day type (weekday or weekend) combination.

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 was 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.

TDM-generated VMT and speeds were provided for 2010 for the time periods described above. Table 4.2-2 lists the AADVMT by HPMS functional class for each county. Table 4.2-3 provides a summary of the speeds in miles per hour (mph) for each county. The column headings in these tables represent the road types used in the modeling and are listed below.

RI	Rural Interstate		UI	Urban Interstate
RPA	Rural Other Principle Arterial		UF	Urban Freeway & Expressway
RMA	Rural Minor Arterial		UPA	Urban Other Principal Arterial
RMjC	Rural Major Collector		UMA	Urban Minor Arterial
RMiC	Rural Minor Collector		UC	Urban Collector
RL	Rural Local		UL	Urban Local
			UH	Urban HOV

Table 4.2-2 2010 CO Maintenance Area AADVMT by Road Type (miles)

County	Durham			Forsyth	Mecklenburg				Wake		
HPMS Road Type	AM	PM	Off-peak	Daily	AM	Midday	PM	Night	AM	PM	Off-peak
RI	41255	53589	72624	NA	NA	NA	NA	NA	14672	29275	29675
RPA	8453	11066	17565	123182	37607	45986	42338	27117	53465	70992	92767
RMA	40171	50640	68161	160403	17023	20700	19749	13711	23839	38804	44561
RMjC	55109	80109	99517	53612	16862	22570	19703	10535	39049	51064	70029
RMiC	22082	32599	41498	124168	32474	40495	41432	20832	18482	31274	32964
RL	26544	47274	52352	133503	66263	89945	81369	42693	52333	96970	101612
UI	493549	671976	1070728	2008312	1736609	2268124	1919704	1315657	1544267	2108059	3169061
UF	320433	453358	667984	3393797	1110226	1389995	1282080	723369	499329	710404	945463
UPA	245321	340152	522121	380472	1111629	1680204	1284698	944660	1152837	1665360	2513928
UMA	315625	518730	740306	1677609	1024878	1553321	1202756	841426	1212659	1947914	2701970
UC	119318	209844	274128	1544519	806596	1207264	941722	642619	500159	836279	1056018
UL	225973	418299	585970	1131387	1459707	2340210	1736882	1126041	1021962	1838887	2366951
UH	NA	NA	NA	NA	17763	374	7595	0	NA	NA	NA

Table 4.2-3 2010 CO Maintenance Area Speeds by Road Type (miles/hour)

County	Durham			Forsyth	Mecklenburg				Wake		
HPMS Road Type	AM	PM	Off-peak	Daily	AM	Midday	PM	Night	AM	PM	Off-peak
RI	64.7	69.7	58.7	NA	NA	NA	NA	NA	64.3	63.8	47.7
RPA	42.9	44.1	40.3	54.3	36	45	37	49	60.7	60.7	58.2
RMA	46.2	53.1	38.0	49.3	32	43	38	45	47.6	48.9	45.2
RMjC	49.4	50.1	46.7	44.6	30	40	31	46	47.5	48.1	46.1
RMiC	40.7	40.7	39.2	45.4	37	42	36	45	36.8	37.9	35.7
RL	27.5	26.6	26.7	44.2	30	29	30	29	24.7	23.2	24.7
UI	63.5	64.0	55.8	60.6	46	58	42	62	60.0	64.1	52.8
UF	53.8	53.5	48.5	50.3	49	55	47	58	57.5	58.6	49.8
UPA	40.6	39.6	34.1	41.5	24	28	22	37	43.8	45.3	36.6
UMA	39.3	39.1	34.5	41.8	24	28	23	37	39.6	41.2	33.8
UC	40.4	40.0	36.5	38.0	22	27	21	36	38.8	39.8	34.3
UL	21.8	21.5	21.7	36.4	22	21	19	24	25.1	23.9	24.2
UH	NA	NA	NA	NA	63	65	66	0	NA	NA	NA

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. 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 that observed average speed = 1

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

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

Or more simply: VHT Fraction B = 1 – 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 mph Avg. Speed – 55 mph (Bin Speed)) / (60 mph (Bin Speed) – 55 mph (Bin Speed)] = 0.4

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

VHT Fraction $A_{(\text{low bin})}$	+	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:

$$VHT_{(\text{Speed Bin X})} = [\sum (\text{VHT Fraction}_{(RT)} \times \text{hourly } VMT_{(RT)}] \div [\sum \text{hourly } VMT_{(RT)}]$$

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.

$$VHT_{(\text{Speed Bin X})} = \frac{[(\text{VHT Fraction}_{(UI)} * \text{hourly VMT}_{(UI)}) + (\text{VHT Fraction}_{(UF)} * \text{hourly VMT}_{(UF)})]}{(\text{hourly VMT}_{(UI)} + \text{hourly VMT}_{(UF)})}$$

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

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

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

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

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

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

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 Source Type Population

The MOVES model requires county-level source type (vehicle type) populations grouped by 13 categories. These data were developed from 2010 North Carolina Department of Motor Vehicles vehicle registration data. Counts of the total number of registered vehicles in each county were first obtained. The total populations were then broken down into 13 categories using the MOVES default source type distribution for each county for the year 2010.

Source type population is used by MOVES to calculate start and evaporative emissions. 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 the Federal Highway Administration's HPMS vehicle classes (as opposed to the classes used with respect to USEPA emissions regulations). Since HPMS vehicle class data is commonly available from state transportation sources, this makes 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 4.2-3. 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 4.2-4 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 the 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 categorizes vehicles into 13 source types, which are subsets of 6 HPMS vehicle types. Presently NCDAQ is unable to develop county source type population data for many of these source type categories based on how NCDOT collect vehicle registration data. The latest vehicle registration data broken down by county and towns is available by January of each year. Since the vehicle types database available from NCDOT differs from what MOVES2010a expects, the NCDAQ relies on MOVES default fractions and applies these fractions to county total vehicle population, minus trailers. It is assumed that trailers do not have engines and do not generate VMT.

4.2.3 Source Type 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. 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 the 2010 data. The NCDOT provided the data based on the number of vehicle types per year from 1974 through 2010. Since MOVES categorizes the vehicle fleet into different vehicle classes and more model years, 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. Vehicles greater than

25 years old were combined and included as the 25th model year. The vehicle count information is 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).

4.2.4 Road Type Distribution

The distribution of VMT traveled by each source type over the five MOVES road types was determined. The basis of this distribution was the 2009 statewide vehicle mix data provided by the NCDOT, which shows, for a given road type, the activity of each source type as a percentage of total vehicle activity. The 2009 statewide vehicle mix dataset was the latest data available at the time this CO inventory was developed. This data was provided for each of twelve HPMS roadway functional classes and thirteen source types. Procedures outlined in USEPA's *Technical Guidance on the Use of MOBILE6.2 for EI Preparation* (Aug. 2004) were used to re-aggregate the mix data from thirteen source types to sixteen source types and to project the 2009 vehicle mix data to the future year of 2010. Table 4.2-5 shows the statewide vehicle mix used for each of the four counties. Column headings represent road types described in Section 4.2.1.

Table 4.2-5 Fraction of VMT on Road Type by Source Type

Source Type*	RI	RPA	RMA	RMjC	RMiC	RL	UI	UF	UPA	UMA	UC	UL
LDV	0.3178	0.3463	0.3599	0.3584	0.3668	0.3609	0.3515	0.3613	0.3685	0.3759	0.3809	0.3723
LDT1	0.0798	0.0871	0.0905	0.0901	0.0922	0.0907	0.0884	0.0908	0.0927	0.0945	0.0958	0.0936
LDT2	0.2657	0.2898	0.3012	0.2999	0.3069	0.3018	0.294	0.3023	0.3083	0.3145	0.3187	0.3114
LDT3	0.0819	0.0893	0.0929	0.0925	0.0946	0.093	0.0906	0.0932	0.0951	0.097	0.0982	0.096
LDT4	0.0376	0.0411	0.0427	0.0425	0.0435	0.0428	0.0417	0.0428	0.0437	0.0446	0.0451	0.0441
HDV2	0.0682	0.0453	0.0344	0.0357	0.029	0.0338	0.0412	0.0334	0.0276	0.0218	0.0178	0.0247
HDV3	0.0066	0.0044	0.0034	0.0035	0.0028	0.0033	0.004	0.0033	0.0027	0.0021	0.0017	0.0024
HDV4	0.0056	0.0037	0.0028	0.0029	0.0024	0.0028	0.0034	0.0027	0.0023	0.0018	0.0015	0.002
HDV5	0.0042	0.0028	0.0021	0.0022	0.0018	0.0021	0.0025	0.0021	0.0017	0.0013	0.0011	0.0015
HDV6	0.0152	0.0101	0.0077	0.008	0.0065	0.0075	0.0092	0.0074	0.0062	0.0049	0.004	0.0055
HDV7	0.018	0.012	0.0091	0.0094	0.0077	0.0089	0.0109	0.0088	0.0073	0.0057	0.0047	0.0065
HDV8A	0.0196	0.013	0.0099	0.0102	0.0083	0.0097	0.0118	0.0096	0.0079	0.0062	0.0051	0.0071
HDV8B	0.0698	0.0463	0.0352	0.0365	0.0297	0.0346	0.0422	0.0342	0.0283	0.0223	0.0182	0.0253
HDBS	0.0035	0.0023	0.0018	0.0018	0.0015	0.0017	0.0021	0.0017	0.0014	0.0011	0.0009	0.0013
HDBT	0.0017	0.0012	0.0009	0.0009	0.0007	0.0009	0.0011	0.0009	0.0007	0.0006	0.0005	0.0006
MC	0.0048	0.0053	0.0055	0.0055	0.0056	0.0055	0.0054	0.0055	0.0056	0.0057	0.0058	0.0057

* Source Type Definitions

LDV -	Light-Duty Vehicles (Passenger Cars)	HDV5 -	Class 5 Heavy-Duty Vehicles (16,001-19,500 lbs. GVWR)
LDT1 -	Light-Duty Trucks 1 (0-6,000 lbs. GVWR, 0-3,750 lbs. LVW)	HDV6 -	Class 6 Heavy-Duty Vehicles (19,501-26,000 lbs. GVWR)
LDT2 -	Light-Duty Trucks 2 (0-6,000 lbs. GVWR, 3,751-5,750 lbs. LVW)	HDV7 -	Class 7 Heavy-Duty Vehicles (26,001-33,000 lbs. GVWR)
LDT3 -	Light-Duty Trucks 3 (6,001-8,500 lbs. GVWR, 0-5,750 lbs. ALVW)	HDV8A -	Class 8a Heavy-Duty Vehicles (33,001-60,000 lbs. GVWR)
LDT4 -	Light-Duty Trucks 4 (6,001-8,500 lbs. GVWR, 5,751 lbs. and greater ALVW)	HDV8B -	Class 8b Heavy-Duty Vehicles (>60,000 lbs. GVWR)
HDV2 -	Class 2b Heavy-Duty Vehicles (8,501-10,000 lbs. GVWR)	HDBS -	School Buses
HDV3 -	Class 3 Heavy-Duty Vehicles (10,001-14,000 lbs. GVWR)	HDBT -	Transit and Urban Buses
HDV4 -	Class 4 Heavy-Duty Vehicles (14,001-16,000 lbs. GVWR)	MC -	Motorcycles

Converter applications were used to reallocate the VMT fractions from the twelve functional classes to the five MOVES road types described below:

- Off-Network (road type 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 (road type 2) – rural highways that can only be accessed by an on-ramp
- Rural Unrestricted Access road type 3) – all other rural roads (arterials, connectors, and local streets)
- Urban Restricted Access (road type 4) – urban highways or freeways that can only be accessed by an on-ramp
- Urban Unrestricted Access (road type 5) – all other urban roads (arterials, connectors, and local streets)

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 volatile organic compounds). 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 4.2.2. Some evaporative emissions are estimated on roadways (i.e., road types 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.

4.2.5 Inspection and Maintenance Program

In 2002, North Carolina implemented a new vehicle emissions inspection program based on vehicle onboard diagnostics (OBD-II). 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. Requirements and specifications of the inspection and maintenance program are established in the State Implementation Plan (SIP) for the North Carolina Inspection and Maintenance (I/M) Program. The I/M SIP specifies a compliance rate of 92%, meaning that at least 92% of vehicles subject to the I/M program must meet the inspection requirements in order for the program to meet the desired emissions reduction goals. The I/M SIP also specifies a 5% waiver rate. This means the program requirements can be waived for vehicles that cannot pass inspection, as long as the total number of waivers issued does not exceed 5% of all subject vehicles.

In developing this emissions inventory, the MOVES model was run with the appropriate parameters needed to show the effects of the North Carolina I/M program in reducing emissions. For each source type subject to an I/M program, the MOVES model uses a compliance factor based on the compliance rate, waiver rate, and "regulatory class coverage adjustment", which accounts for the fraction of vehicles within a source type that are covered by the I/M program. Table 4.2-4 lists the MOVES I/M compliance factors based on the prescribed 92% compliance rate, 5% waiver rate, and class coverage adjustment for the applicable source types.

Table 4.2-6 MOVES I/M Compliance Factors

Source Type	Compliance Factor
Passenger Car	**87.4**
Passenger Truck	**82.2**
Light commercial Truck	**76.9**

4.2.6 Fuel Supply and Formulation

The MOVES model is populated with monthly default fuel formulations (identified by fuel formulation ID) which are fuel year specific. The model incorporates all recent rulemakings (Tier 2, ultra low sulfur diesel, etc). The default dataset was exported from MOVES and was updated to reflect North Carolina's monthly Reid Vapor Pressure (RVP) requirements for gasoline. For the month modeled (January), an RVP value of 15 was used for all four counties modeled. Also, the MOVES default diesel fuel formulation for January 2010 included a fuel sulfur level of 43 parts per million (ppm). This value reflects the transition from low sulfur diesel fuel, (500 ppm sulfur) to ultra low sulfur diesel (15 ppm sulfur), which was gradually phased in over the period from October 15, 2006 to December 1, 2010.

4.2.7 Meteorological Data

Local temperature and humidity data are required inputs for SIP and regional conformity analyses with MOVES. Ambient temperature is a key factor in estimating emissions for on-road vehicles, with substantial effects on most pollutant processes. Relative humidity is also important for estimating NO_x 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. 2010 monthly average (by hour) temperature and relative humidity from three weather stations listed in the table below were provided by State Climate Office of North Carolina.

Table 4.2-7 Average Hourly Temperature and Humidity – January 2010

County	**Forsyth**		**Mecklenburg**		**Durham, Wake**	
Weather Station	**KGSO**		**KCLT**		**KRDU**	
Location	**Piedmont Triad International Airport**		**Charlotte / Douglas International Airport**		**Raleigh-Durham International Airport**	
Hour	Temp., °F	Relative Humidity, %	Temp., °F	Relative Humidity, %	Temp., °F	Relative Humidity, %
12:00 AM-1:00 AM	32.6	68	34.2	70	34.5	66
1:00 AM-2:00 AM	31.9	69	33.2	72	33.7	68
2:00 AM-3:00 AM	31.4	70	32.5	73	32.7	70
3:00 AM-4:00 AM	31.0	71	31.6	75	32.0	72
4:00 AM-5:00 AM	29.8	72	31.0	77	31.4	73
5:00 AM-6:00 AM	29.5	72	30.2	79	30.9	74
6:00 AM-7:00 AM	29.3	71	29.7	79	30.4	75
7:00 AM-8:00 AM	29.3	71	30.1	79	30.7	74
8:00 AM-9:00 AM	32.5	67	33.5	74	33.4	70
9:00 AM-10:00 AM	35.7	59	36.7	65	36.9	62
10:00 AM-11:00 AM	38.7	52	39.7	56	40.2	53
11:00 AM-12:00 PM	40.6	48	42.4	50	42.3	48
12:00 PM-1:00 PM	42.5	45	43.8	47	44.4	45
1:00 PM-2:00 PM	43.4	43	45.3	44	45.6	43
2:00 PM-3:00 PM	44.1	43	45.8	43	46.3	42
3:00 PM-4:00 PM	43.7	43	46.6	43	45.8	43
4:00 PM-5:00 PM	42.0	45	44.8	46	44.2	45
5:00 PM-6:00 PM	40.1	48	42.1	51	41.6	49
6:00 PM-7:00 PM	38.0	53	40.9	53	39.8	52
7:00 PM-8:00 PM	36.7	56	39.0	58	38.3	56
8:00 PM-9:00 PM	36.2	57	37.8	60	37.5	57
9:00 PM-10:00 PM	34.4	61	37.0	62	36.2	60
10:00 PM-11:00 PM	33.5	63	36.0	64	35.4	62
11:00 PM-12:00 AM	33.0	65	34.6	67	34.8	63

4.3 ESTIMATED EMISSIONS FROM ON-ROAD MOBILE SOURCES

Table 4.3-1 lists the CO emissions modeling results. The values listed represent CO emissions from all vehicle types, as well as all vehicle activity, including off network (vehicle exhaust emissions from starts and evaporative emissions) and on-road running exhaust emissions..

Table 4.3-1 January 2010 On-road Mobile Source CO emissions

County	CO emissions, tons/month	CO emissions, tons/day
Durham	5,766	186.0
Forsyth	7,569	244.2
Mecklenburg	22,456	724.4
Wake	19,932	643.0

.

Appendix B.4

Nonroad Mobile Sources

Emission Inventory Documentation

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List of Tables

1.0 INTRODUCTION AND SCOPE

Nonroad mobile sources are equipment that can move but are not licensed to use the public roads and highways. The nonroad mobile source category includes a diverse collection of equipment such as lawn mowers, chain saws, tractors, all terrain vehicles, forklifts and construction equipment. Emissions from this type of equipment are calculated using the National Mobile Inventory Model (NMIM) developed by the United States Environmental Protection Agency (USEPA). This category also includes emissions from aircraft, railroad locomotives, and commercial marine vessels which are calculated outside of NMIM. No commercial marine vessels operate in Durham, Forsyth, Mecklenburg, or Wake counties so there are no emissions reported for this sub-category.

For this maintenance demonstration, emissions of carbon monoxide (CO) are estimated for the year of 2010.

2.0 OVERALL METHODOLOGY

2.1 SOURCE CATEGORY IDENTIFICATION

Nonroad mobile sources were identified using the USEPA guidance document EPA-450/4-91-016, *Procedures for the Preparation of Emissions Inventories for Carbon Monoxide and Precursors of Ozone* (Procedures document). Nonroad mobile source emissions are estimated by the methodologies suggested in the USEPA document, EPA-454/R-05-001, *Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations*; EPA-450/4-81-026d (Revised) *Procedures for Emission Inventory Preparation, Volume IV; Mobile Sources* (Mobile Source Procedures); from the USEPA's NMIM model (incorporating NONROAD2008a released July 6, 2009); and from the Emissions and Dispersion Modeling System version 5.1.3 (EDMS 5.1.3) model developed by the USEPA and the Federal Aviation Administration (FAA).

2.2 EMISSION ESTIMATION APPROACH

For the majority of nonroad mobile categories, emissions were estimated using the USEPA's NMIM model. Model runs were performed for each of the four counties for January, February, and December of 2010. The county sums of these runs were divided by 90 to produce typical winter day emissions for the several nonroad mobile equipment categories for the counties.

Aircraft emissions were calculated with activity data for the year 2010 for the most part. Activity data for the very small airports was from less year specific FAA data but, in several cases, was obtained by phone calls to the airports. Most of the emissions were calculated using the EDMS 5.1.3 model where the the number of landings and takeoffs for specific aircraft and engine combinations are entered. For air taxi activity and general aviation, not calculated with the EDMS 5.1.3 model, methods and emission factors described in *Documentation for Aircraft Component of the National Emission Inventory Methodology* (ERG No.: 0245.03.402.001, January 27, 2011) were employed. Emission factors developed for military aircraft at military airports in North Carolina as part of the 2008 National Emission Inventory (NEI) were used to calculate emissions for military aircraft operating at civilian airports.

Railroad emissions from the 2008 NEI including passenger railroad emissions developed by the North Carolina Division of Air Quality (NCDAQ) for the NEI were used as the starting point for developing 2010 emissions. Growth factors were based on projected railroad fuel use. Future emission reductions due to emission control measures were calculated based on future emission factors published in the USEPA document *Emission Factors for Locomotives*, EPA-420-F-09-025. Two additional trains were added to the Piedmont route in June, 2010. Emission adjustments were made for this to account for extra emissions in December.

3.0 QUALITY ASSURANCE MEASURES

For the NMIM model run, the run specification file (file that displays the variables used to setup a model run) was reviewed by a second person who did not perform the actual runs. The model results (month totals for three winter months) were also evaluated for completeness and comparability to a previous annual run.

For the aircraft portion of the inventory, data was obtained from sources consistent with USEPA emission inventory methodology. Data entry for the EDMS model was reviewed. Spreadsheet calculations were also reviewed by a second person. NEI 2008 emissions projected to 2010 (annual numbers) were compared to those directly calculated (mostly seasonal) and were found to be comparable.

Railroad emission calculations and projection methods were reviewed by a second person.

4.0 EMISSIONS AND DETAILED METHODOLOGY

4.1 CATEGORIES FROM THE NONROAD MODEL WITHIN THE NMIM MODEL

The USEPA included more than 80 different types of equipment in the NONROAD model. To facilitate analysis and reporting, the USEPA grouped the equipment types into twelve equipment categories. These include:

Agricultural equipment	Lawn and garden equipment, commercial
Commercial equipment	Logging equipment
Construction and mining equipment	Pleasure craft (recreational marine)
Industrial equipment	Railroad maintenance equipment
Lawn and garden equipment, residential	Recreational equipment

The eleventh category, aircraft ground support equipment, was not calculated with the NMIM / NONROAD model because the method of calculation performed by the EDMS model was judged to be superior. The twelvth category is underground mining equipment; there are no underground mining operations in the four counties. Additionally, the emissions are estimated for five different engine types. These include: 2-stroke and 4-stroke spark ignition engines, diesel engines, liquid propane gas and compressed natural gas fueled engines.

The NMIM model containing the NONROAD2008a model version was used to estimate emissions for the maintenance plan. NONROAD2008a is the latest release of the USEPA NONROAD model that was first released in June 2000, and incorporates many revisions to improve the model's predictive ability. Compared to NONROAD2005c, this model revision accounts for emission reductions from the Diesel Recreational Marine standards in the Loco/Marine final rule published in the Federal Register (FR) (73FR 25098) and the Small Spark Ignition and Spark Ignition Recreational Marine final rule (FR 59034). There are a number of additional improvements including the ability to model the effects of ethanol blends on fuel tank and hose permeation losses.

The seasonal file for the NONROAD2008a model was modified to place North Carolina in the Southeast states group rather than the Mid-Atlantic group. This change was made because the NCDAQ had reviewed temperature data of North Carolina compared to states in the Southeast and the Mid-Atlantic. The results of this comparison indicated that North Carolina temperatures are more in-line with the Southeast States. Meterological data specific for the year 2010 was incorporated in the NMIM model by modification of the model's CountyYearMonthHour table

For reporting purposes, the resulting emissions were totaled for each equipment category by county.

The NMIM model was operated through the graphic user interface (GUI). A runspec file was created which directed the running of the NONROAD2008a model. A copy of the runspec file is in Section 6.0 of this document. The model was run for January, February, and December of 2010. Values for the three months were summed and then divided by 90 to get tons of CO per day. The summary of the model results expressed in tons emitted per typical winter day are tabulated in Table 4-1.

Table 4-1 CO Emissions for NMIM Equipment Categories

Equipment Categories	**CO tons/day**			
	Durham	**Forsyth**	**Mecklenburg**	**Wake**
Agricultural Equipment	0.00	0.02	0.01	0.03
Commercial Equipment	4.38	10.76	51.99	27.02
Construction and Mining Equipment	3.44	2.00	11.41	9.51
Industrial Equipment	4.55	3.68	6.23	3.80
Lawn and Garden Equipment, Commercial	3.33	3.84	24.12	19.36
Lawn and Garden Equipment, Residential	1.79	2.42	5.67	4.98
Logging Equipment	0.04	0.05	0.04	0.25
Pleasure Craft (Recreational Marine)	0.09	0.04	0.26	0.27
Railway Maintenance	0.00	0.00	0.01	0.00
Recreational Equipment	1.37	0.83	3.73	1.93
Total	18.99	23.64	103.47	67.15

4.2 AIRCRAFT ENGINES AND AIRPORT GROUND SUPPORT

Aircraft engines, like other engines, emit pollutants whenever the engines are in operation. However, the only emissions that are of concern for this inventory are the portion of the operation that occurs below the mixing layer. This is because the emissions tend to disperse whenever the aircraft is above the mixing layer and therefore have little or no effect on ground level air pollutant concentrations.

The aircraft emissions of interest are produced during the landing and takeoff (LTO) cycle. The cycle begins when the aircraft approaches the airport, descending below the mixing layer, lands and taxis to the gate. It continues as the aircraft idles at the gate and then taxis back out to the runway for the subsequent takeoff and climb out as it heads back to cruising altitudes, above the mixing layer. Associated with these emissions are emissions from ground support equipment (GSE) and auxiliary power units (APU) which are small engines used to maintain aircraft power and air conditioning when the main engines are shut off.

Aircraft can be categorized by use into four classifications: commercial, air taxis, general aviation and military. Commercial aircraft include those used for scheduled service transporting passengers, freight or both. Air taxis and commuter aircraft also fly scheduled service carrying passengers and/or freight but usually are smaller aircraft and operate on a more limited basis than commercial carriers. Air taxis may also be used for unscheduled on-demand flights. General aviation includes all other non-military aircraft used for recreational flying, personal transportation, and various other activities. Military aircraft cover a wide range of sizes, uses, and operating missions. Military operations at civilian airports are often associated with National Guard, Army Reserve, and Air Force Reserve training.

Emission estimates were developed by NCDAQ for a typical winter day of 2010 for all airports in the four counties. Emission calculations for commercial aircraft were made using the EDMS 5.1.3 model developed by the USEPA and the FAA. Emissions for air taxi and general aviation (both subgrouped into piston engine and turbine engine categories) were made using emission factors developed by the USEPA working with the FAA. More detail about this process is found in *Documentation for Aircraft Component of the National Emissions Inventory Methodology*, ERG No.: 0245.02.302.001, Contract No.: EP-D-07-097 prepared by Eastern Research Group under contract to E.H. Pechan for the EPA. For military operations at civilian airports, emissions were calculated using emission factors developed by NCDAQ from surveys of military airports in North Carolina for the 2008 National Emission Inventory (NEI). The next paragraph describes the general approach to develop these emission factors.

For the 2008 NEI, requests for counts of operations by aircraft type were sent to the military airports in North Carolina. Two Army airports, two Air Force airports, and one Coast Guard airport supplied the requested information The Marine Corps failed to supply any requested data. From the available data, the EDMS 5.1.3 model was used to calculate the airport's emissions. Seymour Johnson Airforce Base is home to a large number of fighter aircraft. However, it is believed that fighter aircraft operations are not common at civilian airports in NC. The NC Air National Guard (based in Charlotte) is equipped for airlift operations. The Air Force Reserve units based here (at the two Air Force bases) perform refueling and airlift operations. Fighter airplanes tend to make a lot of noise yet we don't hear of strong complaints about noise around our civilian airports. All this considered, it was decided to assume no fighter operations at the civilian airports. Military aircraft at military airports often perform touch and go (T&G) operations for landing practice (they don't actually stop so there are no taxi or ground support emissions) The assumption was made that military operations at civilian airports would have the same proportion of T&Gs to LTOs as at military airports (civilian operations are not considered to include touch and go). Considering all the military airports together and excluding the fighter aircraft, emission factors for military aircraft and ground support were calculated on a per operation basis.

Activity data for commercial flights was obtained from the Bureau of Transportation Statistics (BTS) T-100 Segment data for 2010. This data is reported by month so January, February, and December data were used to calculate commercial flight CO tons per day for the Charlotte Douglas airport in Mecklenburg County and the Raleigh Durham airport in Wake County. December data appeared to be missing for the Smith Reynolds airport in Forsyth County so just January and February data were used. For the rest of the operations data at these three airports an Airport Operations: Standard Report was generated using the FAA's Air Trafic Activity Data System (ATADS). This data, after adjustment with annual T-100 Segment data, was used to calculate emissions from air taxis, general aviation and military flights. For the smallest airports, operations data and based aircraft data was obtained through the FAA National Flight Data Center form 5010 data. This was additionally supplemented with phone calls to three of the small airports because it appeared that the most recent inspection was a number of years in the past. Table 4-2 shows airport emissions.

Table 4-2 CO Emissions from Airports

Equipment Categories	**CO tons/day**			
	Durham	**Forsyth**	**Mecklenburg**	**Wake**
Aircraft and Auxiliary Power Units	0.03	0.31	6.32	2.16
Aircraft Ground Support Equipment	0.00	0.00	4.69	1.26
Total	0.03	0.31	11.01	3.42

4.3 RAILROAD LOCOMOTIVES

Freight railroad companies are categorized by size (Class I, Class II, or Class III). Class I railroad companies are long haul operations, consisting of Norfolk Southern Corporation and CSX Corporation. Class II and Class III railroad companies are short lines serving localized markets. Amtrak and the North Carolina Department of Transportation (NCDOT) Rail Division provide passenger service.

Railroad locomotive emissions for classes I, II, and III plus rail yards were calculated for all of North Carolina as part of the 2008 NEI. This inventory was prepared by the Eastern Regional Technical Advisory Committee (ERTAC) Rail Subgroup for the USEPA. Some of the details of the ERTAC work are based on proprietary information provided by the railroad companies. The calculation methodologies followed procedures acceptable to the USEPA.

Passenger railroad emissions were developed by NCDAQ for 2008. This was done using information supplied by the NCDOT and emission factors from *Emission Factors for Locomotives*, EPA-420-F-09-025. The daily runs of the Piedmont train from Raleigh to Charlotte was increased from two trains to four in June, 2010. Emissions were increased based on the expected additional fuel use.

Growth and control factors were produced to project the 2008 emissions to 2010. Railroad emissions are shown in Table 4-3 below.

Table 4-3 CO Emissions from Railroads

Equipment Categories	**CO tons/day**			
	Durham	**Forsyth**	**Mecklenburg**	**Wake**
Railroad Emissions	0.02	0.02	0.24	0.05

4.4 COMBINED NONROAD EMISSIONS

Table 4-4 Combined Nonroad CO Emissions

County	2010 CO tons/day
Charlotte Maintenance Area	
Mecklenburg	114.71
Raleigh/Durham Maintenance Area	
Durham	19.04
Wake	70.62
Total	89.66
Winston-Salem Maintenance Area	
Forsyth	23.97

5.0 PROJECTION AND CONTROL FACTORS

5.1 RAILROAD EMISSIONS GROWTH AND CONTROL

Railroad growth factors were calculated using national fuel use estimates for freight and for intercity passenger service found on table 46 of the Energy Information Administration's *Annual Energy Outlook, 2011*. Fuel use for 2010 was divided by fuel use for 2008 and the quotient was multiplied by the 2008 emissions to adjust for growth.Control factors were calculated by using recommended CO emission factors for from *Emission Factors for Locomotives*, EPA-420-F-09-025. The control factors were calculated by dividing base year emission factors into the future year emission factors. Since the CO emission factors were the same the control factor was 1 in all cases. Table 5-1 shows the growth and control factors used and the equation used is below:

$$\text{2008 CO emissions} * \frac{\text{2010 fuel use}}{\text{2008 fuel use}} * \frac{\text{2010 CO emission factor}}{\text{2008 CO emission factor}} = \text{2010 CO emissions}$$

An additional adjustment was made to passenger train emissions due to two extra runs (one round trip) of the Piedmont each day starting in June, 2010. Therefore, miles traveled and emissions were greater in December then in January and February. Emissions were originally calculated based on known usage of diesel fuel per mile and miles traveled in each county by all passenger trains. The estimated annual fuel use for the original two Piedmont runs was calculated as was total annual passenger train fuel use in the three counties. Daily emissions were found by adding 59/90 of the original daily emissions to 31/90 of the original daily emissions times the new annual fuel amount divided by the original:

$$\text{CO} \frac{t}{d} * \frac{59}{90} + \text{CO}\frac{t}{d} * \frac{\text{Original fuel use + additional fuel}}{\text{Original fuel use}} * \frac{31}{90} = \text{Adjusted CO} \frac{t}{d}$$

Table 5-1 Railroad CO Growth and Control Factors, 2008 to 2010

Type of Service	Control Factor	Growth Factor
Line Haul Locomotives: Class I Operations	1	0.918868646
Line Haul Locomotives: Class II / III Operations	1	0.918868646
Line Haul Locomotives: Passenger Trains (Amtrak)	1	1.005665722
Yard Locomotives	1	0.918868646

6.0 NMIM RUNSPEC FILE


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