Appendix F.2.
Area and Nonroad Mobile Sources Emissions Inventory Documentation

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LIST OF ACRONYMS

Acronym	Definition
AEO	Annual Energy Outlook
ATADS	Air Traffic Activity Data System
BTS	Bureau of Transportation Statistics
BTU	British Thermal Units
CAIR	Clean Air Interstate Rule
CERR	Consolidated Emissions Reporting Rule
CMU	Carnegie Mellon University
CMV	Commercial Marine Vessel
CNG	Compressed Natural Gas
EDMS	Emissions and Dispersion Modeling System
EF	Emission Factor
EGAS 5.0	Economic Growth Analysis System version 5.0
EIA	Energy Information Administration
EIIP	Emissions Inventory Improvement Program
FAA	Federal Aviation Administration
GF	Growth Factor
HDD	Heavy Duty Diesel
IAQTR	Interstate Air Quality Transport Rule
LPG	Liquid Petroleum Gas
LTO	Landing and Takeoff
MSW	Municipal Solid Waste
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NG	Natural Gas
NIF	National Emissions Inventory Input Format
NOx	Nitrogen Oxides
NWR	National Wildlife Refuge
OTAQ	Office of Transportation and Air Quality
PFC	Portable Fuel Container
PM	Particulate Matter
QA	Quality Assurance
RIA	Regulatory Impact Analysis
SCC	Source Classification Code
SI	Spark-Ignition
SIC	Standard Industrial Classification
SIWG	Special Interest Workgroup
T4	Tier 4
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFA	U.S. Fire Administration
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
VISTAS	Visibility Improvement State & Tribal Association of the Southeast
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds

AREA AND NONROAD MOBILE SOURCES
EMISSIONS INVENTORY DOCUMENTATION

I. INTRODUCTION AND SCOPE

The attainment modeling for the Charlotte-Gastonia-Rock Hill, NC-SC 8-hour ozone nonattainment area (referred to as the Metrolina area) was performed in conjunction with the regional haze modeling being done by the Southeast Regional Planning Organization, Visibility Improvement State and Tribal Association of the Southeast (VISTAS) and the fine particulate matter (PM2.5) and ozone modeling being done by the Association of Southeastern Integrated Planning (ASIP). VISTAS and ASIP are run by the ten Southeast states (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and West Virginia). Since the regional haze and PM2.5 modeling uses annual simulations and includes an intermediate year that is the attainment year required for the Metrolina nonattainment area, the South Carolina Department of Health and Environmental Control (SCDHEC) decided to use this modeling for its attainment demonstration.

The South Carolina emissions inventory was developed by the VISTAS/ASIP contractors. A statewide emissions inventory was developed for modeling purposes and the emission estimates were calculated in tons per year. Section III documents the VISTAS/ASIP-developed 2002 Area Source emissions inventory, and Section IV addresses the development of the 2009 area source emissions inventory. Sections V and VI document the nonroad emissions inventory for 2002 and 2009, respectively.

II. OVERALL METHODOLOGY

A. Source Category Identification

The area source categories were identified from: U. S. Environmental Protection Agency's (USEPA's) guidance document EPA-450/4-91-016, *Procedures for the Preparation of Emission Inventories of Carbon Monoxide and Precursors of Ozone, Vol. 1* (the Procedures document); the *Emissions Inventory Improvement Program (EIIP) Technical Reports, Volume 3, Area Sources, December 2002 version (*the EIIP Tech Report); and a report entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018, Emission Inventories for VISTAS*, which was prepared by VISTAS' contractor company, MACTEC, Inc.

Nonroad mobile sources were identified from the Procedures document. Nonroad mobile source emissions are estimated by the methodologies suggested in: 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); and USEPA's nonroad mobile model, NONROAD2005c, which was released March 21, 2006.

B. Area Source 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 Reports and either the Procedures document or the USEPA's AP 42 *Compilation of Air Pollutant Emission Factors, Fifth Edition* (AP 42).

There are several methods for estimating the activity level for a specific area source category. These are: treating area sources as point sources, surveying local activity levels, apportioning national or statewide activity totals to local inventory areas, using population or employment data.

For certain categories, there can be overlap between the point source emissions and the area source emissions calculated with emission factors. The 2002 point source emissions in these categories were identified so that they could be subtracted where appropriate.

C. Nonroad Source Emission Estimation Approach

Non-highway mobile sources, sometimes referred to as off-road or nonroad mobile sources, are those sources that can move but do not use the highway system. Off-road mobile sources are further divided into nonroad mobile sources, railroad locomotives, aircraft engines, and commercial marine vessels (CMV). The estimation of emissions from mobile sources, like area sources, involves multiplying an activity level by an emission factor.

The majority of the off-road mobile emissions were estimated by using the USEPA's off-road mobile model NONROAD2005c. Direct emissions are generated with this model. Aircraft engine emissions were estimated using the Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) model. Aircraft operations were input into the model, after which the model predicts the engine emissions based on average landing and take-off practices for the aircraft type. For railroad locomotive emissions, emission factors were obtained from the Mobile Source Procedures document, and the activity level was obtained from the various railroad companies.

III. VISTAS DEVELOPED 2002 AREA SOURCE INVENTORY

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. Emissions are calculated on an annual basis in tons per year.

South Carolina uses the CERR 2002 inventory as the basis for the VISTAS/ASIP Area Source Inventory. Section III details the portion of the 2002 base year area source inventory, which was developed for VISTAS/ASIP by the VISTAS contractor, MACTEC, Inc. This information was obtained from the report entitled *Documentation of the Base G 2002 Base Year, 2009, and 2018 Emission Inventories for VISTAS*, which was prepared for VISTAS by MACTEC, Inc. This report is included in Appendix Q.

Several major components of the area source sector of the inventory developed by VISTAS are discussed in Sections III.A. through III.C. Stage II emissions are discussed in Section III.A. and were removed from the area source inventory and included in the mobile sector of the inventory. Also, emissions from portable fuel containers were added and are discussed in Section III.B. Section III.C describes the development of the fires emissions inventory and distinguishes the difference between an actual versus typical inventory with regard to fires.

The following Sections are based on excerpts (with some editing) taken from a document entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS and prepared by MACTEC, Inc.*

A. Vehicle Refueling (Stage II) emissions

For the 2002 inventory, the VISTAS/ASIP States all agreed to remove the Stage II refueling emissions from the area source inventory and include them in the nonroad and on-road sectors.

B. Portable Fuel Containers

Portable fuel containers (PFCs), Source Classification Code (SCC) 2501060300, cover emissions from residential and commercial sector portable gasoline containers. Permeation, diurnal, transport, spillage, and vapor displacement emissions are typically accounted for in this category. Spillage from refueling operations and vapor displacement emissions were not included in the inventory to avoid double counting refueling in the nonroad sector.

MACTEC found that the USEPA had prepared a national inventory of emissions by State for portable fuel containers. Data on emissions from this source prepared by the USEPA were presented in the report, *Estimating Emissions Associated with Portable Fuel Containers (PFCs), Draft Report, Office of Transportation and Air Quality, USEPA, Report # EPA420-D-06-003, February 2006*.

The 2002 county-level emission estimates were obtained through an allocation method based on fuel usage. Initially, 2005 emission estimates, excluding those from vapor displacement and spillage from refueling operations, were obtained from the USEPA's report and assumed to be equal to 2002 values. Permeation, diurnal, and transport emission estimates were summed and allocated to the county-level based on the fuel usage information obtained from the NONROAD2005 model. The SCCs that use containers for refueling were acquired from the spillage file of the NONROAD model. Then, the fuel usages by county from the NONROAD 2005 runs prepared for VISTAS/ASIP were summed for those SCCs by county. The county-level fuel use was then divided by the State total fuel use for the same SCCs to determine the fraction of total State fuel usage and that fraction was used to allocate the State-level emissions to the county.

C. Forest Fires

The fires source category includes wildfire, prescribed burning, and land-clearing fires. These fires can be intermittent in nature, but many of these can produce large quantities of air pollutant emissions. Wildfires in certain rural areas can produce large, short-term organic emissions. Prescribed burning is used as a forest management practice to establish favorable seedbeds, remove competing underbrush, accelerate nutrient cycling, control tree pests and contribute other ecological benefits. Agricultural burning covers agricultural burning practices used to clear and/or prepare land for planting. In land clearing fires, waste from logging operations is often burned under controlled conditions to reduce the potential fire hazards in forests and to remove brush that can serve as a host for destructive insects.

The total wildfire acreage burned was obtained from the South Carolina Forestry Commission for each county in the State. These numbers however are replaced with the 2002 "typical" year for the purpose of modeling. Fire emissions are not easily grown or projected. Thus, the replacement was done so that the fires represented in the area source inventory are considered typical and do not reflect an abnormally low or high year as far as fires. The typical year forest fire inventories were developed by

MACTEC, Inc., with input from state and federal forest resource staff. The typical year covered wildfire, prescribed burning, agricultural fires and land clearing fires. The development of the typical year inventory is described below.

State-level ratios of acres over a longer-term record (three or more years) were developed for each fire type relative to 2002. The 2002 acreage was then scaled up or down based on these ratios to develop a typical year inventory. VISTAS Fire Special Interest Work Group based the ratio on county-level data for States that supplied long-term fire-by-fire acreage data rather than State-level ratios. Where States did not supply long-term fire-by-fire acreage data, MACTEC reverted to using State-level ratios. With one broad exception (wildfires) this method was implemented for all fires. MACTEC solicited long term fire-by-fire acreage data by fire type from each VISTAS State. A minimum of three or more years of data were used to develop the ratios. Those data were then used to develop a ratio for each county based on the number of acres burned in each county for each fire type relative to 2002.

If VISTAS had long term county-prescribed fire data from a State, a county acreage ratio, described below, was developed.

$$\text{Ratio} = \frac{\text{Long term average county level Rx acres}}{\text{2002 actual county level Rx acreage}}$$

This ratio was then multiplied times the actual 2002 acreage to get a typical value (basically the long-term average county level acres). Wherever possible, this calculation was performed on a fire-by-fire basis. The acreage calculated using the ratio was then used with the fuel loading and emission factor values to calculate emissions.

There were three exceptions to this method.

Exception 1: Use of State Ratios for Wildfires

Wildfire estimates were developed using State ratios rather than county ratios because some counties were showing unrealistic ratios, which were created by very short term data records or missing data. In addition, exceptionally large and small fires were removed from the database. VISTAS also removed all fires less than 0.1 acres from the dataset.

Exception 2: Correction for Blackened Acres on Forest Service Lands

Acreage values submitted by the U.S. Forest Service (USFS) for wildfires and prescribed fires on USFS lands represented perimeter acres rather than "blackened" acres. Therefore, for prescribed fires greater than 100 acres in size, the acreage was adjusted to be 80 percent of the initial reported value. For prescribed fires of 100 acres or less, the acreage values were maintained as reported. All reported acreage values for wildfires were adjusted to be 66 percent of their values, as initially reported.

Exception 3: Missing/Non-reported data

When VISTAS did not receive data from a VISTAS State for a particular fire type, a composite average for the entire VISTAS region was used to determine the typical value for that type fire. This technique was applied to all fire types when data was missing.

For wildfires and prescribed burning, ratios were also developed for "northern" and "southern" tier

States within the VISTAS region, and those ratios were applied to each State with missing data depending upon whether they were considered a "northern" or "southern" tier State. Development of "southern" and "northern" tier data was an attempt to account for a change from a predominantly pine/evergreen ecosystem (southern) to a pine/deciduous ecosystem (northern).

Table F2-1 below presents a comparison in tons per year of the 2002 actual fire emissions and the 2002 typical fire emissions for NOx and VOC for wildfires, prescribed burning, agricultural fires and land clearing fires in North Carolina.

Table F2-1
2002 South Carolina Actual and Typical Fire Emissions

	Actual Fire Emissions		Typical Fire Emissions	
Fire Type	NOx (TPY)	VOC (TPY)	NOx (TPY)	VOC (TPY)
Wildfires	1098.04	2408.60	3752.78	8231.91
Prescribed Burning	3574.59	7841.03	576.03	1263.55
Agricultural Fires	-	3351.50	-	2986.33
Landclearing Fires	258.94	600.76	941.29	2183.84

IV. 2009 AREA SOURCE EMISSION INVENTORY DEVELOPMENT

This Section describes the methodology used to develop the 2009 area source inventory. Separate methods for projecting emissions were used for non-agricultural (stationary area), agricultural area sources and forest fire area sources. The agricultural area sources method are for ammonia emissions and are not related to ozone formation; therefore, it will not be discussed in this documentation. Since ammonia is important for regional haze and fine particulate matter, the method for projecting agricultural area sources will be detailed in the respective State Implementation Plans.

The following Sections are based on excerpts (with some editing) taken from the document entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS and prepared by MACTEC, Inc.*

A. Projection of Stationary Area Sources

VISTAS 2002 base year inventory emissions were used as a starting point for calculating 2009 emissions. MACTEC, Inc. first back-calculated uncontrolled emissions from the 2002 base year inventory. Growth and control factors were then applied based on controls initially identified for the Clean Air Interstate Rule (CAIR) and growth factors identified for the CAIR projections. In some cases, Economic Growth Analysis System version 5.0 (EGAS 5.0) growth factors were used if no growth factor was available from the CAIR growth factor files.

The 2009 growth factors were obtained from the USEPA growth factors and indirectly from 2010 and 2015 CAIR growth factors. Using a 2001 base year, interpolation of 2010 and 2015 CAIR growth factors yielded 2009 growth factors. MACTEC used the TREND function of Microsoft Excel for interpolation. Interpolated growth factors were calculated at the State and SCC level.

In a few cases, additional growth factors had to be added for sources that had not initially been included in a draft 2002 inventory. These growth factors were obtained from EGAS 5.0. Finally, updates to growth factors from EGAS 5.0 were made for fuel-fired emission sources. The updated growth factors reflected the most recent data from the Department of Energy's Annual Energy Outlook (AEO). These data were used to reflect changes in energy efficiency resulting from new or updated fuel firing technologies.

B. Projection of Forest Fires Area Sources

Several Federal agencies indicated that they had plans for increased prescribed fire burning in future years and that the "typical" fire inventory would likely not adequately capture those increases. Thus, MACTEC acquired the data necessary to provide 2009 specific projections for the prescribed fire component of the fire inventory.

The U.S. Fish and Wildlife Service (USFWS) submitted annual acreage data by National Wildlife Refuge (NWR) and by county, including estimates of acres burned per day for each NWR. USFS provided fire-by-fire acreage estimates based on mapping projected burning acreage to current 2002 modeling days. However, USFWS did not submit data for VISTAS original base year preparation process, thus there was no known USFWS data in the 2002 actual or typical inventories. MACTEC, therefore, developed a method that could use the county-level data submitted by USFWS.

Several VISTAS/ASIP States run a prescribed fire-permitting program. To avoid double counting, only State data and not USFWS or USFS data was used in those States for the 2002 actual inventory.

The method used by MACTEC to include the USFS data applied a county-level data approach for USFS data where a State had a prescribed fire permitting program and a fire-by-fire replacement for USFS data in States without permit programs. MACTEC used a county level approach for all of the USFWS data. The approach used for each data set is discussed below.

For USFWS data, 2002 annual county acres burned was subtracted from the USFWS projected acreage. A 0.8 factor was applied to the difference to account for blackened acres instead of the total perimeter acres that were reported. The revised total additional USFWS acreage was then added to the total county "typical" acreage to determine future acreage burned for 2009.

MACTEC then allocated the increased acreage to current modeling days. The average daily acres burned data provided by USFWS per NWR/county was used to allocate the acreage to the correct number of days required to burn all of the acres. Guidance supplied by USFWS indicated that up to three times the average daily acres burned could potentially be allocated to any one day.

For the USFS fire-by-fire acreage estimates, MACTEC summed the USFS data at a county-level for States that had permit programs, then added the sum to the typical acreage and allocated the acres to current modeling days. For States that do not have a State-prescribed fire permit program, MACTEC simply replaced the current fire-by-fire records in the database with fire-by-fire records from the USFS and recalculated emissions based on fuel model and fuel loading. VISTAS also applied the same 0.8 correction for blackened acres applied to all USFS supplied acreage as the supplied values represented perimeter acres.

An additional problem with developing year-specific prescribed fire projections was how to adequately capture the temporal profile for those fires. In the 2002 actual fire inventory, fires occur on the same days as state/FLM records. In the 2002 "typical" year inventory, fire acreage increased or decreased from acreage on the same fire days as were in the 2002 actual inventory, since the acres were simply increased for each day based on a multiplier used to convert from actual to typical.

When prescribed fires acreage was added to a future year, MACTEC added acreage to individual fire days proportional to the annual increase (if acreage on a day is 10 percent of annual, add 10 percent of projected increase to that same day).

V. VISTAS DEVELOPED 2002 NONROAD SOURCE INVENTORY

Development of emission estimates for nonroad sources is documented in the MACTEC, Inc. document entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018, Emission Inventories for VISTAS*.

Nonroad mobile sources are those sources that can move but do not use the highway system. Examples include lawn mowers, agricultural equipment, construction equipment, aircraft engines, railroad locomotives, powerboats, and commercial marine (ships). All but the aircraft engine, railroad locomotive emissions and commercial marine activity were estimated using the USEPA's off-road mobile model NONROAD2005c, which was released March 21, 2006. Direct emissions are generated with this model. This version incorporates all the USEPA final nonroad engine emission standards, including the recreational and large spark-ignition engines rules that were published in the Federal Register in November 2002. Although this model is considered to be a final model, an updated version is planned that may incorporate revised inputs for the small spark-ignition (SI) (<19 kW) and recreational marine SI categories in conjunction with additional promulgated nonroad engine standards.

Nonroad mobile sources calculated through the NONROAD model are discussed in Section V.A. Aircraft, railroad and commercial marine emissions are discussed in Sections V.B. through V.D.

A. NONROAD Model Sources

The nonroad mobile source category includes a diverse collection of equipment such as lawn mowers, chain saws, tractors, all terrain vehicles, fork lifts and construction equipment. The USEPA NONROAD2005c model generates emissions directly and includes more than 80 different types of equipment. To facilitate analysis and reporting, the USEPA grouped the equipment types into ten equipment categories. These include:

Agricultural equipment	Lawn and garden equipment
Airport ground support equipment	Logging equipment
Commercial equipment	Railroad maintenance equipment
Construction equipment	Recreational marine equipment
Industrial equipment	Recreational equipment

Additionally, the emissions are broken out by five different engine types. These include: 2 stroke and 4-stroke spark engines, diesel engines, liquid petroleum gas (LPG) and compressed natural gas (CNG) fueled engines.

B. Aircraft Engines

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, has little or no effect on ground level ozone.

The aircraft operations of interest are termed 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 climbout as it heads back to cruising altitudes, above the mixing layer.

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 and/or freight. Air taxis, or 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. General aviation includes all other non-military aircraft used for recreational flying, personal transportation, and various other activities. Military aircraft covers a wide range of sizes, uses, and operating missions. The military aircraft are treated as a separate classification since the LTO operations reported at the airports group all military aircraft together.

Emission factors are available for the many aircraft and engine combinations that exist. Factors for each aircraft exist for four operating modes in the LTO cycle. Emissions are calculated by obtaining data for the number of LTO cycles of the various aircraft at each airport in question, multiplying by the appropriate factors, and summing the results for the year under consideration.

Development of the 2002 aircraft emissions are described in the MACTEC document entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS*. This document refers back to a document entitled, *Development of the VISTAS Draft 2002 Mobile Source Emission Inventory (February 2004 Version)*, prepared by E.H. Pechan & Associates, Inc. Both of these documents are included in Appendix Q.

The starting point for development of aircraft emissions estimates is the 1999 National Emission Inventory (1999 NEI) prepared by the USEPA. These emissions were grown to appropriate values for 2002 and 2009 using growth factors developed by the USEPA for the CAIR.

C. Railroad Locomotives

Railroads are categorized by size (Class I, Class 2) and passenger service. Class I railroads are long haul operations, such as Norfolk Southern Corporation and CSX Corporation. Class II and Class III railroads are short lines, serving localized markets. Passenger service is provided by Amtrak. These entities lease trackage from Class I railroads.

Development of railroad emissions is described in the MACTEC document entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS*. The VISTAS/ASIP railroad emission estimates started with 1999 emission estimates developed for the USEPA's 1999 NEI Version 2 as base year estimates for the VISTAS region. Additional information is provided in *Development of the VISTAS Draft 2002 Mobile Source Emission Inventory (February 2004 Version),* prepared by E.H. Pechan & Associates, Inc.

Projected emissions for 2002 were developed in two steps as described below. For 1999 to 2001, State-level rail fuel consumption was obtained from the Department of Energy, Energy Information Administration's (EIA's) Fuel Oil and Kerosene Sales. For 2001 to 2002, VISTAS applied national growth factors developed from fuel consumption projections in EIA's Annual Energy Outlook. A growth factor of 1.4 was used for locomotives and applied to 1999 emissions to first develop 2001 emissions. Table F2-2 lists the growth factors used to generate 2002 emissions.

Table F2-2 2002 National Rail Transportation Energy Use by Fuel Type (Trillion BTU)			
	2001	2002	Growth Factor (GF)
Intercity Rail (Electric)	10.17	10.40	1.0226
Intercity Rail (Diesel)	16.60	16.88	1.0169
Transit Rail (Electric)	46.36	47.40	1.0224
Intercity/Transit Rail Average (SCC 2285002008)			**1.0206**
Commuter Rail (Electric)	16.13	16.49	1.0223
Commuter Rail (Diesel)	26.31	26.76	1.0171
Commuter Rail Average (SCC 2285002009)			**1.0197**
Freight Rail (Distillate) (SCCs 2285002000, 2285002005, 2285002006, 2285002007, 2285002010)	512.81	492.32	0.9600

Source: Department of Energy, Energy Information Administration, Annual Energy Outlook 2003: Table 34. Transportation Sector Energy Use by Fuel Type Within a Mode

D. Commercial Marine Vessels (CMV)

The following description of development of commercial marine emission estimates is based on excerpts (with some editing) taken from the MACTEC document entitled *Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS,* and a document entitled, *Development of the VISTAS Draft 2002 Mobile Source Emission Inventory (February 2004 Version),* prepared by E.H. Pechan & Associates, Inc.

An initial 2002 base year emissions inventory for commercial marine vessels (CMV) was prepared for VISTAS in early 2004. The methods and data used to develop the inventory are presented in a February 9, 2004 report, *Development of the VISTAS Draft 2002 Mobile Source Emission Inventory (February 2004 Version)*, prepared by E.H. Pechan & Associates, Inc. Revisions to the initial 2002 emissions inventory (prepared by Pechan) were implemented to ensure that the latest State and local data were incorporated. For CMV, South Carolina provided no revised data.

For 2002 commercial marine vessels (CMVs), Pechan used 1999 emission estimates developed for the USEPA's 1999 NEI Version 2 as base year estimates for the VISTAS region. Pechan then improved the spatial distribution of CMV emission estimates for the VISTAS region.

Ideally, CMV emission estimates would be developed using local activity data that account for vessel type, engine type and mode of operation (cruise, maneuvering, and hotelling). Creating this type of "bottom-up" emission inventory requires a large amount of effort. Therefore, Pechan utilized port-specific emission estimates developed for the 1999 NEI, distributed using a revised allocation methodology, which incorporates information on the number of port facilities in each county.

The 2002 VISTAS commercial marine inventory is based on the USEPA's 1999 NEI Version 2.0, projected to 2002 using appropriate growth factors. The 1999 NEI estimated emissions for these categories according to the following Source Classification Codes (SCC):

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2280002100	Mobile Sources	Marine Vessels, Commercial	Diesel	Port emissions
2280002200	Mobile Sources	Marine Vessels, Commercial	Diesel	Underway emissions
2280003100	Mobile Sources	Marine Vessels, Commercial	Residual	Port emissions
2280003200	Mobile Sources	Marine Vessels, Commercial	Residual	Underway emissions

For the 1999 NEI, commercial marine diesel emissions were developed by obtaining 2000 emission estimates for all pollutants except SO2 from the USEPA's Office of Transportation and Air Quality (OTAQ) marine diesel regulatory background documentation (Draft Regulatory Impact Analysis - Control of Emissions from Compression-Ignition Marine Engines). To estimate emissions for 1999, 2000 estimates were backcast using growth factors obtained from the draft Regulatory Impact Analysis (RIA) cited above. Steam-powered residual CMV emission estimates were developed by obtaining fuel usage data from OTAQ and applying fuel-based emission factors. A similar method was used for diesel SO_2 emissions. National diesel usage was estimated assuming a sulfur content of 0.25 percent and USEPA emission factors.

In apportioning, distillate and residual fuels are considered separately. National diesel emissions were disaggregated into port and underway emissions estimates based on the assumption that 75 percent of distillate fuel is consumed within the port, while the remaining fuel is consumed while underway, consistent with USEPA guidance. National residual emissions were disaggregated into port and underway emissions estimates based on the assumption that 25 percent of residual fuel is consumed within the port, while the remaining fuel is consumed while underway.

To allocate to counties, port emissions were assigned to the 150 largest U.S. ports based on activity obtained from the U.S. Army Corps of Engineers (USACE). The percentage of total traffic for each port was calculated by dividing the port-level traffic by the total traffic. Emissions for each port were then assigned to a single county.

Underway emissions are assigned to counties based on a county's shipping lane traffic. The Bureau of Transportation Statistics' (BTS) National Transportation Atlas Databases-1999 contains data on the thousand tons per mile traveled for each shipping lane link in the United States (BTS-CD26). Where navigable rivers form a county or State boundary, the shipping lane traffic is proportioned to individual counties based on the length of shoreline that is shared. For example, if two counties share a navigable river, and both counties have the same length of shoreline, the shipping traffic is split evenly between the two counties. Shipping lanes that are not within counties, for example in the ocean, are associated to States based on BTS assignments. These waterway weights are then evenly distributed among the counties within these States that have navigable waterways. All shipping activity is summed at the county-level and compared with national shipping activity to determine what portion of activity can be attributed to individual counties. These proportions were used in disaggregating the national CMV emission estimates to the county level.

States that share borders with non-VISTAS States along the Mississippi and Ohio Rivers have expressed concern about the representativeness of port emission estimates at a county-level. Revising the county-level emissions estimates would allow more accurate modeling of emissions in the VISTAS states.

For underway emissions, Pechan believes that the allocation procedure results in a reasonable distribution of county-level emissions. However, the methodology to allocate port emissions results in all the emissions being assigned to a single county.

Port areas encompass multiple States and counties and, in some cases, multiple waterways. Therefore, the emissions allocation process must incorporate all counties in the vicinity of the port where activity is occurring. This is especially true for inland rivers where activity takes place on both riverbanks and for ten river miles or more outside the port city. The revised methodology allocates port emissions based on a surrogate for port-related activity in each county, rather than using a single county to define the port.

The report, Waterborne Commerce of the United States, Calendar Year 1999, hereinafter referred to as Waterborne Commerce, presents the cargo tonnage and number of vessel trips in major waterways of the United States. The report defines port areas, which USACE uses to develop the Top 150 Ports in the United States by amount of cargo tonnage. As discussed previously, the 1999 NEI allocates all the port emissions to these 150 ports based on the cargo tonnage handled by the port. Pechan uses this allocation of emissions to each port area as the starting point of its revised allocation process. Port Charleston (Charleston Harbor, SC) and the Port of Georgetown (Georgetown Harbor, SC - Winyah Bay) are the two main ports in South Carolina.

The next step was to develop a list of counties that make up the port area. Port area definitions were obtained from Waterborne Commerce. The port area definition for Port Charleston was "Ocean to Goose Creek via Cooper River and Town Creek; to the Standard Wharf on Ashley River; to the Mount Pleasant Memorial Highway Bridge on Shem Creek; to the Airco Alloys Wharf on Shipyard River; Wando River to Cainhoy." The port area definition for the Port of Georgetown was "Atlantic Ocean Entrance to Winyah Bay, SC, to and including turning basin in Sampit River at the City of Georgetown, SC.". Using the port definitions by river mile, Pechan established which counties are included in each port area. Port Charleston is included in the counties of Charleston and Berkeley. The Port of Georgetown is included in Georgetown County.

The next step in allocating emissions is to develop a surrogate for the amount of CMV activity in each county of the port area. Pechan assumed that the activity of vessels in each county is related to the number of port facilities operating in a given county. Port facilities include terminals, piers, wharves, and docks that are involved in all types of commercial activity and support services. Pechan obtained the number of port facilities in each county from USACE reports, The Port Series Reports. The USACE periodically surveys the commercial marine industry to obtain information on port facilities and publishes it in The Port Series Reports. The reports give the name, location, operations, and describe the physical and inter-modal characteristics of the facilities. The data includes the location of the facility by river mile, State, and county.

For each port area, Pechan calculated the ratio between the number of port facilities in each county to the total number of facilities in all counties that make up the port area. This ratio was used to allocate emissions for each port area to the county-level. The ratio for Port Charleston was 0.7097 in Charleston county and 0.2903 in Berkeley county. The ratio for the Port of Georgetown was 1.0 in Georgetown County. Pechan was directed to perform the reallocation for all VISTAS ports.

VI. 2009 NONROAD SOURCE EMISSION INVENTORY DEVELOPMENT

The subsections that follow describe the projection process used to develop 2009 nonroad projection estimates for sources found in the NONROAD model and those sources estimated outside of the model (locomotives, airplanes, and commercial marine vessels).

A. Projection of NONROAD Model Sources

NONROAD model input files were prepared based on the 2002 base year inventory input files with appropriate updates for the projection years. Other specific updates for the projection years for NONROAD model sources consist of:

- Revision of the emission inventory year in the model (as well as various output file naming commands) to be reflective of the projection year.

- Revision of the fuel sulfur content for gasoline and diesel powered equipment.

- Implementation of a limited number of local control program changes (national control program changes are handled internally within the NONROAD model, so explicit input file changes are not required).

All equipment population growth and fleet turnover impacts are handled internally within the NONROAD model, so that explicit input file changes are not required.

The final NONROAD2005c that was used for inventory development is capable of handling separate diesel fuel sulfur inputs for land based and marine based nonroad equipment in a single model execution. The following diesel fuel sulfur values were used:

Diesel Fuel Sulfur (ppm)	2002	2009
Land-Based	2500	348
Marine-Based	2638	408

B. Projection of Non-NONROAD Model Sources

Using the 2002 base year emissions inventory for aircraft, locomotives, and CMV prepared as described earlier in this document, corresponding emission projections for 2009 were developed. The following description is largely taken from the MACTEC document entitled, *Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS*. Briefly, the methodology relies on growth and control factors developed from inventories used in support of recent USEPA rulemakings, and consists of the following steps:

(a) Begin with the 2002 base year emission estimates for aircraft, locomotive, and CMV.

(b) Detailed inventory data (both before and after controls) for these same emission sources for 1996, 2010, 2015, and 2020 were obtained from the USEPA's CAIR Technical Support Document. Using these data, combined growth and control factors for the period 2002 - 2009 were estimated using straight line interpolation between 1996 and 2010 (for 2009). This is done at the State county SCC pollutant level of detail.

(c) The USEPA growth and control data are matched against the 2002 VISTAS base year data using State county SCC pollutant as the match key. Ideally, there would be a one-to-one match and the process would end at this point. Unfortunately, actual match results were not always ideal, so additional matching criteria were required. For subsequent reference, this initial (highest resolution) matching criterion is denoted as the "CAIR Primary" criterion.

(d) A second matching criterion is applied that utilizes a similar, but higher-level SCC (lower resolution) matching approach. For example, SCC 2275020000 (commercial aircraft) in the 2002 base year inventory data would be matched with SCC 2275000000 (all aircraft) in the CAIR data. This criterion is applied to records in the 2002 base year emissions file that are not matched using the "CAIR Primary" criterion, and is also performed at the State county SCC pollutant level of detail. For subsequent reference, this is denoted as the "CAIR Secondary" criterion. A number of unmatched records continued to remain at the end of this process, so a third level matching criterion was required.

(e) In the third matching step (the most frequently used SCC in the USEPA CAIR files for each of the aircraft, locomotive, and commercial marine sectors) is averaged at the State level to produce a "default" State and pollutant specific growth and control factor for the sector. The resulting factor is used as a "default" growth factor for all unmatched county SCC pollutant level data in each State. In effect, State-specific growth data are applied to county level data for which an explicit match between the VISTAS 2002 base year data and the USEPA CAIR data could not be developed. The default growth and control SCCs are 2275020000 (commercial aircraft) for the aircraft sector, 2280002000 (commercial marine diesel total) for the CMV sector, and 2285002000 (railroad equipment diesel total) for the locomotive sector. Matches made using this criterion are denoted as "CAIR Tertiary" matches.

(f) According to USEPA documentation, the CAIR baseline emissions include the impacts of the (then proposed) Tier 4 (T4) nonroad diesel rulemaking, which implements a low sulfur fuel requirement that affects both future CMV and locomotive emissions. However, the impacts of this rule were originally intended to be excluded from the initial VISTAS 2018 forecast, which was to include only "on-the-books" controls. (The T4 rule was finalized subsequent to the development of the preliminary 2018 inventory in March of 2004.) Given its final status, T4 impacts have now been moved into the "on the books" inventory for nonroad equipment. In addition, since there are no other proposed rules affecting the nonroad sector between 2002 and 2018, there is no difference between the 2018 "on the books" and 2018 "on the way" inventories for the sector; therefore, only a single forecast inventory (for each evaluation year) was developed. Nevertheless, since the algorithms developed to produce the VISTAS forecasts were developed when there was a distinction between the "on the books" and "on the way" inventories, the distinct algorithms used to produce the two inventories have been maintained even though the conceptual distinctions have been lost. This approach was taken for two reasons. First, it allowed the previously developed algorithms to be utilized without change. Second, it allowed for separate treatment of the T4 emissions impact which was important as those impacts have changed between the proposed and final T4 rules. Thus, previous USEPA inventories that include the proposed T4 impacts would not be accurate, and the procedural discussion continues to reflect the distinctions between non-T4 and T4 emissions, as these distinctions continue to be intrinsically important to the forecasting process. A second set of USEPA CAIR files that excluded the Tier 4 diesel impacts was therefore obtained, and the same matching exercise described above in steps (b) through (e) was performed using these "No T4" files. It is important to note that the matching exercise described in steps (b) through (e) cannot simply be replaced, because the "No T4" files obtained from the USEPA include only those SCCs specifically affected by the T4 rule (e.g., diesel CMV and locomotives). In effect, the matching exercise was augmented (rather than replaced) with an additional three criteria analogous to those described in steps (c) through (e), and these are denoted as the "No T4 Primary," "No T4 Secondary," and "No T4 Tertiary" criteria. Because they exclude the impacts of the proposed T4 rule, matches using the "No T4" criteria supersede matches made using the basic CAIR criteria (as described in steps (c) through (e) above).

(g) The CAIR matching criteria were overridden for any record for which States provided local growth data. Only North Carolina provided these forecasts, as North Carolina has provided specific growth factors for airport emissions in four counties.

(h) Using this approach, each State county SCC pollutant was assigned a combined growth and control factor using the USEPA CAIR forecast or locally provided data. The 22,838 data records for aircraft, locomotives, and CMV in the 2002 base year emissions file were assigned growth factors in accordance with the following breakdown:

48 records matched State provided growth factors,
4,179 records matched using the CAIR Primary criterion,
240 records matched using the CAIR Secondary criterion,
7,463 records matched using the CAIR Tertiary criterion,
720 records matched using the No T4 Primary criterion,
3,858 records matched using the No T4 Secondary criterion, and
6,330 records matched using the No T4 Tertiary criterion.

(i) Finally, the impacts of the T4 rule as adopted were applied to the grown "non T4" emission estimates. The actual T4 emission standards do not affect aircraft, locomotive, or CMV directly, but associated diesel fuel sulfur requirements do affect locomotives and CMV. Lower fuel sulfur content affects both SO2 and PM emissions. Expected fuel sulfur content was obtained for 2009 from the USEPA technical support document for the final T4 rule (*Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines, EPA420 R 04 007, May 2004*). According to that document, the average diesel fuel sulfur content for locomotives and CMV is expected to be 408 parts per million by weight (ppmW) in 2009. This compares to expected non T4 fuel sulfur levels of 2599 ppmW in 2009. Table F2-3 uses calculated emissions estimates for base and T4 control scenarios to estimate emission reduction impacts.

Table F2-3
Estimated Emission Reduction Impacts based on T-4 Rule

				2009
CMV SO_2	=	Non-T4 SO_2	×	0.1569
Locomotive SO_2	=	Non-T4 SO_2	×	0.1569
CMV PM	=	Non-T4 PM	×	0.8962
Locomotive PM	=	Non-T4 PM	×	0.8117

However, since the diesel fuel sulfur content assumed for the 2002 VISTAS base year inventory, upon which the 2009 inventory was based, is 2500 ppmW, a small adjustment to the emission reduction multiplier calculated from the T4 rule is appropriate since they are measured relative to modestly different sulfur contents (2599 ppmW for 2009). Correcting for these modest differences produces the emission reduction impact estimates relative to forecasts based on the VISTAS 2002 inventory shown in Table F2-4.

Table F2-4 **Estimated Emission Reduction Impacts Relative to VISTAS 2002 Base Year Values**				
				2009
CMV SO_2	=	Non-T4 SO_2	×	0.1632
Locomotive SO_2	=	Non-T4 SO_2	×	0.1632
CMV PM	=	Non-T4 PM	×	0.9004
Locomotive PM	=	Non-T4 PM	×	0.8187

These factors were applied directly to the non T4 emission forecasts to produce the final VISTAS 2009 emissions inventories for aircraft, locomotive, and CMV.

During the development of the preliminary 2018 VISTAS inventory in March 2004, this process yielded reasonable results and exhibited no particular systematic concerns. However, when the 2009 Base F inventory was developed, significant concerns related to SO_2 and PM were encountered. Essentially, what was revealed by the Base F 2009 forecast was a series of apparent inconsistencies in the CAIR 2010 and 2015 emission inventories (as compared to the 1996 and 2020 CAIR inventories) that were masked during the construction of the "longer-term" 2018 inventory.

For the most part, the issue seems to be centered on SO2 and PM records, which are those records primarily affected by the T4 rule. But, as noted above, there does not seem to be any pattern of consistency that would indicate that either inclusion or exclusion of T4 rule impacts is the underlying cause. Moreover, where they occur, the observed growth extremes generally affect both SO_2 and PM equally, while one would expect PM effects to be buffered if the T4 rule was the underlying cause since changes in diesel fuel sulfur content will only affect a fraction of PM (e.g., sulfate), while directly reducing SO_2.

While forecast inventories for aircraft, locomotives, and CMV were developed for 2009 and 2018 using both growth methods, it was ultimately decided to utilize the 1996-2020 growth basis since it provided more reasonable growth rates for 2009.