

# **Appendix B1**

Area and Non-Nonroad Model  
Inventory Document  
(Maryland Department of the Environment)



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**MARYLAND DEPARTMENT OF THE ENVIRONMENT**  
**AIR AND RADIATION MANAGEMENT ADMINISTRATION**

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**State Implementation Plan**

**2011 Base Year SIP Emissions  
Inventory Methodologies**

Prepared for:

U.S. Environmental Protection Agency

Prepared By:

Maryland Department of the Environment

**Maryland Department of the Environment  
2011 Base Year Emissions Inventory Methodologies**

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## **1.0 INTRODUCTION**

In 2012, U.S. EPA designated area nationwide as nonattainment for the new 8-Hour Ozone National Ambient Air Quality Standard (NAAQS) The 1990 Clean Air Act Amendments (CAAA) requires all states to revise and submit State Implementation Plans (SIP) for areas classified as nonattainment of the NAAQS for ozone.

As part of designation of nonattainment areas for the 8-hour ozone standard, a new attainment demonstration SIP will be necessary. A key element in the overall SIP planning process is the need for an updated emissions inventory. This document presents the 2011 Base Year Ozone SIP Emissions Inventory for Maryland as required by the CAAA of 1990. It includes NO<sub>x</sub> and VOC emissions for all anthropogenic emissions for the State of Maryland. These emissions are categorized as point, quasi-point, area, biogenic, on-road mobile and non-road mobile.

This technical report documents the procedures and methodologies that were used in the development of summer day volatile organic compound (VOC) and nitrogen oxides (NO<sub>x</sub>) emissions for all counties in Maryland. This report describes the following:

1. Identification of stationary and mobile sources included in the inventory;
2. Sources of data, and data collection methods used in the development of the inventory;
3. Methods and procedures used to estimate emissions
4. Assumptions considered in the development of the emissions inventories.

The intent of this report is to describe how the inventory was prepared and what information was considered in the inventory development.

This document is comprised of six sections, one section for each source category type.

## **2.0 POINT SOURCES**

### **2.1 INTRODUCTION**

The Maryland Department of the Environment Air and Radiation Management Administration (ARMA) is the lead agency responsible for compiling the point source emissions inventory, including identification of sources, documenting the method used to calculate emissions from each source, and presenting the findings. In order to provide EPA with a written documentation of emissions calculations for major point sources, confidential information was included in the documentation. It is included with the understanding that EPA is also bound to respect the confidentiality of the information, including appropriate storage of the information. Any contractors employed by EPA to review the inventory are also subject to confidentiality provisions, or the EPA must remove the confidential material before submitting the document for review. This information does not appear in copies prepared public review.

The Maryland stationary point source inventory is the result of efforts to characterize air emissions sources since the early 1970's. This section describes data collection, verification and emission estimation methods used to estimate point source emissions from stationary sources. For the 2011 Periodic Emissions Inventory, point sources are defined as stationary commercial or industrial operations that emit more than 10 tons per year of volatile organic compounds (VOC); 100 tons per year of carbon monoxide (CO), sulfur oxides (SO<sub>x</sub>), particulate matter with an aerodynamic diameter less than 10 micrometers (PM<sub>10</sub>), and total suspended particulates (TSP); or 25 tons per year of oxides of nitrogen (NO<sub>x</sub>). In addition, stationary sources included in previous PEI submissions were included herein regardless of the amount of air pollutants emitted. These emissions criteria are more commonly referred to as “emissions thresholds” or simply, “thresholds.”

### **2.2 COMPILING THE POINT SOURCE LIST**

Maryland has a substantial database of both small and large air emission sources compiled over the last eighteen years. Since the thirteen central counties of Maryland and Baltimore City have been nonattainment for ozone since before 1982 and 80% of the state's population and major industrial sources lie within these counties, the database of over 10,700 sources (both above and below the point source thresholds) is reasonably complete. The list of point sources in this inventory was developed by applying the appropriate thresholds to the emission levels in the database to differentiate between point and area stationary sources. Sources with emission levels greater than the threshold or sources previously included in PEI submittals are by definition point sources while sources with emissions levels less than the thresholds are by definition area sources.

Several methods of source identification are used by ARMA to ensure the point source inventory is as complete as possible. The primary data source is the Permitting Program, which oversees the registration requirements found in Title 26, Subtitle 11, Chapter 02, Code of Maryland



Regulations (COMAR). The Compliance Program identifies other point sources through annual facility inspections and through investigations conducted in response to citizen complaints.

The primary means of new source identification is the steady influx of permit applications and equipment registrations. Many sources are required by COMAR 26.11.02, Permits, Approvals and Registration, to register with ARMA. From 700 to 1,000 new sources are registered with the Department each year. Most of these sources are not considered to be point sources as defined for inventory purposes, even though they require permits. As an example, emissions from some sources can be less than one ton per year. However, all sources that are registered with the Department are tracked until the Department receives notification that the equipment or emission source has ceased operations. An emissions source or its equipment is not permanently deleted from the registration database until the installation is demolished.

The Department has established a Small Business Assistance Program as required by the Clean Air Act Amendments to acquaint the owners of potential sources with the State's permitting requirements, including air quality permits. The Department has also published a guidebook, Environmental Regulation: A Business Guide to the Maryland Department of the Environment's Permitting Process as part of its outreach program.

A secondary means of new source identification are the emission sources identified by Compliance Program staff during annual field inspections of major point sources. During these inspections, unregistered equipment is sometimes discovered. Statewide response to the Air Pollution Report and the Air Quality Complaint Hotline, has also led to the discovery of previously unidentified emissions sources. Sources discovered in this manner may be the result of the citizen complaints, or the result of further investigation of visual evidence such as buildings, storage yards, visible emissions, etc., sighted elsewhere during the response.

### **2.2.1 EMISSION CALCULATIONS**

The ARMA technical staff uses one of the following methodologies to calculate criteria pollutant emissions:

- EPA-supplied emission factors
- EPA-supplied emission models
- Material balances
- Emissions based on source test data
- Agency or company-generated emission factors

The Compliance Program facility inspectors calculate annual emissions estimates following their annual facility inspections. The results are then entered into ARMA's Registration Files for Facilities and Equipment, which lists facilities by premise numbers and equipment by registration numbers under each facility. Both the stack and fugitive emissions, from all registered equipment at a specific facility are summed to yield the annual facility emissions

estimate. This total facility estimate is used to determine whether the facility satisfies the criteria for classification of as a point source.

The estimation of emissions on a facility-wide basis can result in emissions from equipment in some subcategories, such as boilers, being obscured. For example, boiler emissions are included in the Amerada Hess Corporation's total emissions. Therefore, these boiler emissions are included with emissions from gasoline storage and handling operations and included in the Storage, Transportation and Marketing of Petroleum Products and Volatile Organic Liquids source category rather than in External Combustion Sources category.

Emissions from specific subcategories of sources can be extracted from the inventory to estimate possible reductions from various control strategies. However, the emissions from specific equipment subcategories cannot be excluded from the facility-wide emissions because of the limitations of the software used to create the Registration File. Therefore, subcategories of equipment emissions are not included in the inventory as separate line items for to do so would result in the double counting of those emissions.

The estimates prepared by the facility inspectors following the annual inspection of each facility are compared to the annual emissions reported by each facility in its Annual Emissions Certification. A person who owns or operates a major facility as defined in COMAR 26.11.01.05-1 must submit to the Department an emissions statement by April 1 of each year for the previous calendar year. The owner or operator of the facility must further certify that the emissions statement is accurate to the best of the owner/operator's best knowledge. After the certified emissions statements are logged in, they are thoroughly reviewed by the assigned facility inspectors. Each inspector compares their emissions estimate to that prepared by the respective company for consistency of methodology and final emissions estimate results. The facility inspectors resolve any discrepancies between the two estimates with the owner/operator of the facility in question. When all discrepancies are resolved to the satisfaction of MDE, the final emissions estimates are then submitted as an update to ARMA's Registration File for Facilities and Equipment.

#### **2.2.1.1 Seasonal Adjustments**

ARMA has collected extensive data for the temporal allocation of emissions. Companies send us annual, quarterly, monthly, and daily usage, activity, and emission estimates. More specific information allows allocation of emissions to time of day.

In cases where the facilities did not provide peak ozone season emission estimates, the peak ozone season emissions were calculated by the following method and are included in the emissions summary tables, by county, at the end of this section:

- 1) Annual emissions in pounds per year were converted into pounds per day emissions by dividing annual emissions by operating days,
- 2) Pounds per day emissions were then multiplied by a seasonality factor,

- 3) The seasonality factor was based on the quarterly percentage of operations estimated by the company adjusted for June, July, and August.
- 4) The ratio obtained in Step 3 was multiplied by the daily emissions calculated in Step 1 to generate the seasonally adjusted emissions.

### **2.2.2 Consolidated Emissions Reporting Rule (CERR)**

MDE-ARMA compiled a 2011 point source emission inventory in order to satisfy EPA reporting requirements under the Consolidated Emissions Reporting Rule. This will be the primary resource for developing refined estimates of PM<sub>2.5</sub> and NH<sub>3</sub> emissions.

## **3.0 AREAS SOURCES**

### **3.1 EMISSION ESTIMATION METHOD BY CATEGORY**

#### **3.1.1 PETROLEUM DISTRIBUTION LOSSES**

Evaporative emissions occur at all points in the gasoline distribution process. These operations, generally inventoried as area sources, are gasoline dispensing outlets and gasoline tank trucks in transit. Bulk terminals and gasoline bulk plants, which are intermediate distribution points between refineries and outlets, have been inventoried as point sources. Most gasoline dispensing outlets emit less than 10 tons of VOC per year and therefore have been inventoried using area source methods.

VOC emissions from gasoline dispensing outlets result from vapor losses during tank truck unloading into underground storage tanks, vehicle fueling (boat fueling at marinas), and underground storage tank breathing. Evaporative losses from each activity in this source category have been tabulated separately so that various emission reduction control measures could be easily evaluated.

Emissions from vehicle fueling, including spillage during fueling, were calculated with the MOVES model and the methodology is described in Section 5.0 Mobile Sources. Tank truck unloading, underground tank breathing, tank trucks in transit and aircraft refueling were calculated using emissions factors from AP-42 and EIIP.

### 3.1.1.1 Tank Truck Unloading

SCC: 25 01 060 053  
25 01 060 051

#### **Description:**

Emissions from tank truck unloading are affected by whether the service station tank is equipped for submerged, splash or balance filling. Therefore calculations were based on the filling method used and gallons sold.

#### **Pollutants**

VOC and HAPs

#### **Method and**

#### **Data Sources:**

The method used to calculate emissions (all VOC), is presented in EIIP<sup>1</sup>, Chapter 11, Gasoline Marketing, which extracts the emission factors from AP-42, Volume I, Table 5.2-7.

#### *Activity*

The Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices) provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county. Vehicle registration data was collected from the Maryland Department of Transportation, Motor Vehicle Administration that supplied the data to MDE's Mobile Sources Control Program (see Appendices). Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

Percentages of submerged, balanced submerged and splash-fill tanks were determined with the assistance of MDE Waste Management. MDE staff reported no splash filling at Maryland service stations in 2011. All underground storage tanks within the nonattainment areas of the State of Maryland are required to use vapor-balance submerged filling methods. Waste Management's underground tank inspection program and regulations concerning underground storage tanks have eliminated splash-fill tanks in the state. A recent SSCD study determined that the rule effectiveness factor for vapor balance controls was 91%.

An activity level of 7 days per week was used, based on observations by MDE staff of unloading at Maryland retail gas stations. A rule effectiveness of 91% was determined from a study of Stage I compliance performed in Regions III and IV by the MDE/ARMA enforcement program in 1991. In the attainment counties outside of Regions III and IV, a

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<sup>1</sup> Emission Inventory Improvement Program

default rule effectiveness of 80 % was used. This survey data was used to determine the penetration of each filling technology. The total fuel sales in the county were multiplied by the fraction using each filling technology. The AP-42 technology-specific emission factors were then used to estimate emissions from submerged filling and balanced submerged filling. The emissions from each filling technology were summed to estimate total emissions.

| <b>Filling Method</b> | <b>Non-Attainment Area</b> | <b>Transport Region</b> | <b>Attainment Area</b> |
|-----------------------|----------------------------|-------------------------|------------------------|
| Submerged             | 9%                         | 9%                      | 20%                    |
| Balanced Submerged    | 91%                        | 91%                     | 80%                    |
| Splash                | 0%                         | 0%                      | 0%                     |

### *Emission Factors*

Emission factors are affected by true vapor pressure and temperature. Emissions from loading petroleum liquid can be estimated (with a probable error of ±30 percent) using the following expression<sup>2</sup>:

$$L_L = 12.46 * \frac{S * P * M}{T}$$

where:

- $L_L$  = loading loss, pounds per 1000 gallons (lb/10<sup>3</sup> gal) of liquid loaded  
(The loading loss is equivalent to an emission factor)
- $S$  = a saturation factor (see Table 5.2-1)
- $P$  = true vapor pressure of liquid loaded, pounds per square inch absolute (psia)  
(see Figure 7.1-5, Figure 7.1-6, and Table 7.1-2)
- $M$  = molecular weight of vapors, pounds per pound-mole (lb/lb-mole)  
(see Table 7.1-2)
- $T$  = temperature of bulk liquid loaded, °R (°F + 460)

Table 5.2-1 from AP-42 shows that the saturation factor (S) is a constant for a specific petroleum liquid, carrier and type of loading service

The true vapor pressure (P) can be estimated from the Reid vapor pressure using the following equation:

$$P = \exp \left\{ \left[ 0.7553 - \left( \frac{413.0}{T + 459.6} \right) \right] S^{0.5 * \log_{10}(RVP)} - \left[ 1.854 - \left( \frac{1042}{T + 459.6} \right) \right] S^{0.5} + \left[ \left( \frac{2416}{T + 459.6} \right) - 2.013 \right] \log_{10}(RVP) - \left( \frac{8742}{T + 459.6} \right) + 15.64 \right\}$$

The molecular weight varies slightly with temperature and pressure, however for this analysis it is assumed to be constant.

<sup>2</sup> AP42, Chapter 5.2: Transportation and Marketing of Petroleum Liquids

Proportioning the loading factors yields

$$\frac{LL2}{LL1} = \frac{12.46 * S2 * P2 * M2 / T2}{12.46 * S1 * P1 * M1 / T1} = \frac{P2 * T1}{P1 * T2} \qquad LL2 = LL1 * \frac{P2 * T1}{P1 * T2}$$

The loading factor or emission factor is directly proportional to true vapor pressure and inversely proportional to temperature in degrees Rankin.

LL1 = 0.3 at RVP of 10 and 60 F; this yields LL1 =0.3; P =5.186; T=520 R

To calculate LL2 at RVP of 6.7 and 81.8 F or P = 5.094; T = 541.8 R

$$LL2 = LL1 * \frac{P2 * T1}{P1 * T2} = 0.3 * \frac{5.094 * 520}{5.186 * 541.8} = 0.2828$$

Initial emission factors of 0.3 lb<sub>VOC</sub> per 1000 gallons throughput for balanced submerged filling and 7.3 lb<sub>VOC</sub> per 1000 gallons throughput for submerged filling were used in all Maryland counties. These factors were then adjusted with county-specific monthly average temperature and true vapor pressure values using the above technique.

| <b>Filling Method</b> | <b>Base Emission Factor</b><br>Lb. VOC per 1,000 gallon |
|-----------------------|---|
| Balanced Submerged    | 0.3   |
| Submerged             | 7.3   |
| Diesel Fuel Unloading | 0.014   |

**Point Source Adjustments**

Emissions from Andrews Airforce Base were subtracted from Prince Georges County emission totals.

**Adjustment for Controls**

Controls for this source category are reflected in the emission factors.

**Spatial and Temporal Allocations**

*Spatial*

Spatial allocation source data was base on vehicle registration data that was provided through the Maryland Department of Transportation, Motor Vehicle Administration and source data supplied to MDE’s Mobile Sources Control Program (see Appendices). Diesel

fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

***Temporal***

Monthly temporal allocation activity data was provided through the Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices) provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county.

**Emissions Calculation**

The equation for estimating emissions from tank truck unloading is:

$$E_{fj} = \frac{(G_i \times F_{i(fm)} \times EF_{fm}) + (G_i \times F_{i(fm)} \times EF_{fm})}{2000} \quad \text{Where:}$$

$E_{fj}$  = Emissions of VOC in tons per day from tank truck unloading per county i

$G_i$  = Gallons of gasoline sold in county i during 2011

$F_{i(fm)}$  = Fraction of gasoline dispensed per county i per filling method (balanced submerged or submerged) during 2011

$EF_{fm}$  = Emission factor per filling method for tank truck unloading adjusted by RVP and temperature:  
(0.3 lb. VOC/1000 gallon throughput or 7.3 lb. VOC/1000 gallon throughput)

Tank Truck Unloading Sample Calculation (Carroll County)

To calculate fuel usage for Carroll County:

| <b>Filling Method</b> | <b>Carroll County<br/>Adjusted Emission Factor<br/>Lb. voc per 1,000 gallon</b> |
|-----------------------|---|
| Balanced Submerged    | 0.2486  |
| Submerged             | 6.0503  |
| Diesel Fuel Unloading | 0.014   |

Total fuel sold in Maryland in 2011<sup>3</sup> = 2,446,714,344 gallons

Allocate gallons of fuel sold to the county level by the 2011 county vehicle registration proportion:

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<sup>3</sup> Annual sales of gasoline from Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices)



$$\frac{\text{Carroll County vehicle registration}^4}{\text{Total MD vehicle registration}} = \frac{160,603}{4,512,010} = 0.0356$$

$G = 2,446,714,344 \times 0.0356 = \mathbf{87,089,715}$  gallons sold in Carroll County

$EM = (G * \text{Market \%} * \text{EF adjusted} / 1000) / 2000$

EMbs = balanced submerged emissions

EMs = submerged emissions

$EMbs = (\mathbf{87,089,715} * 91\% * 0.2486 / 1000) / 2000 = 9.85$  tons VOC per year

$EMs = (\mathbf{87,089,715} * 9\% * 6.0503 / 1000) / 2000 = 23.71$  tons VOC per year

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<sup>4</sup> State of Maryland Motor Vehicle Administration and MDE Mobile Sources Control Program (see Appendices).

### 3.1.1.2 Stage II Refueling

SCC: 25 01 060 100

#### **Description**

Emissions from Stage II refueling are substantially less than those from Stage I because gasoline vapors that ordinarily might have escaped during vehicle fueling are re-circulated by a special nozzle back into the pump. The start year for Stage II refueling in all Maryland ozone nonattainment areas was 1993. Gasoline stations were required to have Stage II nozzles installed by November of that year. Calculations were based on the filling method used and gallons sold.

#### **Pollutants**

VOC

#### **Method and Data Sources**

EPA recommends that the MOVES model be used to generate refueling (Stage II) emission factors for highway vehicle emission inventories (EPA, 2003). The model, designed to support the evaluation of air pollution from gasoline- and diesel-fueled vehicles, generates emission factors for tailpipe emissions and refueling activities.

#### *Activity*

The MOVES model produces estimates of refueling emissions in units of grams per mile. These values are multiplied by fuel economy (in units of miles per gallon) and total gasoline sales (in units of gallons purchased/sold) in the study area resulting in refueling emissions in terms of grams. It should be noted that MOBILE makes use of improved predictive equations to calculate refueling emission factors, including sensitivity to temperature and Reid vapor pressure (RVP), and these have not yet been incorporated into published AP-42 factors for refueling. Additionally, the user may provide information on local Stage II emission controls to develop an emission factor for controlled emissions.

Refueling emissions have two mechanisms of introducing emissions to the environment: (1) vapor displacement from the vehicle fuel tank during refilling; and (2) gasoline spillage during refueling. The MOBILE user may request either a single emission factor that combines the two mechanisms or separate emission factors for displacement and spillage. Because both mechanisms should be taken into account when estimating refueling emissions, the preferred approach is to request the combined emission factor.

#### *Emission Factors*

ARMA mobile sources staff ran the MOVES2010b model to estimate the refueling emissions using the grams per mile (g/mile) methodology described above. The emission estimates were converted from grams to tons.

## **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

## **Adjustment for Controls**

Controls for this source category include Stage II Vapor Recovery Systems and Onboard Refueling Vapor Recovery (ORVR) systems. The controls are reflected in the emission estimates produced by the (MOVES2010b) model.

## **Spatial and Temporal Allocations**

### *Spatial*

The MOBILE6.2 model spatially allocates input files specify state county-level gasoline sales data to spatially allocate emission estimates.

### *Temporal*

The MOBILE6.2 model allocates monthly activity data per state county-level and national level estimates.

## **Emissions Calculation**

The equation for estimating emissions from tank truck unloading is:

$$E_{S_{II}} = \frac{(G_i \times EF_{S_{II}} \times MPG \times SAF)}{2000} \quad \text{Where:}$$

$E_{S_{II}}$  = emissions of VOC in tons per day from stage II refueling

$G_i$  = gallons of gasoline sold in county i during 2011

$EF_{S_{II}}$  = emission factor for stage II refueling from the MOBILE6 model (grams/mile)

MPG = average fuel economy (miles/gallon)

SAF = seasonal adjustment factor to reflect summer weekday emissions

### Stage II Refueling Sample Calculation

Since all calculations are included in the MOBILE6.2 model output, a sample calculation is not available for this source category.

### 3.1.1.3 Underground Tank Breathing

SCC: 25 01 060 201

#### **Description:**

Underground tank breathing occurs when gasoline is drawn out of the tanks and into the pump lines. During this process air moves into the tank evaporating gasoline and emitting vapors.

#### **Pollutants**

VOC and HAPs

#### **Method and**

#### **Data Sources:**

The method used to calculate emissions (all VOC), is presented in EIIP<sup>5</sup>, Chapter 11, Gasoline Marketing, which extracts the emission factors from AP-42, Volume I, Table 5.2-7.

#### *Activity*

The Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices) provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county. Vehicle registration data was collected from the Maryland Department of Transportation, Motor Vehicle Administration that supplied the data to MDE's Mobile Sources Control Program (see Appendices). Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

#### *Emission Factors*

An emission factor of 1.0 lbs. VOC per 1000 gallons throughput was used. The emission factor was taken from EIIP, Chapter 11, Gasoline Marketing, which extracts the emission factors from AP-42, Volume I, Table 5.2-7. Factors were adjusted with county-specific monthly average temperature and true vapor pressure values.

MDE used the same sources for gasoline sales and car registration as in tank truck unloading (see Appendices).

#### **Point Source**

#### **Adjustments**

No subtraction of emissions from point sources is necessary.

---

<sup>5</sup> Emission Inventory Improvement Program

## Adjustment for Controls

Controls for this source category are reflected in the emission factors.

## Spatial and Temporal Allocations

### *Spatial*

Spatial allocation source data was based on vehicle registration data that was provided through the Maryland Department of Transportation, Motor Vehicle Administration and source data supplied to MDE's Mobile Sources Control Program (see Appendices). Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

### *Temporal*

Monthly temporal allocation activity data was provided through the Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices) provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county.

## Emissions Calculation

The equation used to estimate emissions from underground tank breathing is:

$$E_{\text{utb}} = \frac{(G_i \times EF_{\text{utb}})}{2000} \quad \text{Where:}$$

$E_{\text{utb}}$  = emissions of VOC in tons per day from underground tank breathing and emptying

$G_i$  = gallons of gasoline sold in county i during 2011

$EF_{\text{utb}}$  = emission factor for underground tank breathing (1.0 lbs. VOC/1000 gallon throughput)

### Underground Tank Breathing Sample Calculation (Carroll County)

To calculate fuel usage for Carroll County:

Total fuel sold in Maryland in 2011<sup>6</sup> = **2,668,913** kgallons

---

<sup>6</sup> Annual sales of gasoline from Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices)

Allocate gallons of fuel sold to the county level by the 2011 county vehicle registration proportion:

$$\frac{\text{Carroll County vehicle registration}^7}{\text{Total MD vehicle registration}} = \frac{160,603}{4,512,010} = 0.0356$$

$G_{\text{carr}} = 2,668,913 \times 0.0356 = 95,013$  kgallons sold in Carroll County in 2011.

$EF_{\text{utb}} = 0.8288$  lbs. VOC/1000 gallon

$$E_{\text{utb}} = \frac{(93,983 \times 1000 \times 0.8288 / 1000)}{2000}$$

$E_{\text{utb}} = 39.37$  tons VOC per year

---

<sup>7</sup> State of Maryland Motor Vehicle Administration and MDE Mobile Sources Control Program (see Appendices).

### 3.1.1.4 Gasoline Tank Trucks in Transit

SCC: 25 05 030 120

#### Description

Breathing losses from tank trucks during the transport of gasoline are caused by leaking delivery trucks, pressure in the tanks, and thermal effects on the vapor and on the liquid. A worst case situation arises if a poorly sealed tank has been loaded with gasoline and pure air becomes saturated. During the vaporization process, pressure increases and venting occurs. Emissions from this source category include the evaporation of petroleum vapor from:

- loaded tank trucks during transportation of gasoline from the bulk plant/terminal to the service station or other dispensing outlet, and
- from empty tank trucks returning from service stations to bulk plant/terminals

#### Pollutants

VOC

#### Method and Data Sources

The method used to calculate emissions (all VOC), is presented in EIIP<sup>8</sup>, Chapter 11, Gasoline Marketing (Stage I & Stage II), and dated September 1997.

#### *Activity*

#### *Emission Factors*

EPA documents the emission factors in AP-42, Table 5.2-5 and EIIP states the emission factors within the above-referenced document in Table 11.3-1. The AP-42 emission factors represent a typical range of values. EIIP averages the “typical range values” within AP-42 and arrives at average emission factor values of 0.055 and 0.005 lbs. VOC per 1000-gallon gasoline, respectively for emissions from empty tank trucks and emissions from full tank trucks.

| <b>Emission Source</b>          | <b>EIIP Table 11-3.1<br/>Lb/1000 gallon<br/>“Average”</b> | <b>AP-42 Table 5-2.5<br/>Lb/1000 gallon<br/>“Typical Range”</b> |
|---------------------------------|---|---|
| Gasoline Tank Trucks in Transit |   |   |
| Empty Tank Trucks               | <b>0.055</b>  | <b>0 - 0.11</b>   |
| Full Tank Trucks                | <b>0.005</b>  | <b>0 - 0.01</b>   |

MDE used the same sources for gasoline sales and car registration as in tank truck unloading (see Appendices). MDE used the emission factors from EIIP, Volume I, and Table 5.2-5, of 0.06 pounds VOC per 1000 gallons throughput (combines 0.005 lb VOC/1000 gallon full tank

<sup>8</sup> Emission Inventory Improvement Program

truck delivery and 0.055 lb VOC/1000 gallon empty tank return). MDE also used a bulk facility throughput adjustment factor of 1.09 and calculated throughput by a ratio of county retail sales and state retail sales times state fuel sales.

Emission Factors:

|                                |  |
|--------------------------------|--|
| Full tank truck delivery       | 0.005 lbs. VOC per 1000 gallons        |
| <u>Empty tank truck return</u> | <u>0.055 lbs. VOC per 1000 gallons</u> |
| Combined (full & empty)        | 0.060 lbs. VOC per 1000 gallons        |

Bulk Facility Throughput Adjustment Factor: 1.09

Equation:

$$E_{tt} = \frac{(G_i \times 1.09 \times EF_{tt})}{2000} \quad \text{Where:}$$

$E_{tt}$  = emissions of VOC in tons per day from tank trucks in transit

$G_i$  = thousand gallons of fuel sold in county i

$EF_{tt}$  = Combined (full & empty) tank trucks in transit emission factor

2011 Gasoline Tank Trucks in Transit Sample Calculation (Carroll County)

To calculate fuel usage for Carroll County:

Total on-road and non-road fuel sold in Carroll County = **98,329** kgallons

$G = 98,329$  kgallons sold in Carroll County

$$E_{tt} = \frac{(98,329 \times 1.09 \times 0.06)}{2000}$$

$E_{tt} = 3.22$  tons VOC per year emitted from tank trucks in transit in Carroll County.



### 3.1.1.5 Aviation Gasoline Distribution Stage 1 and Stage 2

SCC: 25 01 080 050  
25 01 080 100

#### **Description**

In Stage I aviation gasoline (also called “AvGas”) used in small reciprocating piston-engines is shipped to airports for use in civil aviation. AvGas is first placed into bulk terminals, and then into tanker trucks. These filling processes will cause the displacement of vapors into the atmosphere during the transfer of gasoline from tank trucks to storage tanks, and vice versa.

Stage II is the transfer of fuel from the tanker trucks into general aviation aircraft; during this process vapors are also displaced into the atmosphere.

#### **Pollutants**

VOC, Pb (Lead), and HAPs

#### **Point Source**

##### **Adjustments**

No subtraction of emissions from point sources is necessary.

##### **Adjustments for**

##### **Controls**

No adjustments for controls.

#### **Spatial and**

#### **Temporal**

#### **Allocations**

##### *Spatial*

County-level AvGas fuel distributions reported through Energy Information Administration -EIA was spatial allocated for this sources.

##### *Temporal*

Annual county-level emissions from PAD-level AvGas consumption from EIA, Petroleum Supply Annual 2011 reports were temporally allocated for this sources.

#### **Method and**

#### **Data Sources**

MDE staff used the methodology developed from the PECHAN/ERTAC Study, 2007, base on terminals using AvGas fuel activity assumptions data.

##### *Activity*

MDE used selected data from the Department of Energy’s State Energy Data System obtain fuel consumption data. MDE used airport survey data and the Maryland Aviation

Administration's 2011 Operations Count for Public-Use Airports to obtain operational counts. A few airports, such as Andrews Air Force Base, provided their own operations count (see Appendices).

| Fuel Type         | Fuel Consumption<br>(1,000 Gallons) |
|-------------------|-------------------------------------|
| Commercial Jet    | 123,900                             |
| Aviation Gasoline | 1,806                               |
| Military Jet      | 1,239                               |

***Emission Factors***

Emission factors for AvGas distribution come from the (TRC Environmental Corporation's ***Estimation of Alkylated Lead Emissions, Final Report***, which was prepared for the U.S Environmental Protection Agency, Office of Air Quality Planning and Standards. RTP, NC 1993.

The emissions factors are separated by emissions source such as

EF<sub>tf</sub> = Aviation Gasoline from Tank Fill

EF<sub>st</sub> = Aviation Gasoline from Storage Tank

EF<sub>c</sub> = Aviation Gasoline from Composite

EF<sub>bl</sub> = Aviation Gasoline from Breathing Losses

**Factors Not Used:**

EF<sub>v</sub> = Aviation Gasoline from Valves (There are NO AvGas Facilities/Tank Farms in MD)

EF<sub>p</sub> = Aviation Gasoline from Pumps (There are NO AvGas Facilities/Tank Farms in MD)

| EF Type                                 | VOC Emission Factors | Units           |
|---|----------------------|-----------------|
| Tank Fill                               | 0.009021383          | LB/GALLON AvGas |
| Storage Tank                            | 0.003605215          | LB/GALLON AvGas |
| Composite                               | 0.010306575          | LB/GALLON AvGas |
| Breathing Losses                        | 0.001694117          | LB/GALLON AvGas |
| Valves Not Used                         | 0.573201882          | LB/VALVE*DAY    |
| Pumps Not Used                          | 5.952481079          | LB/SEAL*DAY     |
| EF <sub>sum</sub> (Sum of Factors Used) | 0.024627290          | LB/GALLON AvGas |
| Tanker to Truck Transfer Stage II       | 0.0136               | LB/GALLON AvGas |

Emission Estimate Equation: County Level

$$EM = EF_{sum} \times \text{Fraction of LTOs} \times \text{Amount of Aviation Gasoline}$$

$$EM_i = EF_{sum} \times (CA_i / SA_i) \times F_i$$

Where:

$F_i$  = County aircraft fuel use

$CA_i$  = County aircraft activity (LTO)

$SA_i$  = State aircraft activity (LTO)

$EF_{sum_i}$  = **Sum of Factors Used**

$EM_i$  = specific county (i) emissions from aircraft refueling in tons VOC per year

2011 Sample Calculation for Stage I AvGas Distribution (Allegany County)

$$F_{\text{Allegany}} = 1,806,000 \text{ gallons}$$

$$\text{Fraction of LTOs} = \frac{CA_{\text{Allegany}}}{SA} = \frac{15,561}{882,301} = 0.0176$$

$$EF_{sum \text{ Allegany Stage I}} = 0.0246272899 \text{ lb/gal AvGas}$$

$$EM_{\text{Allegany}} = (0.0246272899 \times 0.0176 \times 1,806,000) / 2000 = 0.39 \text{ tons VOC /year}$$

2011 Sample Calculation for Stage II AvGas Distribution (Allegany County)

$$F_{\text{Allegany}} = 1,806,000 \text{ gallons}$$

$$\text{Fraction of LTOs} = \frac{CA_{\text{Allegany}}}{SA} = \frac{15,561}{882,301} = 0.0176$$

$$EF_{sum \text{ Allegany Stage II}} = \mathbf{0.0136} \text{ lb/gal AvGas}$$

$$EM_{\text{Allegany}} = (0.0136 \times 0.0176 \times 1,806,000) / 2000 = \mathbf{0.22} \text{ tons VOC /year}$$

### 3.1.1.6 Petroleum Vessel Unloading Losses

SCC:

|            |                |
|------------|----------------|
| 2505020030 | crude oil      |
| 2505020090 | distillate oil |
| 2505020120 | Gasoline       |
| 2505020150 | jet naphtha    |
| 2505020060 | residual oil   |
| 2505020180 | kerosene       |

#### Description

Petroleum liquids are transported via ships and barges, and on-land transportation. The procedures discussed below relate to marine transport of petroleum liquids. This category does not include emissions from fuel consumed by vessels while in transit or in port. Evaporative VOC emissions from ocean going ships and barges carrying petroleum liquids result from loading losses, ballasting losses and transit losses. Petroleum liquids are classified into groups which are represented by crude oil, gasoline, jet naphtha, distillate oil/kerosene, or residual oil. Loading and ballasting losses do not occur with pipeline transport of petroleum products (AP-42, Section 5.2).

**Loading losses** occur as organic vapors in “empty” cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks. These vapors are a composite of vapors formed in three ways:

- Vapors which are formed in the “empty” tank by evaporation of residual product from previous loads;
- Vapors transferred to the tank from a vapor balance system that was used when the previous load was being unloaded; and
- Vapors generated in the tank as the new product is being loaded.

Loading losses are usually the largest source of evaporative emissions from petroleum vessels (EPA, 1996).

**Ballasting losses** are associated with the unloading of petroleum liquids at marine terminals and refinery loading docks. It is common practice to load several cargo tank compartments with sea water after the cargo has been unloaded. This water, called “ballast,” improves the stability of the empty tanker during the subsequent voyage. Ballasting emissions occur as vapor-laden air in the empty cargo tank is displaced to the atmosphere by ballast water being pumped into the tank.

**Transit losses** are similar to breathing losses associated with petroleum storage. Transit loss is the expulsion of vapor from a vessel compartment through vapor contraction and expansion, which are the result of changes in temperature and barometric pressure. This loss may be accompanied by slight changes in the level of the liquid in the tank due to liquid expansion or contraction due to the temperature change. Some ships are equipped with controls for these losses.

## Pollutants

VOC

## Method and Data Sources

### *Activity*

The method used to calculate emissions (all VOC) is presented in EIIP<sup>9</sup>, Chapter 12, Marine Vessel Loading, Ballasting and Transit, dated May 1998.

A significant part of the emissions from this source are from the Eastern Shore of Maryland because petroleum products are delivered to this area by barge rather than by pipeline as in the rest of the state. To compile emissions MDE used guidance in EIIP, Chapter 12, Marine Vessel Loading, Ballasting and Transit and emissions factors from EIIP Table 12.4-5, Waterborne Commerce of the United States, Waterways and Harbors Atlantic Coast, Part 1, 2010 data, and AP-42, Table 7.1-2 liquid densities. Waterborne Commerce supplied tonnage and type of petroleum products delivered to the various ports in Maryland for the year 2010 (see Appendices). Tonnages of petroleum delivered were converted into Kgal.s (1000 gallons) and then used to calculate emissions.

### *Factors*

| <b>UNCONTROLLED VOC EMISSION FACTORS FOR PETROLEUM CARRYING MARINE VESSELS (EPA, 1996)</b> |   |   |  |   |
|--|---|---|--|---|
| <b>Petroleum Liquid</b>  | <b>Ship/Ocean Vessel Loading (Lbs. voc per 1,000 gallons Transferred)</b> | <b>Barge Loading (Lbs. voc per 1,000 gallons Transferred)</b> | <b>Ballasting (Lbs. voc per 1,000 gallons Transferred)</b> | <b>Transit (Lbs. voc per 1,000 gallons Transferred)</b> |
| Crude Oil  | 0.61  | 1   | 1.1  | 1.3   |
| Gasoline   | 1.8   | 3.4   | 0.8  | 2.7   |
| Jet Naphtha / Other  | 0.5   | 1.2   | NA   | 0.7   |
| Distillate Oil / Kerosene  | 0.005   | 0.012   | NA   | 0.005   |
| Residual Oil   | $4 \times 10^{-5}$  | $9 \times 10^{-5}$  | NA   | $3 \times 10^{-5}$                                      |

<sup>9</sup> Emission Inventory Improvement Program

Data obtained from sources such as the *Waterborne Commerce of the United States* are typically provided in terms other than 1,000 gallons (Mgal) as is required in EIIIP Equation 12.4-1 and must be converted. Equation 12.4-3 can be used to convert units from 1,000 ton (Mtons) to Mgal. Where:

$$PP_V = (PP_M / d) \times (2,000 \text{ lb/ton}) \times (\text{Mgal}/1,000 \text{ gallons}) \times (1,000 \text{ tons/Mtons})$$

$PP_V$  = Amount of petroleum liquid (Mgal)

$PP_M$  = Amount of petroleum liquid (Mtons)

$d$  = Density of petroleum liquid; see Table 7.1-2 in AP-42 (lb/gallon)

|                | Density <sup>10</sup><br>(lb/gal) |
|----------------|-----------------------------------|
| Distillate Oil | 7.10                              |
| Residual Oil   | 7.90                              |
| Gasoline       | 5.60                              |
| Kerosene       | 7.00                              |
| Crude Oil      | 7.10                              |
| Jet Naphtha    | 6.40                              |

If controls exist, then control efficiency can be calculated:

$$PP_C = PP_U \times (1 - CE/100)$$

Where:

$PP_C$  = Controlled emissions (tons)

$PP_U$  = Uncontrolled emissions (tons)

CE = Control efficiency (%)

Equation:

$$PV_P = \frac{[(SOEF_P \times PP_{S,P}) + (BREF_P \times PP_{B,P}) + (BLEF_{P,U} \times 0.20 \times PP_{BL,P}) + (TREF_P \times PP_{T,P})]}{2000}$$

Where:

$PV_P$  : Total VOC emissions from petroleum vessel loading, ballasting, and transit for each of the petroleum liquids (p) transported: crude oil, gasoline, kerosene, distillate oil, and residual oil (tons)

$SOEF_P$ : Ship/ocean vessel loading emission factor (pounds VOC per 1,000 gallons transferred)

<sup>10</sup> AP-42, Table 7.1-2

- PP<sub>S,P</sub>: Amount of petroleum liquid (p) loaded into ships and ocean vessels in the inventory region (1,000 gallons)
- BREF<sub>P</sub>: Barge vessel loading emission factor (pounds VOC per 1,000 gallons transferred)
- PP<sub>B,P</sub>: Amount of petroleum liquid (p) loaded into barges in the inventory region (1,000 gallons)
- BLEF<sub>P,U</sub>: Ballasting emission factor (pounds VOC per 1,000 gallons water ballasted)
- PP<sub>BL,P</sub>: Amount of petroleum liquid (p) unloaded from vessels that are ballasted (1,000 gallons)
- TREF<sub>P</sub>: Vessel transit emission factor (pounds VOC per week per 1,000 gallons transferred)
- PP<sub>T,P</sub>: Amount of petroleum liquid (p) transported by marine vessels in the inventory region (1,000 gallons)

2011 Petroleum Vessel Unloading Losses Sample Calculation (Gasoline – Baltimore City)

| <b>Gallons (in Thousands) of Petroleum Shipped in Baltimore Harbor</b> |                  |                       |                 |                    |                     |                 |
|--|------------------|-----------------------|-----------------|--------------------|---------------------|-----------------|
|  | <b>Crude Oil</b> | <b>Distillate Oil</b> | <b>Gasoline</b> | <b>Jet Naphtha</b> | <b>Residual Oil</b> | <b>Kerosene</b> |
| Baltimore City   | <b>5,634</b>     | <b>10,986</b>         | <b>329,286</b>  | <b>625</b>         | <b>405,316</b>      | <b>241,143</b>  |

Tonnage of distillate oil shipped in Baltimore Harbor (from Waterborne Commerce of the U.S., 2010) were converted in thousands of gallons (Kgal.s) and then used to calculate emissions.

Vessel Loading Emissions

For vessel loading operations, 90 percent of the total throughput was loaded at terminals with a control system of 95 percent efficiency. According to the local port authorities, transit time in the inventory area is two days (2/7 of a week). Emissions for each emission point are calculated using Equation 12.4-1 and the emission factors from Table 12.4-5. In this example, emissions for each emission point are calculated separately and then totaled. Note that CE is applied to vessel loading emissions, and transit emissions are apportioned to two days per week by multiplying emissions by 2/7.

Baltimore City:

Vessel Loading gas = 0.00 Kgal

Barge Loading gas = 0.00 Kgal

Ballasting gas = 0.00 Kgal

Transit gas = 329,286 Kgal

Baltimore gas Total = (0.00 + 0.00 + 0.00 + 329,286) = 329,286 Kgal

**Vessel Loading** (gasoline) emissions are calculated:

$$PV_{GAS} = [(1.8 \text{ lbs}_{VOC}/\text{Kgal}) \times (0.00 \text{ Kgal}/\text{yr}) \times \{0.10 + [0.9 (1 - 95/100)]\}] \div 2,000 \text{ lb}/\text{ton}$$
$$PV_{GAS} = 0.00 \text{ tons}/\text{year}$$

**Barge Loading** emissions are calculated:

$$PV_{GAS} = [(3.4 \text{ lbs}_{VOC}/\text{Kgal}) \times (0.00 \text{ Kgal}/\text{yr})] \div 2,000 \text{ lb}/\text{ton}$$
$$PV_{GAS} = \mathbf{0.00} \text{ tons}/\text{year}$$

**Ballasting** emissions are calculated:

$$PV_{GAS} = [(0.8 \text{ lbs}_{VOC}/\text{Kgal}) \times (0.00 \text{ Kgal}/\text{yr}) \times (0.20)] \div 2,000 \text{ lbs}/\text{ton}$$
$$PV_{GAS} = \mathbf{0.00} \text{ tons}/\text{year}$$

Note that the calculation for ballasting emissions in the equation includes a correction term of 0.20. This correction term reflects the practice of loading a ship or barge at some fraction of *capacity* when *ballasting*.

**Transit** emissions are calculated:

According to the Maryland Port Authorities transit time is 6 hours out of 24 or 25% during a week (7 days).

$$PV_{GAS} = (2.7 \text{ lbs}_{VOC}/\text{Kgal}) \times (329,286 \text{ Kgal}/\text{yr}) \times (0.25/7\text{wk}) \div 2,000 \text{ lbs}/\text{ton}$$
$$PV_{GAS} = \mathbf{15.88} \text{ voc tons}/\text{year}$$

Total VOC emissions are calculated as follows:

$$\text{Total}_{VOC} = \mathbf{0.00} \text{ tons}/\text{year} + \mathbf{0.00} \text{ tons}/\text{year} + \mathbf{0.00} \text{ tons}/\text{year} + \mathbf{15.88} \text{ tons}/\text{year}$$
$$\text{Total}_{VOC} = \mathbf{15.88} \text{ tons}/\text{yr}$$



### 3.1.1.7 Portable Fuel Containers

SCC: 25 01 011 011 (Residential – Permeation)  
25 01 011 012 (Residential – Diurnal)  
25 01 011 013 (Residential – Transport)  
25 01 011 014 (Residential – Refiling At The Pump - Vapor Displacement)  
25 01 011 015 (Residential – Refiling At The Pump - Spillage)  
25 01 012 011 (Commercial – Permeation)  
25 01 012 012 (Commercial – Diurnal)  
25 01 012 013 (Commercial – Transport)  
25 01 012 014 (Commercial – Refiling At The Pump - Vapor Displacement)  
25 01 012 015 (Commercial – Refiling At The Pump - Spillage)

#### Description

Portable fuel containers (PFCs) store and transport fuel from gasoline service stations to residential homes and businesses. Emissions from PFC use include:

- **Permeation Emissions**, which are produced after fuel has been stored long enough in a can for fuel molecules to infiltrate and saturate the can material.
- **Diurnal Emissions**, which result when stored fuel vapors escape to the outside of a gas can through any possible openings while the gas can is subjected to daily cycle of increasing and decreasing ambient temperatures. Diurnal emissions are dependent on the closed- or open-storage condition of a gas can.
- **Transport Emissions** arise when fuel escapes (e.g., spills, etc.) from gas cans that are in transit.
- **Equipment Refueling Emissions** results when fuel escapes (e.g., spillage, vapor displacement) during the refueling of nonroad equipment; however these emissions are handled by EPA’s NONROAD model. Activity data from the NONROAD model were used to estimate these emissions (described below).

Both residential and commercial PFCs are included. The SCCs for PFCs are also new and are shown above.

#### Pollutants

VOC

#### Method Data Sources and

The method used to calculate emissions (all VOC), is adopted from a CARB<sup>11</sup> survey and methodology adopted by OTC<sup>12</sup>.

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<sup>11</sup> ARB’s Mailout MSC 99-25, “Public Meeting to Consider Approval of CA’s Portable Gasoline-Container Emissions Inventory, “ (ARB, 199b)

<sup>12</sup> Control Measure Development Support Analysis of Ozone Transport Commission Model Rules, E.H. PECHAN & Associates, Inc. 5528-B Hempstead Way, Springfield, VA 22151, March 31, 2001.

Portable fuel container emissions are calculated by accounting for emissions from five different components related to gas container use: permeation, diurnal, transport-spillage, refueling spillage and refueling vapor displacement emissions. The permeation, diurnal emissions (associated with storage) and transport-spillage (associated with filling the can) emissions are included in the area source inventory. The equipment refueling spillage and refueling vapor displacement emissions are calculated from the non-road model and are included in the non-road inventory

### ***Activity***

The following input data is required to calculate emissions for this source category.

1. Rather than assuming that the numbers of PFCs per household and per business were consistent across the entire State, MDE used EPA's non-road emissions model (NONROAD2005) to estimate nonroad consumption of gasoline by county by source category classification (SCC) code. Each SCC code has a unique usage (commercial versus residential), a unique ratio of the percent of fuel dispensed from PFCs \* The previous draft version of this report (EPA420-D-06-003) was based on estimates from the draft NONROAD2004 model.(versus from fuel pumps), and a unique spillage rate (grams per gallon).
2. Number of commercial businesses<sup>13</sup> 2002 expected to have at least one gas can by county, NAICS 11, 23, 31, 32, 33, 411, 447, 45299, 484, 488, 493, 53131, 5321, 532291, 5323, 5324, 54132, 54162, 54169, 56173, 71391, 71393, 7212, 811, and 81293.
3. MDE was able to estimate by county by source category classification (SCC) code the total quantity of gasoline supplied from PFCs as well as the total spillage (from using the PFCs to refuel the individual pieces of equipment) for residential usage and for commercial usage. For example, running the NONROAD2005 model for calendar year 2011 produced the following estimates (obtained by summing the individual state-by-state estimates).

### ***Emission Factors***

Separate emission factors were developed for permeation, diurnal, transport and spillage emissions for PFC (both for commercial and residential PFCs). These emission factors were derived from CARB's survey data (CARB, 1999).

### **Point Source Adjustments**

Because the application of architectural surface coating is defined as an area source, there is no need to subtract point source emissions from the total, and all emissions estimated for this source are area source emissions.

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<sup>13</sup> Total 2011 employment and business establishments by 6 digit NAICS code and by county, County Business Patterns

## Adjustment for Controls

Maryland's COMAR 26.11.13.07 rule regulates control adjustments of VOC emissions from portable fuel containers (PFC's) that requires performance standards for PFCs and/or spouts that will reduce emissions do to storage, transport, and refueling activities. (2011 control efficiency of 65% and a control factor of 35.75%). COMAR web link: [http://www.dsd.state.md.us/comar/title\\_search/Title\\_List.aspx](http://www.dsd.state.md.us/comar/title_search/Title_List.aspx)

## Spatial and Temporal Allocations

### *Spatial*

For the residential PFC SCCs, emissions were allocated to the local area level based on a housing surrogate. Commercial PFC emissions were allocated to the local area level based on commercial and industrial business location.

### *Temporal*

For the residential PFC SCCs, the emissions were allocated based on the monthly and weekday/weekend day temporal profiles for residential lawn and garden equipment in the NONROAD model. For the commercial PFC SCCs, these emissions were allocated based on temporal profiles for the NONROAD model engines used in commercial applications.

## Emissions Calculation

The equation used to estimate emissions from portable fuel containers is:

Equation:

The residential-gas-can population is calculated as follows:

$$\text{Pop}_R = (N)*(A)*(\text{Count}_R) \quad (\text{Eq. 1})$$

where:

|                  |   |  |
|------------------|---|--|
| $\text{Pop}_R$   | = | Statewide Residential-Gas-Can Population             |
| $N$              | = | Number of Occupied-Housing Units in OTC State        |
| $A$              | = | Percentage of Households with Gas Cans (46%)         |
| $\text{Count}_R$ | = | Average Number of Residential-Gas Cans per Household |

Statewide residential-gas-can-permeation emissions are computed as follows:

$$\text{HC}_{PR} = \Sigma (\text{Pop}_R)*(S)*(EF_P)*(B_R)*(Size_R)*(Level)/CF \quad (\text{Eq. 2})$$

where:

|                  |   |  |
|------------------|---|--|
| $\text{HC}_{PR}$ | = | Permeation Emissions in tons per day (tpd) |
| $\text{Pop}_R$   | = | Statewide Residential-Gas-Can Population   |

|                   |   |   |
|-------------------|---|---|
| EF <sub>P</sub>   | = | Appropriate Permeation-Emission Factor (g/gal-day)  |
| S                 | = | Percentage of Gas Cans Stored with Fuel (70%)   |
| B <sub>R</sub>    | = | Percentage of Cans Stored in Closed Condition with respect to Material (Plastic 53%; Metal 13%) |
| Size <sub>R</sub> | = | Weighted Average Capacity of Residential-Gas Cans (2.34 gal.)                                   |
| Level             | = | Weighted Average Amount of Stored Fuel (49%)  |
| CF                | = | 907,184.5844 g/ton  |

Diurnal emissions from both open- and closed-system-residential-gas cans are calculated as follows:

$$HC_{DR} = (Pop_R) * (S) * (EF_D) * (B_R) * (Size_R) * (Level) \quad (\text{Eq. 3})$$

|        |                   |   |   |
|--------|-------------------|---|---|
| Where: | HC <sub>DR</sub>  | = | Diurnal Emissions (tpd) for Residential-Gas Cans with respect to Storage Condition (Open or Closed) and Material (Plastic or Metal) |
|        | Pop <sub>R</sub>  | = | Statewide Residential-Gas-Can Population  |
|        | S                 | = | Percentage of Gas-Can Population Stored with Fuel (70%)   |
|        | EF <sub>D</sub>   | = | Appropriate Diurnal-Emission Factor with respect to Storage Condition and Material (g/gal-day or g/day)                             |
|        | B <sub>R</sub>    | = | Percentage of Gas-Can Population with respect to Storage Condition and Material   |
|        | Size <sub>R</sub> | = | Weighted Average Capacity of Residential-Gas Cans (2.34 gal.)   |
|        | Level             | = | Weighted Average Amount of Stored Fuel (49%)  |
|        | CF                | = | 907,184.5844 g/ton  |

Residential-transport-spillage emissions are determined as:

$$HC_{TR} = (Pop_R) * (S) * (Refill_R) * (EF_T) * (B_R) \quad (\text{Eq. 4})$$

|        |                     |   |  |
|--------|---------------------|---|--|
| Where: | HC <sub>TR</sub>    | = | Residential-Gas-Can-Transport-Spillage Emissions (tpd)                                       |
|        | Pop <sub>R</sub>    | = | Statewide Residential-Gas-Can Population   |
|        | S                   | = | Percentage of Gas Cans Stored with Fuel (70%)  |
|        | Refill <sub>R</sub> | = | Average Number of Residential-Gas-Cans-Pump-Refills per Day per Can (refill/day from survey) |
|        | EF <sub>T</sub>     | = | Transport-Emission Factor with respect to Storage Condition (g/refill)                       |
|        | B <sub>R</sub>      | = | Percentage of Gas Cans with respect to Storage Condition and Material                        |
|        | CF                  | = | 907,184.5844 g/ton   |

The commercial-gas-can population is calculated as follows:

$$Pop_C = (N_C) * (Count_C) \quad (\text{Eq. 5})$$

Where:  $Pop_C$  = Statewide Commercial-Gas-Can Population  
 $N_C$  = Number of Occupied Businesses in State  
 $Count_C$  = Average Number of Gas Cans per Business

Statewide commercial-gas-can-permeation emissions are computed as follows:

$$HC_{PC} = \Sigma (Pop_C)*(S)*(EF_P)*(B_C)*(Size_C)*(Level) \quad (Eq. 6)$$

Where:  $HC_{PC}$  = Permeation Emissions (tpd)  
 $Pop_C$  = Statewide Commercial-Gas-Can Population  
 $EF_P$  = Appropriate Permeation-Emission Factor (g/gal-day)  
 $S$  = Percentage of Gas Cans Stored with Fuel (70% for Residential Survey)  
 $B_C$  = Percentage of Applicable Gas Cans Stored in Closed Condition  
 $Size_C$  = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal)  
 $Level$  = Weighted Average Amount of Stored Fuel (49% from Residential Survey)  
 $CF$  = 907,184.5844 g/ton

The amount of diurnal emissions from both open- and closed-system commercial-gas cans is calculated as follows:

$$HC_{DC} = (Pop_C)*(S)*(EF_D)*(B_C)*(Size_C)*(Level) \quad (Eq. 7)$$

Where:  $HC_{DC}$  = Diurnal Emissions (tpd) for Commercial-Gas Cans with respect to Storage Condition (Open or Closed) and Material (Plastic or Metal)  
 $Pop_C$  = Statewide Commercial-Gas-Can Population  
 $EF_D$  = Appropriate Diurnal-Emission Factor with respect to Storage Condition and Material (g/gal-day or g/day)  
 $S$  = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)  
 $B_C$  = Percentage of Gas Cans with respect to Storage Condition and Material  
 $Size_C$  = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal.)  
 $Level$  = Weighted Average Amount of Stored Fuel (49% from Residential Survey)  
 $CF$  = 907,184.5844 g/ton

The non-lawn-and-garden-equipment commercial-gas-can refills at the pump is derived as follows:

$$REFILL_c = \left[ \frac{(\Sigma Fuel)}{(SIZE_c)*(POP_{NON})*(S)} \right] \quad (Eq. 8)$$

Where:

|                     |   |   |
|---------------------|---|---|
| Refill <sub>C</sub> | = | Average Number of Non-Lawn-and-Garden Equipment Commercial-Gas-Cans Pump Refills per Day per Can (refill/day) |
| Fuel                | = | Non-Lawn-and-Garden Equipment Fuel Consumption (gal/day) for 2000   |
| Size <sub>C</sub>   | = | Weighted Average Capacity of Commercial-Gas Cans (3.43 gal/can-refill)  |
| POP <sub>NON</sub>  | = | Statewide Commercial-Gas-Can Population with respect to Non-Lawn-and-Garden Businesses                        |
| S                   | = | Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)   |
| CF                  | = | 907,184.5844 g/ton  |

The commercial-transport-spillage emissions are determined as:

$$HC_{TC} = (Pop_C) * (S) * (B_C) * (Refill_C) * (EF_{TC}) \quad (Eq. 9)$$

Where:

|                     |   |   |
|---------------------|---|---|
| HC <sub>TC</sub>    | = | Commercial-Gas-Can-Transport-Spillage Emissions (tpd)                           |
| Pop <sub>C</sub>    | = | Statewide Commercial-Gas-Can Population   |
| S                   | = | Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)           |
| B <sub>C</sub>      | = | Percentage of Gas Cans with respect to Storage Condition and Material           |
| Refill <sub>C</sub> | = | Average Number of Gas-Cans Pump Refills per Day per Can                         |
| EF <sub>TC</sub>    | = | Transport-Spillage Emission Factor (g/refill) with respect to Storage Condition |
| CF                  | = | 907,184.5844 g/ton  |

The total area source portable fuel container emissions are summed as follows:

$$E_{PFC - A} = HC_{PR} + HC_{DR} + HC_{TR} + HC_{PC} + HC_{DC} + HC_{TC}$$

$$E_{PFC - SD} = E_{PFC - A} * SAF // AADF$$

Where:

|                       |   |   |
|-----------------------|---|---|
| E <sub>PFC - A</sub>  | = | (tons/yr) for an annual emission of pollutant by county   |
| E <sub>PFC - SD</sub> | = | (tons/day) for a typical summer day emission of pollutant |
| AADF                  | = | Annual activity day factor (WAF * 52 weeks/year)          |
| SAF                   | = | Seasonal adjustment factor                                |

### 3.1.2 STATIONARY SOURCE SOLVENT APPLICATION

#### 3.1.2.1 Dry Cleaners

SCC: 24 20 000 000

##### **Description**

Dry-Cleaning facilities utilize solvents in their cleaning process which causes the emission of VOCs into the air.

##### **Pollutants**

VOC

##### **Method and Data Source**

Emissions from the dry-cleaning process were estimated by taking county employment and adjusted employment numbers from dry-cleaning and multiplying them by a given per capita emission factor for VOCs.

##### *Activity*

The County Business Patterns reports employment data for the counties of Maryland. Employment data is listed by the North American Industrial Classification Standard (NAICS) code(s) (81231, 81232, and 81233) that are used to determine county-level employment. Employment data collected was allocated to each county using *County Business Patterns* employment data for 2010 for the counties of Maryland. County Business Patterns internet addresses (<http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl>). Midpoint adjustments were determined for counties which had employment given a letter range.

##### *Emission Factor*

Emission factors for dry cleaning came from 2008 Emission Inventory Data & Documentation (<http://www.epa.gov/ttn/chief/net/2008inventory.html>) Nonpoint section for Dry Cleaning: in Table 2, created by EPA and ERTAC committee through a joint study.

VOC = 10 lbs per person.

##### **Point Source Adjustments**

None

##### **Adjustments for Controls**

None

## **Spatial and Temporal Allocations**

### *Spatial*

Data for spatial allocation is not available for this source.

### *Temporal*

Data for temporal allocation is not available for this source.

## **Emissions Calculation**

Emissions are calculated for each county using emission factors and activity as:

$$E_{x,y} = EMP_x \times EF_y$$

where:

$E_{x,y}$  = annual emissions for county x and pollutant y

$EMP_x$  = employment data associated with county x

$EF_y$  = emission factor for pollutant y

### 2011 Sample Calculation Dry-Cleaning Emissions (Anne Arundel County)

$$E_{\text{Allegany}} = EMP_{\text{Allegany}} \times EF_{\text{voc}}$$

$$E_{\text{Allegany}} = 440 \text{ person} \times 10 \text{ lbs voc/person}$$

$$E_{\text{Allegany}} = 4,400 \text{ lbs. voc}$$

$$E_{\text{Allegany}} = 2.2 \text{ tons voc per year}$$



### 3.1.2.2 Industrial and Institutional Cleaning

SCC: 24 15 300 000

#### Description

Industrial and Institutional Cleaning (Cold Cleaning Degreasing) is seen primarily at auto repair stations or manufacturing facilities, where solvents at room temperature (or slightly warmed) are used to clean parts via immersion or rinsing.

Industrial and Institutional Cleaning are usually individually small emission sources and because they are widely scattered and frequently used, they are most easily treated as area sources. If they are collocated at a major source, they may be included in the point source inventory and those emissions will need to be subtracted from the area source estimate.

There are two basic types of cleaning machines: batch and in-line cleaning machines (also called continuous cleaning machines). Both of these equipment types are designed to use solvent to clean parts. The solvent is either used to clean in its non-vapor liquid form (at a temperature below the boiling point, referred to as cold cleaning), or heated to a temperature above its boiling point (referred to as vapor cleaning). Other solvent cleaning operations involve the use of solvent in wipe-cleaning and equipment cleanup. Emissions from solvent cleaning machines can also be considered to be point sources; therefore, the estimation process for the source category must take this into account to prevent double counting of emissions. Additionally, emissions from solvent cleanup may be included as a part of an industry- or process-specific emission estimate.

#### Pollutants

VOC and HAP (Trichloroethylene – 79016)

#### Method and Data Source

MDE staff used the methodology developed from the PECHAN/ERTAC Study, 2007, base on emplacement activity data and method documented in EIIP<sup>14</sup>, Chapter 6, Solvent Cleaning, dated September 1997 to emission estimation for this source category.

#### *Activity*

The County Business Patterns reports employment data for the counties of Maryland. Employment data is listed by the North American Industrial Classification Standard (NAICS) code(s) that are used to determine county-level employment. Employment data collected was allocated to each county using *County Business Patterns* employment data for 2010 for the counties of Maryland. County Business Patterns internet addresses (<http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl>).

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<sup>14</sup> Emission Inventory Improvement Program

An activity level of 6 days a week with no seasonal adjustment factor was used as recommended in the EIIP document. Solvent storage and recycling centers such as Safety Kleen are included in the point source inventory. The 2010 County Business Patterns employment data for Maryland by county is listed in the appendices. A 2002 reduction factor (Phase II Attainment Plan for the Baltimore Nonattainment Area and Cecil County) of 53.60% was applied to the calculated emissions. This factor combines reductions from technology rules and good housekeeping practices and the application of rule effectiveness as shown below:

$$\text{Reduction factor} = (\text{control efficiency}) \times (\text{rule effectiveness}) \times (\text{rule penetration})$$

$$\text{Reduction factor} = 0.67 \times 0.80 \times 1.00$$

$$\text{Reduction factor} = 0.5360$$

***Emission Factor***

Table 6.5-2 of the EIIP document lists a total emission factor of 87 lbs. VOC per employee per year for solvent cleaning operations. The emission factor for the HAPs Trichloroethylene – 79016 was developed from the PECHAN/ERTAC Study, 2007. The study included a HAP Trichloroethylene emission factor base on a percent weight factor of total solvent VOC which is 0.00686. This percent weight factor of total solvent VOC was multiply by the total emission factor of 87 lbs. VOC per employee per year and divided by 100 that resulted in Trichloroethylene emission factor of 0.59685 lbs. Trichloroethylene /yr/employee.

Factors

- E<sub>cc</sub> = 87 lbs VOC per employee per year for cold cleaning degreasers
- CE<sub>cc</sub> = 67%
- RE<sub>cc</sub> = 80%
- RP<sub>cc</sub> = 100%

Note:

Emissions from this source category have increased because of a change in the emission factor and emission estimation methodology. In previous emission inventories, only cold cleaning degreasing operations were considered an area source and open top and conveyor degreasing operations were considered point sources that were listed in the MDE/ARMA registration files. No point source emissions were then subtracted from the area source inventory. MDE previously used an emission factor from AP-42, Section 4.6 – Solvent Degreasing, Table 4.6-1<sup>15</sup>. This table reports a 4.0 lbs. VOC per capita emission factor that includes 25 percent non-reactive VOCs, yielding an effective emission factor of 3.0 lbs. VOC per capita. A 1996 reduction factor of 0.70 was applied to the calculated emissions (rule effectiveness was not applied). This factor

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<sup>15</sup> Non-methane VOC Emissions from small cold cleaning degreasing operations

combines reductions from technology rules and good housekeeping practices. In effect, MDE increased the emission factor from 3.0 to 4.3.

**Point Source Adjustments**

Solvent cleaning emissions from facilities identified as point sources were subtracted from the area source inventory to avoid double counting.

**Adjustment for Controls**

Maryland has adopted a cold and vapor degreasing regulation (COMAR 26.11.19.09). The regulation mandates that all cold degreasing material must have a vapor pressure less than or equal to 1 mm Hg at 20 degrees centigrade after May 15, 1996. The regulation also requires that good operating practices be implemented to minimize VOC losses. MDE estimates a 67 percent control efficiency for this control.

**Spatial and Temporal Allocations**

*Spatial*

CBP employment data was spatial allocation for this source.

*Temporal*

Annual employment data through CBP for temporal was allocate for this source.

**Emissions Calculation**

The equation used to estimate emissions from cold cleaning/degreasing is:

Equation:

$$E_{CC} = \left\{ \frac{EMPL_j * EF_{cc}}{2000} * [1 - (CE_{cc} * RE_{cc} * RP_{cc})] \right\} - E_{PtSourceCC}$$

Where:

- $E_{cc}$  = Emissions of VOC in tons/day from cold cleaners
- $EMPL_j$  = 2010 employment of county j
- $EF_{cc}$  = VOC emissions factor for cold cleaning degreasing
- $CE_{cc}$  = Control efficiency for cold cleaning degreasing
- $RE_{cc}$  = Rule Effectiveness for cold cleaning degreasing
- $RP_{cc}$  = Rule Penetration for cold cleaning degreasing
- $E_{PtSourceCC}$  = Point Source Emissions from cold cleaning degreasing

2011 Sample Calculation for Cold Cleaning Degreasing Products Industrial and Institutional (Baltimore County)

$(22,809^{16} \text{ employee} \times 87 \text{ lbs. VOC /employee/year}) / (\text{tons}/2000 \text{ lbs.}) = 992 \text{ tons VOC /year emitted.}$

Converting to tons per day:  $992 / (312 \text{ operating days per year}^{17}) = 3.18 \text{ tons VOC per day emitted}$   
(there is no seasonal adjustment<sup>18</sup>).

To adjust for controls

$992 \text{ tons VOC /year} \times [1 - (0.67 \times 0.80 \times 1.00)] = \mathbf{460.38 \text{ tons VOC / year emitted}}$  with 2002 controls applied

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<sup>16</sup> *County Business Patterns* 2010 employment data for Maryland by Counties (see appendices)

<sup>17</sup> 6 days per week operation from EIIP

<sup>18</sup> No seasonal adjustment from EIIP

### 3.3.2.3 Surface Coating

Surface coating includes paints, enamels, varnishes, lacquers and other product finishes. Some of those coatings contain a solvent-based liquid carrier; others use a water-based liquid carrier but still contain a small portion of solvents. Solvents are also used to clean up painting equipment. The primary types of surface coating applications are architectural coatings, automobile refinishing and traffic paints.

#### 3.1.2.3 Architectural Surface Coating

SCC: 24 01 002 000 (Solvent-based)

SCC: 24 01 003 000 (Water-based)

#### Description

Architectural surface coating is an area source that occurs from homeowners and contractors painting homes, buildings and signs.

#### Pollutants

VOC

#### Method and Data Sources

MDE staff used an alternative per capita emission estimation method documented in EIIP<sup>19</sup>, Chapter 3, Architectural Surface Coating, dated November 1995. The document provides an outline for developing a per capita usage factor, and for using that usage factor and an emission factor to calculate a VOC emission estimate.

#### *Activity*

Determine the per capita usage factor by dividing the national total architectural surface coating quantities<sup>20</sup> for solvent- and water-based coatings by the U.S. population<sup>21</sup> for that year.

#### Per Capita Usage Factor Development

The table below shows a portion of Table 2 from the U.S. Bureau of Census MA325F(10)-1 - Paint and Allied Products 2010. This section of the table summarizes the market information available on architectural coatings for the year of 2010. In the table, types of paints are identified as being either solvent- or water-based paints, except for the two types listed as Architectural Lacquers and Architectural Coatings N.S.K. These latter types of paints can be assumed to be entirely solvent-based coatings. The calculation to

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<sup>19</sup> Emission Inventory Improvement Program

<sup>20</sup> Total national coating usage is compiled by the Bureau of the Census, Report MA325F—Paint and Allied Products, available on the Census Bureau Bulletin Board, (301)457-2310.

<sup>21</sup> Population data from the U.S. Bureau of the Census, Population Estimates Branch (see Appendices).

obtain the number of gallons of solvent based paints totals the gallons for Exterior Solvent Type, Interior Solvent Type, Architectural Lacquers and Architectural Coatings N.S.K:

$$\text{Solvent-Based Paints} = 113,964 \text{ thousand gallons of paints}$$

The calculation to obtain the number of gallons of water based paints totals the gallons for Exterior Water Type and Interior Water Type:

$$\text{Water-Based Paints} = 510,560 \text{ thousand gallons of paints}$$

The per capita usage factor is calculated by dividing the total usage of solvent based paints by the U.S. population, and the total usage of water based paint by the U.S. population.

$$\begin{aligned} \text{Per Capita Solvent Based Usage Factor} &= \frac{\text{Gallons of Solvent Based Paints}}{\text{U. S. Population}} \\ &= \frac{113,964,000}{311,591,917} \\ &= 0.3657 \end{aligned}$$

$$\begin{aligned} \text{Per Capita Water Based Usage Factor} &= \frac{\text{Gallons of Water Based Paints}}{\text{U. S. Population}} \\ &= \frac{510,560,000}{311,591,917} \\ &= 1.6386 \end{aligned}$$

Table 2. Quantity and Value of Shipments of Paint and Allied Products: 2010 and 2009

| Product code | Product description   | Year | Quantity |
|--------------|---|------|----------|
| 3255101      | Architectural coatings  | 2010 | 643,900  |
|              |   | 2009 | 634,874  |
| 3255101111   | Exterior, solvent thinned paints and tinted bases, including barn and roof paints             | 2010 | 33,847   |
|              |   | 2009 | 33,571   |
| 3255101115   | Exterior, solvent thinned enamels and tinted bases, including exterior-interior floor enamels | 2010 | 17,367   |
|              |   | 2009 | 14,755   |
| 3255101119   | Exterior, solvent thinned undercoaters and primers  | 2010 | 6,816    |
|              |   | 2009 | 6,448    |

|            |   |      |        |
|------------|---|------|--------|
| 3255101121 | Exterior, solvent thinned clear finishes and sealers  | 2010 | 4,028  |
|            |   | 2009 | 4,054  |
| 3255101125 | Exterior solvent thinned stains, including shingle and shake                                | 2010 | 13,618 |
|            |   | 2009 | 12,096 |
| 3255101129 | Exterior, other solvent thinned coatings, including bituminous paints                       | 2010 | 1,578  |
|            |   | 2009 | 1,671  |
| 3255101131 | Exterior, water thinned paints and tinted bases, including barn and roof paints             | 2010 | 92,625 |
|            |   | 2009 | 93,665 |
| 3255101135 | Exterior, water thinned exterior-interior deck and floor enamels                            | 2010 | 10,583 |
|            |   | 2009 | 10,727 |
| 3255101139 | Exterior, water thinned undercoaters and primers  | 2010 | 10,587 |
|            |   | 2009 | 10,725 |
| 3255101141 | Exterior, water thinned stains and sealers  | 2010 | 21,501 |
|            |   | 2009 | 20,678 |
| 3255101145 | Exterior, other exterior water thinned coatings   | 2010 | 9,035  |
|            |   | 2009 | 8,980  |
| 3255101211 | Interior, flat solvent thinned wall paint and tinting bases, including mill white paints    | 2010 | 1,155  |
|            |   | 2009 | 1,288  |
| 3255101215 | Interior, gloss and quick drying enamels and other gloss solvent thinned paints and enamels | 2010 | 3,983  |
|            |   | 2009 | 3,389  |
| 3255101219 | Interior, semigloss, eggshell, satin solvent thinned paints and tinting bases               | 2010 | 9,870  |
|            |   | 2009 | 9,691  |
| 3255101221 | Interior, solvent thinned undercoaters and primers  | 2010 | 21,702 |
|            |   | 2009 | (D)    |
| 3255101225 | Interior, solvent thinned clear finishes and sealers  | 2010 | (S)    |
|            |   | 2009 | (S)    |

|            |  |      |         |
|------------|--|------|---------|
| 3255101229 | Interior, solvent thinned stains   | 2010 | 1,309   |
|            |  | 2009 | 1,216   |
| 3255101231 | Interior, other solvent thinned coatings   | 2010 | (D)     |
|            |  | 2009 | (D)     |
| 3255101235 | Interior, flat water thinned paints and tinting bases                                  | 2010 | 144,394 |
|            |  | 2009 | 142,894 |
| 3255101239 | Interior, semigloss, eggshell, satin, and other water thinned paints and tinting bases | 2010 | 183,428 |
|            |  | 2009 | 176,562 |
| 3255101241 | Interior, water thinned undercoaters and primers                                       | 2010 | 38,407  |
|            |  | 2009 | 42,781  |
| 3255101245 | Interior, other interior water thinned coatings, stains, and sealers                   | 2010 | 5,119   |
|            |  | 2009 | 5,250   |
| 3255101249 | Architectural lacquers   | 2010 | 4,086   |
|            |  | 2009 | 4,126   |
| 3255104    | Product finishes for original equipment manufacturers (OEM), excluding marine coatings | 2010 | 329,931 |
|            |  | 2009 | 285,070 |
| 3255104111 | Automobile, light truck, van, and sport utility vehicle finishes                       | 2010 | 43,172  |
|            |  | 2009 | 31,580  |
| 3255104121 | Automobile parts finishes  | 2010 | 2,792   |
|            |  | 2009 | 1,929   |
| 3255104131 | Heavy duty truck, bus, and recreational vehicle finishes                               | 2010 | 5,757   |
|            |  | 2009 | 5,352   |
| 3255104141 | Other transportation equipment finishes, including aircraft and railroad               | 2010 | 5,369   |
|            |  | 2009 | 4,187   |
| 3255104211 | Appliance, heating equipment, and air-conditioner finishes                             | 2010 | 3,990   |
|            |  | 2009 | 4,266   |
| 3255104215 | Wood furniture, cabinet, and fixture finishes  | 2010 | 34,578  |



|            |  |      |        |
|------------|--|------|--------|
|            |  | 2009 | 32,500 |
| 3255104219 | Wood and composition board flat stock finishes   | 2010 | 7,135  |
|            |  | 2009 | 6,274  |
| 3255104221 | Metal building product finishes (including coatings for aluminum extrusions and siding)      | 2010 | 36,455 |
|            |  | 2009 | 35,303 |
| 3255104225 | Container and closure finishes   | 2010 | 40,164 |
|            |  | 2009 | 35,647 |
| 3255104229 | Machinery and equipment finishes, including road building equipment and farm implement       | 2010 | 10,151 |
|            |  | 2009 | 9,462  |
| 3255104231 | Non-wood furniture and fixture finishes, including business equipment finishes               | 2010 | 22,155 |
|            |  | 2009 | 20,710 |
| 3255104235 | Paper, paper board, film, and foil finishes, excluding pigment binders                       | 2010 | (S)    |
|            |  | 2009 | 10,854 |
| 3255104239 | Electrical insulating coatings   | 2010 | 1,015  |
|            |  | 2009 | 866    |
| 3255104241 | Thermoset general decorative, appliance powder coatings 1/                                   | 2010 | 8,951  |
|            |  | 2009 | 6,933  |
| 3255104245 | Thermoset general decorative, automotive powder coatings 1/                                  | 2010 | 3,765  |
|            |  | 2009 | 2,437  |
| 3255104249 | Thermoset general decorative, architectural powder coatings (such as aluminum extrusions) 1/ | 2010 | 1,096  |
|            |  | 2009 | 959    |
| 3255104251 | Thermoset general decorative, lawn and garden powder coatings 1/                             | 2010 | 999    |
|            |  | 2009 | 890    |
| 3255104255 | Thermoset general decorative, general metal finishing powder coatings 1/                     | 2010 | 19,806 |
|            |  | 2009 | 16,225 |
| 3255104259 | Thermoset functional powder coatings (for pipe, rebar,                                       | 2010 | (D)    |

|            |   |      |         |
|------------|---|------|---------|
|            | electrical insulation, etc.) 1/   | 2009 | (D)     |
| 3255104261 | Thermoplastic powder coatings (all) 1/  | 2010 | (D)     |
|            |   | 2009 | (D)     |
| 3255104263 | Other powder coatings   | 2010 | (D)     |
|            |   | 2009 | (D)     |
| 3255104265 | Other industrial product finishes   | 2010 | 23,378  |
|            |   | 2009 | 20,774  |
| 3255107    | Special purpose coatings, including all marine coatings   | 2010 | 168,326 |
|            |   | 2009 | 158,575 |
| 3255107111 | Industrial new construction and maintenance paints, interior  | 2010 | 35,570  |
|            |   | 2009 | 34,704  |
| 3255107115 | Industrial new construction and maintenance paints, exterior  | 2010 | 16,571  |
|            |   | 2009 | 13,886  |
| 3255107121 | Traffic marking paints (all types; shelf goods and highway department)  | 2010 | 37,335  |
|            |   | 2009 | 35,047  |
| 3255107131 | Automotive, other transportation and machinery refinish paints and enamels, including primers   | 2010 | 55,899  |
|            |   | 2009 | 52,504  |
| 3255107141 | Marine paints, ship and off-shore facilities and shelf goods for both new construction and marine refinish and maintenance. Excludes spar varnish | 2010 | 10,924  |
|            |   | 2009 | 11,498  |
| 3255107151 | Marine paints for yacht and pleasure craft, new construction, refinish and maintenance  | 2010 | (D)     |
|            |   | 2009 | (D)     |
| 3255107161 | Aerosol - paint concentrates produced for packaging in aerosol containers   | 2010 | (D)     |
|            |   | 2009 | (D)     |
| 325510B    | Miscellaneous allied paint products   | 2010 | 145,119 |
|            |   | 2009 | 134,263 |
| 325510B111 | Paint and varnish removers  | 2010 | (D)     |

|            |  |      |        |
|------------|--|------|--------|
|            |  | 2009 | 5,075  |
| 325510B121 | Thinners for lacquers and other solvent based paint products   | 2010 | (D)    |
|            |  | 2009 | 30,249 |
| 325510B131 | Pigment dispersions  | 2010 | (D)    |
|            |  | 2009 | 25,877 |
| 325510B141 | Other miscellaneous allied paint products, including brush cleaners, ink vehicles, putty and glazing compounds, etc. | 2010 | 83,708 |
|            |  | 2009 | 73,062 |

### *Emission Factor*

Use the emission factors for architectural surface coatings (EPA, 1993A), that are shown in Table 5-2 of the EIIP document and reproduced below:

| <b>Coating Type</b> | <b>VOC Content<br/>Lbs / gallon</b> |
|---------------------|-------------------------------------|
| Water-based         | 0.74                                |
| Solvent-based       | 3.87                                |
| Total               | 4.61                                |

This activity occurs 7 days a week and is usually more common in the summer months as indicated by a seasonal adjustment factor of 1.3 (see Table 5.8-1 in Procedures). It should be noted that 99% of solvents in these coatings are VOC.

### **Point Source Adjustments**

Because the application of architectural surface coating is defined as an area source, there is no need to subtract point source emissions from the total, and all emissions estimated for this source are area source emissions.

### **Adjustment for Controls**

EPA surface coating regulation provides a 20% reduction for phase I of the AIM rule and 31% reduction for phase II; this creates a 44.8% control efficiency.

**Spatial and Temporal Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions Calculation**

The equation used to estimate emissions from architectural surface coatings is:

Equation to calculate solvent-based emissions is:

$$EM_{ASC-SB} = \frac{POP_i \times UF_{ASC-SB} \times EF_{SB} \times [(1 - (CE_{ASC} \times RE_{ASC} \times RP_{ASC}))]}{2000}$$

Where:

- EM<sub>ASC-SB</sub> = VOC emissions in tons per day from solvent-based architectural surface coatings
- POP<sub>i</sub> = 2011 population of county i
- UF<sub>ASC-SB</sub> = Usage factor for solvent-based architectural surface coatings
- EF<sub>SB</sub> = VOC emission factor for solvent-based architectural surface coatings
- CE<sub>ASC</sub> = Control efficiency<sup>22</sup> for architectural surface coatings
- RE<sub>ASC</sub> = Rule effectiveness<sup>23</sup> for architectural surface coatings
- RP<sub>ASC</sub> = Rule penetration for architectural surface coatings

Equation to calculate water-based emissions is:

$$EM_{ASC-WB} = \frac{POP_i \times UF_{ASC-WB} \times EF_{WB} \times [(1 - (CE_{ASC} \times RE_{ASC} \times RP_{ASC}))]}{2000}$$

Where:

- EM<sub>ASC-WB</sub> = VOC emissions in tons per day from water-based architectural surface coatings
- POP<sub>i</sub> = 2011 population of county i
- UF<sub>ASC-WB</sub> = Usage factor for water-based architectural surface coatings
- EF<sub>WB</sub> = VOC emission factor for water-based architectural surface coatings
- CE<sub>ASC</sub> = Control efficiency for architectural surface coatings

<sup>22</sup> An overall 44.8% reduction in emissions is due to EPA’s AIM regulation

<sup>23</sup> EPA’s AIM regulation is a federal rule applying to architectural surface coatings

RE<sub>ASC</sub> = Rule effectiveness for architectural surface coatings  
RP<sub>ASC</sub> = Rule penetration for architectural surface coatings

2011 Example Calculation Architectural Surface Coating (Allegany County)

Solvent-Based

POP<sub>Allegany</sub> = 74692 persons  
UF<sub>ASC-SB</sub> = 0.3657 gal/capita  
EF<sub>SB</sub> = 3.87 lbs. VOC/gal/year  
CE<sub>ASC</sub> = 44.8%  
RE<sub>ASC</sub> = 100%  
RP<sub>ASC</sub> = 100%

EM<sub>ASC-SB</sub> = ((74,692 x 0.3657 x 3.87) x [1 - (0.448 x 1.00 x 1.00)]) / 2000  
EM<sub>ASC-SB</sub> = 29.18 tons VOC per year

Water-Based

POP<sub>Allegany</sub> = 74692 persons  
UF<sub>ASC-WB</sub> = 1.6386 gal/capita  
EF<sub>WB</sub> = 0.74 lbs. VOC/gal/year  
CE<sub>ASC</sub> = 44.8%  
RE<sub>ASC</sub> = 100%  
RP<sub>ASC</sub> = 100%

EM<sub>ASC-WB</sub> = ((74,692 x 1.6386 x 0.74) x [1 - (0.448 x 1.00 x 1.00)]) / 2000  
EM<sub>ASC-WB</sub> = 25.00 tons VOC per year

### 3.1.2.4 Auto Refinishing

SCC: 24 01 005 000

#### Description

Automobile refinishing is the repainting of worn or damaged automobiles, light trucks and other vehicles. Coating of new cars is not included in this category but falls under industrial coating. In automobile refinishing, lacquers and enamels are usually applied with hand-operated spray guns. Because the vehicles contain heat-sensitive plastics and rubber, the coatings are dried or cured in low-temperature ovens or at ambient conditions. MDE adopted a regulation based upon federal guidance that requires the use of reformulated coatings and equipment with greater transfer efficiency in the application of coatings.

#### Pollutants

VOC

#### Method and Data Sources

MDE staff used an alternative per employee emission estimation methodology documented in EIIP<sup>1</sup>, Chapter 13, Auto Body Refinishing, dated January 2000. The document provides an outline for developing a per employee emission factor using a national VOC emission estimate and national employment data.

#### *Activity*

MDE calculated an emission factor of 592.6774 lbs. VOC per employee per year using an estimate of 151.9 million pounds of solvents sold nationally in 2007 and dividing it by 2007 County Business Patterns employment number of 256,331 for NAICS 81112: Automotive Body, Paint, Interior and Glass Repair. The amount of solvent sold was provided by the EPA in conjunction with The Freedonia Group and ERTAC.

EPA had a federal rule already in effect allowing a 37% reduction of emission for auto body refinishing in 2011. Maryland has an auto body regulation this is more stringent than the national rule, which allowed MDE to take an additional 8% reduction.

The autobody refinishing category does not include new car coating.

#### *Emission Factor:*

592.6774 lbs of VOC per employee per year

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<sup>1</sup> Emission Inventory Improvement Program

**Point Source  
Adjustments**

No autobody refinishing emissions from facilities identified as point sources were subtracted from the area source.

Autobody refinishing emissions from facilities identified as point sources were subtracted from the area source inventory to avoid double counting.

**Adjustment for  
Controls**

An EPA memo on auto body refinishing allows a 37% reduction for the federal rule. Maryland's auto body regulation allowed MDE to take an additional 8% reduction.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate emissions from automobile refinishing is:

$$E_{AR} = \frac{EMP_J \times EF_{AR} \times [1 - (RE \times RP \times CE)]}{2000} - E_{Point\ Source\ AR}$$

Where:

$E_{AR}$  = VOC emissions in tons per year from auto refinishing

$EMP_J$  = Number of employees in county j for NAICS 811121 (auto refinishing) from County Business Patterns

$EF_{AR}$  = VOC emission factor for auto refinishing

$E_{Point\ Source\ AR}$  = Point source emissions from auto body refinishing

Divided by 2000 lbs. to convert to tons

2011 Example Calculation Auto Refinishing (Baltimore County)

$$E_{AR} = \frac{678 \times 592.6774 \times [1 - (1.0 \times 1.0 \times .08)]}{2000} - 0.00$$

$E_{AR} = 184.84 \text{ Tons}_{VOC} / \text{year}$

### 3.1.2.5 Traffic Markings

#### SCC: 24 01 008 000 - Traffic paints

#### **Description**

Traffic paints are used to mark pavement, the majority of which is used to create dividing lines for traffic lanes. These markings are applied by state or local highway maintenance crews or by contractors. VOC emissions result from the evaporation of organic solvents during and shortly after the application of the marking paint. All traffic paint emissions are included in the area source inventory.

#### **Pollutants**

VOC

#### **Method and Data Sources**

MDE surveyed city, county, and state agencies for gallons of paint used and the VOC content of the paint used.

#### *Activity*

The Maryland State Highway Administration (SHA) keeps data on gallons of traffic marking paint used by district and a few individual counties. For emissions from SHA line painting, each county's proportion of the total district's lane miles was multiplied by total gallons painted in a district to get an estimated amount of gallons used for each county. In a few counties, SHA does all the line painting. Also, data was collected from the Maryland Aviation Administration (MAA) and the Mass Transit Administration (MTA).

MDE was able to gather information on gallons of traffic paint used during the ozone season and during a year. The Material Safety Data Sheets and Environmental Data Sheets were collected for each paint and solvent used by each local jurisdiction and State agency doing the striping. It was necessary to collect data on yellow and white paint separately because the amount of VOCs per gallon is different for each type of paint.

The emission totals are slightly lower than in previous inventories because many jurisdictions have switched to latex (water-borne) paints for traffic marking, and those areas already using latex paints have switched to using a latex paint that is lower in VOC content than what was previously used. The widespread use of latex paints means that there are no longer any emissions from the solvents used to clean painting equipment when oil based paints are used.

The following information was collected from all public agencies using traffic marking paint in Maryland:



Gallons of yellow traffic paint and solvent used in 2011  
Gallons of white traffic paint and solvent used in 2011

The MSDS and Environmental Data Sheets per type of paint provided the following information:

- Percent volatile by weight
- Percent water by weight
- Percent volatile organic compounds by weight
- Total VOC (lbs./gal)
- VOC/gallon less water

*Emission Factor*

| <b>Traffic Paints</b> | <b>VOC Emission Factor<br/>(lbs. VOC/gallons)</b> |
|-----------------------|---|
| Yellow Paint          | 0.36 to 0.78                                      |
| White Paint           | 0.11 to 0.78                                      |

The VOC pound per gallon of paint was obtain from the Material Safety Data Sheet (MSDS) for each color and brand of paint used. The appropriate factor was used for each calculation and the table above shows the range for each color.

**Point Source  
Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustment for  
Controls**

MDE surveyed the various state agencies that apply coatings to road surfaces and transportation projects. MDE collected data on the gallons of paint applied and the VOC content of the paint. MDE made emission estimates based on this data and therefore no controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

## Emissions Calculation

### Traffic Paint Sample Calculation (Harford County)

(1) Calculate VOC emissions from yellow and white traffic paints for year 2011

a. State Highway Administration (SHA) Traffic Paint Use

Total yellow gallons used in 2011 = 13,107 gallons

Total VOC per gallon of yellow paint used<sup>25</sup> = 0.57 lbs. VOC /gallon

Total white gallons used 2011 = 17,374 gallons

Total VOC per gallon of white paint used<sup>26</sup> = 0.57 lbs. VOC /gallon

$$E_{\text{Yellow Paint}} = \frac{(13,107 \text{ gallons}) \times (0.57 \text{ lbs. VOC /gallon})}{(2,000 \text{ lbs./ton})}$$

$$E_{\text{Yellow Paint}} = 3.735 \text{ tons / year}$$

$$E_{\text{White Paint}} = \frac{(17,374 \text{ gallons}) \times (0.57 \text{ lbs. VOC /gallon})}{(2,000 \text{ lbs./ton})}$$

$$E_{\text{White Paint}} = 4.952 \text{ tons / year}$$

$$E_{\text{Local Paint Total}} = E_{\text{Yellow Paint}} + E_{\text{White Paint}}$$

$$E_{\text{Local Paint Total}} = 3.735 + 4.952$$

$$E_{\text{Local Paint Total}} = \mathbf{8.687 \text{ tons / year}}$$

b. Maryland Aviation Administration (MAA) Traffic Paint Use

The MAA did not apply any paint in Harford County.

c. Maryland Transportation Administration (MTA) Traffic Paint Use

The MTA did not apply any paint in Harford County.

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<sup>25</sup> MSDS from Caroline County's Department of Public Works, Division of Highways

<sup>26</sup> MSDS from Caroline County's Department of Public Works, Division of Highways

d. Local Jurisdiction Traffic Paint Use Harford County

Total yellow gallons used in 2011 = 4,320 gallons  
Total VOC per gallon of yellow paint used<sup>27</sup> = 0.78 lbs. VOC /gallon  
Total white gallons used 2011 = 1,149 gallons  
Total VOC per gallon of white paint used<sup>28</sup> = 0.78 lbs. VOC /gallon

$$E_{\text{Yellow Paint}} = \frac{(4,320 \text{ gallons}) \times (0.78 \text{ lbs. VOC /gallon})}{(2,000 \text{ lbs./ton})}$$

$$E_{\text{Yellow Paint}} = 1,685 \text{ tons / year}$$

$$E_{\text{White Paint}} = \frac{(1,149 \text{ gallons}) \times (0.78 \text{ lbs. VOC /gallon})}{(2,000 \text{ lbs./ton})}$$

$$E_{\text{White Paint}} = 0.448 \text{ tons / year}$$

$$E_{\text{Local Paint Total}} = E_{\text{Yellow Paint}} + E_{\text{White Paint}}$$

$$E_{\text{Local Paint Total}} = 1.685 + 0.448$$

$$E_{\text{Local Paint Total}} = 2.133 \text{ tons / year}$$

(2) VOC emissions from paint cleaning solvent use were zero. None of the above listed agencies used cleaning solvents.

(3) Total VOC emissions from traffic paint use and paint cleaning solvent use :

$$E_{\text{Paint Total}} = E_{\text{SHA Paint Total}} + E_{\text{MAA Paint Total}} + E_{\text{MTA Paint Total}} + E_{\text{Local Paint Total}} + E_{\text{Paint Solvent}}$$

$$E_{\text{Paint Total}} = \mathbf{8,687} + 0.0 + 0.0 + \mathbf{2.133} + 0.0$$

$$E_{\text{Paint Total}} = \mathbf{10,820} \text{ tons / year}$$

Yellow Total = 3.735 + 1.685 = 5.42 tons / year

White Total = 4.952 + 0.448 = 5.40 tons / year

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<sup>27</sup> MSDS from Caroline County's Department of Public Works, Division of Highways

<sup>28</sup> MSDS from Caroline County's Department of Public Works, Division of Highways

### 3.1.2.6 Industrial Surface Coating

SCC: 24 01 015 000 (Finish Wood Product Manufacturing)  
24 01 020 000 (Wood Furniture and Fixtures)  
24 01 025 000 (Metal Furniture and Fixtures)  
24 01 030 000 (Paper, Film, and Foil)  
24 01 040 000 (Metal Cans)  
24 01 060 000 (Household Appliances Manufacturing)  
24 01 065 000 (Electronic and Other Electrical)  
24 01070 000 (Motor Vehicles)  
24 01 075 000 (Aircraft)  
24 01 080 000 (Marine)  
24 01 085 000 (Railroads)  
24 01 090 000 (Miscellaneous Manufacturing)  
24 01 100 000 (Industrial Maintenance Coatings)  
24 01 200 000(Other Coatings)

#### Description

Industrial surface coatings are applied during the manufacture of a wide variety of products, including furniture, cans, automobiles, other transportation equipment, machinery, appliances, metal coil, flat wood, wire and other miscellaneous products. In addition, coatings are used in maintenance operations at industrial facilities but these are considered paint sources.

#### Pollutants

VOC and HAPs

#### Method and Data Sources

MDE used the methods and procedures documented in EIIP<sup>29</sup>, Chapter 8, Industrial Surface Coatings, dated September 1997. Applicable point source emissions (those within the same NAICS) taken from the MDE/ARMA registration files have been subtracted from the emissions calculated on a per capita and per employee basis; and are presented below.

#### *Activity*

The choice between using per capita factors or per employee factors for categories where made based on the quality of data. County Business Patterns (internet address: <http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl>) lists employee data by North American Industry Classification System (NAICS). Many values are based on actual data. However, some county NAICS list a range for the number of employees through a letter code. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a NAICS matched the sum of the number of employees reported per county. For those categories where all or most of the employment data was listed as a range, the per capita factor was assumed to be more reliable and was used to calculate emissions. The U.S. Census Bureau reports population

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<sup>29</sup> Emission Inventory Improvement Program

statistics for the counties of Maryland. Population statistics for 2011 for the counties of Maryland were collected from the U.S. Census Bureau Internet address (<http://www.census.gov>).

Because the emission factors were developed based on NAICS employment data and 2010 was the last year employment data was available per NAICS, MDE used the 2010 County Business Patterns as the source for employment figures.

***Emission Factor***

Per employee factors were used for the industry surrogate employment SIC and NAICS because they are generally more reliable (see Procedures, Table 4-10.1), and a comparison with per capita emissions in one county showed that for these SICs, the per capita factors led to a large overestimation of emissions. Per capita factors were used for the industry surrogate population SIC and NAICS because they prove to be more reliable for emission calculations than the per employee factor.

| <b>Industry</b>                    | <b>SCC</b> | <b>NAICS</b>   | <b>Surrogate</b> |
|------------------------------------|------------|--|------------------|
| Finish Wood Product Manufacturing  | 2401015000 | 321  | Employment       |
| Wood Furniture and Fixtures        | 2401020000 | 337110, 337121, 337122, 337127, 337129, 337211, 337212, 337215, 339111 | Employment       |
| Metal Furniture and Fixtures       | 2401025000 | 337124, 337127, 337214, 337215, 339111                                 | Employment       |
| Paper, Film, and Foil              | 2401030000 | 322222   | Employment       |
| Metal Cans                         | 2401040000 | 33243  | Employment       |
| Household Appliances Manufacturing | 2401060000 | 3352   | Employment       |
| Electronic and Other Electrical    | 2401065000 | 331319, 31422, 331491, 35921, 335929                                   | Employment       |
| Motor Vehicles                     | 2401070000 | 3361, 3362, 3363   | Employment       |
| Aircraft                           | 2401075000 | 3364   | Employment       |
| Marine                             | 2401080000 | 3366, 488390   | Employment       |
| Railroads                          | 2401085000 | 3365   | Employment       |
| Miscellaneous Manufacturing        | 2401090000 | 339, 3369  | Employment       |
| Industrial Maintenance Coatings    | 2401100000 | NA <sub>a</sub>  | Population       |
| Other Coatings                     | 2401200000 | NA <sub>a</sub>  | Population       |

Furthermore, NAICS used were the best correspond to SIC for each source category so that emission factors that were generated from EIIP SIC data could be used. EPA provided the correlation between NAICS and SIC. Per employment emission factors are listed in Table 8.5-1 in the EIIP Industrial Surface Coating document and below. As an example, MDE has chosen finish wood product manufacturing for presentation of an

equation and emissions by county. The EIIP document lists no seasonal adjustment factor.

**Industrial Maintenance Coatings (NAICS) and Other Coatings (NAICS)**, per capita emission factors are listed in Table 8.5-2 in the EIIP Industrial Surface Coating document and below.

| <b>Industry</b>                    | <b>Per Employment VOC Emission Factor<br/>(lbs. VOC/employee/year)</b> | <b>Per Capita VOC Emission Factor<br/>(lbs. VOC/person/year)</b> |
|------------------------------------|--|--|
| Finish Wood Product Manufacturing  | 43   | NA   |
| Wood Furniture and Fixtures        | 244  | NA   |
| Metal Furniture and Fixtures       | 772  | NA   |
| Paper, Film, and Foil              | 735  | NA   |
| Metal Cans                         | 2,326  | NA   |
| Household Appliances Manufacturing | 254  | NA   |
| Electronic and Other Electrical    | 24.7   | NA   |
| Motor Vehicles                     | 164  | NA   |
| Aircraft                           | 15   | NA   |
| Marine                             | 198  | NA   |
| Railroads                          | 222  | NA   |
| Miscellaneous Manufacturing        | 136  | NA   |
| Industrial Maintenance Coatings    | NA   | 0.8  |
| Other Coatings                     | NA   | 0.8  |

### **Point Source Adjustments**

Applicable point source emissions (those within the same NAICS) taken from the MDE/ARMA registration files have been subtracted from the calculated emissions, and their emissions are separated from the totals presented below.

### **Adjustment for Controls**

MDE surveyed the various state agencies that apply coatings to road surfaces and transportation projects. MDE collected data on the gallons of paint applied and the VOC content of the paint. MDE made emission estimates based on this data and therefore no controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

Equation:

$$E_{FW} = \frac{EMPL_i \times EF_{FW}}{2000}$$

Where:

$E_{FW}$  = VOC emissions in tons per year from finish wood product manufacturing.

$EMPL_i$  = employees in county i employed in NAICS 321.

$EF_{FW}$  = VOC emission factor for finished wood which is 43 lbs. VOC per employee per year

2011 Example Calculation Industrial Surface Coating – Finish Wood Product Manufacturing  
(Baltimore County)

Number of employees in NAICS 321 in Baltimore County

(2010 County Business Patterns): 52

Emission factor for finish wood product manufacturing (lbs. VOC/employee/year): 43<sup>30</sup>

5 days per week activity level, no seasonal adjustment factor

$$E_{FW(\text{Baltimore Co})} = \frac{(52 \times 43)}{2000}$$

$E_{FW(\text{Baltimore Co})} = 1.12$  tons VOC per year

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<sup>30</sup> Table 8.5-1, EIIP Chapter 8 Industrial Surface Coatings

### 3.1.2.7 Industrial Adhesives and Sealants

SCC: 2440020000

#### Description

Industrial adhesives are the application of a liquid or powder substance, such as solvent type paints, varnishes, and lacquers to a surface for decorative or protective purposes. The substances can be applied by brushing, rolling, spraying, dipping or flow coating. VOCs are released into the air as the substance dries. Powder coatings are applied to a hot surface and then melted; VOCs are released as the powder melts and dries.

#### Pollutants

VOC and HAPs

#### Method and

#### Data Sources

MDE staff used EPA's "Solvent Mass Balance" methodology for estimating emissions from nonpoint solvents, which uses the total solvent production and sales for a particular source category to estimate overall emissions then subtracting out emissions due to point sources, waste management, and recycling.

#### *Activity*

Per capita activity data was used and downloaded from the US Census Bureau (internet address: <http://www.census.gov>) July 1, 2011 population statistic estimates for the counties of Maryland<sup>31</sup>.

#### *Emission Factor*

MDE used the emission factor of 1.10 lbs/capita/year developed by Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Adhesives and Sealants, California Air Resources Board document for adhesives and sealants (CARB RACT/BARCT for Adhesives/ Sealants, Dec 1998)<sup>32</sup>.

CARB RACT/BARCT estimated emission factor calculation for adhesives/sealants is as following:

VOC = 45 tons/day estimated in 1994 \* 365 days/year \* 2000 lbs/ton / 29,760,021 capita where 45 tons/day is the estimated state-wide emissions for industrial adhesives in California, 2000 lbs/ton is a conversion factor, and 29,760,021 capita is the 1990 population of California.

VOC Emf = 1.10 lbs/capita/year of industrial adhesives

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<sup>31</sup> 2011 estimated population from U.S. Bureau of the Census, Population Estimation Branch (see Appendices).

<sup>32</sup> Emission factors were developed by CARB RACT/BARCT for Adhesives/ Sealants, Dec 1998.



## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

### Adjustment for Controls

Maryland has adopted an industrial adhesive and coatings regulation (COMAR 26.11.19.15). The regulation is similar to the one proposed by the Ozone Transport Commission (OTC) and achieves VOC reductions through two basic components: sale and manufacture restrictions that limit the VOC content of specified adhesives, sealants and primers sold in the state; and use restrictions that apply primarily to commercial/industrial applications.

A reasonably available control technology determination (CARB RACT/BARCT for Adhesives/Sealants, Dec 1998) prepared by the California Air Resources Board (CARB) in 1998 forms the basis of this model rule. In the years 1998-2001, the provisions of the CARB determination were adopted in regulatory form in various air pollution control districts in California including the Bay Area, Ventura County, Sacramento Metropolitan and San Joaquin Valley.

CARB and OTC estimate a 64.4 percent reduction in emissions from the source category regulation that was fully implemented in Maryland in 2009.

### Spatial and Temporal Allocations

#### *Spatial*

Data for spatial allocation is not available for this source.

#### *Temporal*

Data for temporal allocation is not available for this source.

### Emissions Calculation

Equation:

$$E_{OC} = \frac{POP_i \times EF_{OC}}{2000} \times [1 - (CE \times RE \times RP)]$$

Where:

$E_{OC}$  = VOC emissions in tons per year from industrial adhesives.

$POP_i$  = 2011 population of county i (Appendix A Section 1).

$EF_{OC}$  = VOC emission factor for industrial adhesives.

CE = Control Efficiency

RE = Rule Effectiveness

RP = Rule Penetration

To adjust for control efficiency OTC-PECHAN Control Measure Report:

2011 base year where:  
CE = 0.644, RE = RP = 1.

Then new emission control efficiency for 2011 is:  $[1 - (0.644 \times 1 \times 1)] = 1$

2011 Per Capital Sample Calculation for industrial adhesives in Montgomery County:

2011 U.S. Census Bureau Population Estimate for Montgomery County: 989,794<sup>33</sup>  
Emission factor for industrial adhesives (lbs. VOC/person/year): 1.10<sup>34</sup>

5 days per week activity level, no seasonal adjustment factor

Equation:

$$E_{OC} = \frac{POP_i \times EF_{OC}}{2000} \times [1 - (CE \times RE \times RP)]$$

2011 Per Capital Sample Calculation for industrial adhesives in Montgomery County:

$989,794 \times 1.10 \text{ lbs. VOC/capita/year} \times [1 - (0.644 \times 1.0 \times 1.0)] = 387,603 \text{ lbs. VOC per person}$

Converting to tons per year:  $387,603 / 2000 \text{ lbs. per year} = 193.80 \text{ tons VOC per year.}$

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<sup>33</sup> 2011 estimated population from U.S. Bureau of the Census, Population Estimation Branch (see Appendices).

<sup>34</sup> Emission Inventory Improvement Program Vol. III, Ch. 6, September 1997.

### 3.1.2.8 Graphic Arts

SCC: 24 25 000 000 (Screen & Plateless)  
24 25 010 000 (Offset Lithography)  
24 25 020 000 (Letterpress)  
24 25 030 000 (Rotogravure)  
24 25 040 000 (Flexography)

#### Description

Graphic arts include operations that are involved in the printing of newspapers, magazines, books and other printed materials. There are six basic operations used in graphic arts: lithography, gravure, letterpress, flexography, screen printing and metal decorating (plateless). In our calculations screen and plateless printing were paired together and make up a combined 6% market share of all printing. Lithography accounts for nearly half of all graphic arts operations.

#### Pollutants

VOC

#### Method and Data Sources

MDE staff used an alternative per capita emission estimation method documented in EIIP<sup>4</sup>, Chapter 7, Graphic Arts, dated November 1996. The EIIP methodology recommended an emission factor of 1.3 lbs. VOC per capita per year emission factor (EPA, 1991) for graphic arts sources emitting less than 100 tons VOC per year. Yearly activity was used with no seasonal adjustment factor as recommended in Table 5.8-1 in Procedures. All point source graphic arts facilities (NAICS 11531) in the ARMA registration files for 2011 emissions were subtracted from the area source inventory.

#### *Activity*

The estimated percentage of market share, reported in Table 7.2-3 of the EIIP document and reproduced below, was used to allocate the total graphic arts emissions to specific printing types. Maryland has different regulations regarding specific types of printing operations and thus to calculate controlled emissions the estimated percentage that each type of printing operation contributes to the total had to be determined.

| Type of Printing (MS <sub>type</sub> ) | Estimated Percentage of Product Market Share |
|--|--|
| Rotogravure                            | 18   |
| Flexography                            | 18   |
| Offset Lithography                     | 47   |
| Letterpress                            | 8  |
| Screen                                 | 3  |
| Plateless                              | 3  |

<sup>4</sup> Emission Inventory Improvement Program

***Emission Factor***

1.3 lbs. VOC per capita per year

**Point Source  
Adjustments**

Graphic arts emissions from facilities identified as point sources were subtracted from the area source inventory to avoid double counting.

**Adjustment for  
Controls**

Control efficiency is based on Maryland regulations for each type of printing process and has been developed within technical support documents for the graphic arts printing regulations. Rule penetration has been defined as the estimated percentage that each type of printing operation. Rule effectiveness has been assigned the EPA default value of 80 per cent.

|                                 | Lithographic | Rotogravure | Letterpress | Flexographic | Screen |
|---------------------------------|--------------|-------------|-------------|--------------|--------|
| Rule Effectiveness (RE)         | 0.800        | 0.800       | 0.800       | 0.800        | 0.800  |
| Rule Penetration (RP)           | 1.000        | 1.000       | 1.000       | 1.000        | 1.000  |
| Control Efficiency (CE)         | 0.750        | 0.630       | 0.000       | 0.540        | 0.350  |
| Reduction factor (RE x RP x CE) | 0.600        | 0.504       | 0.000       | 0.432        | 0.280  |

**Spatial and  
Temporal  
Allocations**

***Spatial***

Data for spatial allocation is not available for this source.

***Temporal***

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate emissions from graphic arts is:

Equation:

$$E_{GA} = \frac{MS_{type} \times POP_i \times EF_{GA}}{2000} \times (1 - RF_{GA})$$

Where:

- $E_{GA}$  = VOC emissions in tons per year from graphic arts
- $MS_{type}$  = Market share percent of the type of printing
- $POP_i$  = 2011 population of county i (Appendix A)
- $EF_{GA}$  = VOC emission factor for graphic arts (1.3<sup>35</sup> lbs. VOC per person per year)
- $RF_{GA}$  = Reduction Factor for Printing
- $RF_L$  = Reduction Factor for Lithographic Printing
- $RF_{LP}$  = Reduction Factor for Letterpress Printing
- $RF_R$  = Reduction Factor for Rotogravure Printing
- $RF_F$  = Reduction Factor for Flexographic Printing
- $RF_S$  = Reduction Factor for Screen & Plateless Printing

2011 Example Calculation Graphic Arts (Anne Arundel County)

$$E_{GAL} = \frac{0.47 \times 544,403 \times 1.3}{2000} \times (1 - 0.600)$$

$$E_{GALP} = \frac{0.08 \times 544,403 \times 1.3}{2000} \times (1 - 0.0)$$

$$E_{GAR} = \frac{0.18 \times 544,403 \times 1.3}{2000} \times (1 - 0.504)$$

$$E_{GAF} = \frac{0.18 \times 544,403 \times 1.3}{2000} \times (1 - 0.432)$$

$$E_{GAS} = \frac{0.06 \times 544,403 \times 1.3}{2000} \times (1 - 0.280)$$

$$E_{GASum} = (E_{GAL} + E_{GALP} + E_{GAR} + E_{GAF} + E_{GAS})$$

$$E_{GASum} = (66.53 + 28.31 + 31.59 + 36.18 + 15.29)$$

$$E_{GASum} = 177.89 \text{ tons VOC per person (Totals may be slightly different due to rounding)}$$

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<sup>35</sup> Emission factor from EIIP Chapter 7 Graphic Arts

### 3.1.2.9 Asphalt Paving and Roofing

SCC: 24 61 022 000 Emulsified  
24 61 020 000 Misc. Application (Road Oil)  
24 61 021 000 Cutback  
24 61 023 000 Roofing

#### Description

The two types of asphalt paving used for road paving and repair are cutback asphalt and emulsified asphalt. Cutback asphalt is a liquefied road surface prepared by blending (or "cutting back") asphalt cement with different petroleum distillates or (road oils). The second type, emulsified asphalt, is also a liquefied road surface, but is prepared with a water/soap mixture instead of petroleum distillates. Cutback asphalt emits more VOCs, and its use has been limited in Maryland to the non-ozone period of April 15 to October 15. Asphalt like tar is also used for roofing similar to rubberizing.

#### Pollutants

VOC

#### Method and Data Sources

MDE calculated emissions for this category by using a combination of factors from the Sacramento Metropolitan Air Quality Management District (SMAQMD) 1991 Survey, the California Air Resources Board, and EPA's AP-42. It estimated that 80% of all asphalt used in Maryland is for paving, and the remaining 20% is for roofing.

#### *Activity*

Total barrels of asphalt used in Maryland was obtained from the Energy Information Administration (EIA) and separated to county level. Maryland used 3,322,000 barrels of asphalt in 2010. Also, 2011 population statistics for the counties of Maryland were collected from the Census Bureau Internet address (<http://www.census.gov>).

#### *Emission Factors:*

| Asphalt Related Material | VOC Emission Factors | EF Units |
|--------------------------|----------------------|----------|
| Emulsified               | 17.9                 | lbs/ton  |
| Road Oils                | 70.4                 | lbs/ton  |
| Cutback                  | 268.3                | lbs/ton  |
| Asphalt Roofing          | 6.2                  | lbs/ton  |

**Point Source  
Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustment for  
Controls**

State of Maryland Department of Environment regulations (COMAR 26.11.11.02B), prohibit use of cutback asphalt paving from April 15 to October 15 so ozone precursor emissions from cutback asphalt application were not calculated. Cutback asphalt is made by blending asphalt cement with petroleum distillates that evaporate when the road surface is "cured" after application. Cutback was given a control efficiency of 100 %, rule effectiveness of 80%, and rule penetration of 100%. All other asphalts had no controls applied. Emulsified asphalt is asphalt cement mixed with a blend of water and an emulsifier, usually soap.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

Emission estimates were calculated by converting total barrels used to tons of asphalt, multiplying it by appropriate emission factor, and then proportioning them by population to the county level. There is 350 lbs of asphalt in each barrel. Out of all asphalt used in the state, approximately 80% is used for paving and 20% is used for roofing. Paving asphalt usage is further separated below:

| <b>Paving Asphalt Percent</b> |            |
|-------------------------------|------------|
| Paving Hot-mix:               | <b>92%</b> |
| Paving Emulsified:            | <b>5%</b>  |
| Paving Road Oils:             | <b>2%</b>  |
| Paving Cutback                | <b>1%</b>  |
| Roofing of state total        | <b>20%</b> |

| <b>Tons of Paving Asphalt</b> |                |
|-------------------------------|----------------|
| Hot-mix:                      | <b>427,874</b> |
| Emulsified:                   | <b>23,254</b>  |
| Road Oils:                    | <b>9,302</b>   |
| Cutback                       | <b>4,651</b>   |
| Roofing                       | <b>116,270</b> |

Hot-mix emissions were calculated by facilities and reported with point source inventory.

The equation used to estimate emissions from asphalt paving is:

$$E_A = \frac{CLA_{Type} \times EF_{Type}}{2000} \times (1 - (RE \times RP \times CE))$$

Where:

$E_A$  = VOC emissions tons

$CLA_{Type}$  = Estimated amount of asphalt type used (tons)

$EF_{Type}$  = emission factor for type of asphalt in lbs. VOC per ton of asphalt per yr

RE = Rule Effectiveness

RP = Rule Penetration

CE = Control efficiency

### 2011 Emulsified Asphalt Sample Calculations: Anne Arundel County

$$E_A = \frac{CLA_{Type} \times EF_{Type}}{2000} \times (1 - (1 \times 1 \times 0))$$

$$E_{Ann\ Arundel} = \frac{2,172 \times 17.9}{2000} \times (1 - (1 \times 1 \times 0))$$

$$E_{Ann\ Arundel} = 19.44 \text{ tons VOC}$$

Below is an alternate calculation method and check, by estimating emission for the state and ratioing out Anne Arundel County by county population.

$E_{MDEm\ Total} = 23,254$  tons of asphalt for all of Maryland.

Total Maryland Population for 2011 was 5,828,289 people.

Anne Arundel County population for 2011 was 544,403.

Usage ratio for Anne Arundel County is  $USEa = (544,403 / 5,828,289) = 0.0934$

$$E_{MDEmulsified} = \frac{23,254 \times 17.9}{2000} \times (1 - (1 \times 1 \times 0))$$

$$E_{MDEmulsified} = 208.12 \text{ tons VOC Maryland}$$

$$E_{Ann\ Arundel} = (208.12 \times 0.0934) \text{ tons VOC}$$

$$E_{Ann\ Arundel} = 19.44 \text{ tons VOC}$$

(Similar calculation can be done for each asphalt type for each county)



### **3.1.2.10 Synthetic Organic Chemical Storage Tanks**

This category is fully represented in the point source inventory.

### **3.1.2.11 Pesticide Application**

**SCC: 24 61 800 000**

#### **Description**

Pesticides are substances or mixtures used to control plant and animal life for the purposes of: agricultural production, public health from pest-borne disease, reducing property damage due to pests, and improving the aesthetic quality of outdoor and indoor surroundings. Agriculture, homeowners, industry, and government agencies use pesticides. The largest usage of pesticides by weight is in agriculture. Agricultural pesticides control weeds, insects, mites, fungi, nematodes, and other threats to the yield, quality, or safety of food production.

Emissions arise from pesticide use because of the volatile nature of many ingredients, solvents, or other additives used in the formulations. Many pesticide formulations use solvents as carriers for more active organic or inorganic ingredients. In pesticide formulations, the organic or inorganic solute is the "active ingredient" (AI), while the solvent carrier is the "inert carrier." Thus, the terms "active" and "inert" in pesticide formulations refer to toxicological action, and are not indicators of photochemical activity. Both the active and inert ingredients in these formulations evaporate and contribute to VOC emissions.

#### **Pollutants**

VOC and HAPs

#### **Method and**

#### **Data Source:**

Activity data for 2011 was not available and the Pesticide Regulation Section of the Maryland Department of Agriculture reported that the amount of pesticide usage for the state did not change from 2004. The emissions for this category have remained constant and are the same as our last report; for these reasons the following estimation description is the same as previous.

Maryland Agricultural Statistics service in cooperation with the Pesticide Regulation Section of the Maryland Department of Agriculture compiled information for Maryland's 2000 pesticide statistics document. The document, Maryland Pesticide Statistics for 2000, reported pesticide usage in pounds used in a year by active ingredient for each Maryland County. Along with the pounds of AI applied, the document also listed the form of many pesticides and the formulation of some selected pesticides. From this, MDE used the EIIP's emission inventory reference document titled Pesticides – Agricultural and Nonagricultural, December 1997, Section 9.2.2 to generate the VOC

emissions for the active ingredient and inert carrier of the pesticide. This required assumptions and other references to collect the best information used in the calculations. Emission estimation for 2011 was adapted from 2002 averaged pounds of pesticide per acre.

The EPA method for estimating pesticide emissions uses a six-step procedure as follows:

1. Determine both the application method and the quantity of pesticide product applied.
2. Determine the type of formulation used.
3. Determine the specific AI(s) in the formulation and their vapor pressure(s).
4. Determine the percentage of the AI (or each AI) present.
5. Determine the VOC content of the formulation.
6. Calculate the emissions.

MDE slightly deviated from this method, since information was presented to MDE in pounds of active ingredient. With the active ingredient, the vapor pressure and general application method (surface application or soil incorporation) was determined from the EPA's AP-42 document or The SCS/ARS/CES Pesticide Properties Database For Environmental Decision-Making, by R. D. Wauchope, et al. Then the form (i.e. wet-table powder, emulsified concentrate, granule, etc.) of the most likely pesticide was determined from a list in the Maryland Pesticide Statistics for 2000. Also, the statistics listed some formulations, for example 80% inert, 20% AI. Most of the formulations were assumptions based on the information provided with the form of the pesticide in the Maryland Pesticide Statistics for 2000.

The table below lists the EIIP emissions factors taken from AP-42 (Table 9.2.2-4) used to calculate this category.

**Uncontrolled Emission Factors for Pesticide Active Ingredients**

| Vapor Pressure Range<br><br>(mm Hg at 20° to 25° C) | Emission Factor |          |
|---|-----------------|----------|
|   | kg/Mg           | lbs./ton |
| Surface Application                                 |                 |          |
| $1 \times 10^{-4}$ to $1 \times 10^{-6}$            | 350             | 700      |
| $> 1 \times 10^{-4}$                                | 580             | 1160     |
| Soil Incorporation                                  |                 |          |
| $< 1 \times 10^{-6}$                                | 2.7             | 5.4      |
| $1 \times 10^{-4}$ to $1 \times 10^{-6}$            | 21              | 42       |
| $> 1 \times 10^{-4}$                                | 52              | 104      |

Equations:

$$E_{\text{pest}} = \text{VOC Emissions from Active Ingredient (AI)} + \text{VOC Emissions from the Inert Ingredients (Inert)}.$$

$$\text{VOC Emissions Active Ingredients (AI)} = (\text{lbs AI} / \text{year}) \times (\text{lbs VOC} / \text{lb AI})$$

$$\text{VOC Emissions Inert Ingredients} = [(\text{lbs AI} / \text{year}) / \% \text{ AI}] \times \% \text{ Inert Ingredients} \times \% \text{ VOC}_{\text{INERT INGREDIENTS}}$$

$$E_{\text{pest}} = \frac{(\text{lbs AI/year}) \times \text{EF}_{\text{AI}} \text{ in lbs VOC/ton AI}}{2000 \text{ lbs. Per ton}} + \frac{(\text{lbs AI/year})}{(1 - \% \text{ Inert})} \times (\% \text{ Inert}) \times (\% \text{ VOC in Inert})$$

$$\text{Daily Emissions} = \frac{\text{Annual Emissions}}{312 \text{ days / year}} \times \text{Seasonal Adjustment Factor}$$

where:

AI = Active Ingredient (lbs. /yr)

EF<sub>AI</sub> = Emission Factor (lbs. VOC / ton AI)

% inert = percentage of formulation that contains the Inert Carrier

% VOC in the inert = percentage of VOCs in the Inert Carrier portion of the pesticide

SAF = seasonal adjustment factor of 1.3 to adjust for the summer ozone season

MDE assumed six working days per week and 100% volatilization of the VOC portion of the inert carrier.

Sample Calculations:

The following information was compiled from The Maryland Pesticide Statistics for 2000 and The SCS/ARS/CES Pesticide Properties Database for Environmental Decision-Making:

**Table 3-26  
Allegany County Pesticide Information**

| Pesticide                     | V. Press |              | Formulation |                   | % VOC |                        | Alleg. lbs of A.I. | VOC Alleg. Lbs/yr |
|-------------------------------|----------|--------------|-------------|-------------------|-------|------------------------|--------------------|-------------------|
|                               | mm Hg    | Application  | Type        | Formula (% Inert) | Inert | EF lbs. VOC/ lbs. A.I. |                    |                   |
| <b>2,4-D</b>                  | 8E-06    | foliar spray | gas         | 0.8               | 0.29  | 0.35                   | 2,058              | 3107.580          |
| <b>Acephate</b>               | 1.7E-06  | crop spray   | gas         | 0.8               | 0.29  | 0.35                   | 62                 | 93.620            |
| <b>Alachlor</b>               | 1.4E-05  | soil spray   | gas         | 0.15              | 0.29  | 0.35                   | 19                 | 7.622             |
| <b>Amitrole</b>               | 4.40E-07 | foliar spray | gas         | 0.784             | 0.29  | 0.35                   | 6                  | 8.416             |
| <b>Atrazine</b>               | 2.89E-07 | soil surface | wp          | 0.8               | 0.25  | 0.35                   | 478                | 645.300           |
| <b>Azinphos-Methyl</b>        | 2E-07    | crop spray   | ec          | 0.35              | 0.56  | 0.35                   | 33                 | 21.501            |
| <b>Azoxystrobin</b>           |          | crop spray   | gas         | 0.77              | 0.29  | 0.35                   | 1                  | 1.321             |
| <b>Bacillus thuringiensis</b> | neg      | crop spray   | gr          | 0.96              | 0.25  | 0.35                   | 107                | 679.450           |
| <b>Benomyl</b>                | 1E-10    | crop spray   | wp          | 0.8               | 0.25  | 0.35                   | 9                  | 12.150            |
| <b>Bifenthrin</b>             | 1.8E-07  | crop spray   | gas         | 0.1               | 0.29  | 0.35                   | 2                  | 0.764             |
| <b>Boric Acid</b>             | 0.0001   | spray        | wp          | 0.1               | 0.25  | 0.35                   | 4                  | 1.511             |
| <b>Captan</b>                 | 8E-08    | crop spray   | gas         | 0.5               | 0.29  | 0.35                   | 727                | 465.280           |

| Pesticide          | V. Press  | Application           | Formulation | Formula   | % VOC | EF                     | Alleg.      | VOC              |
|--------------------|-----------|-----------------------|-------------|-----------|-------|------------------------|-------------|------------------|
|                    | mm Hg     |                       | Type        | (% Inert) | Inert | lbs. VOC/<br>lbs. A.I. | lbs of A.I. | Alleg.<br>Lbs/yr |
| Carbaryl           | 1.2E-06   | crop spray            | gas         | 0.5       | 0.29  | 0.35                   | 93          | 59.520           |
| Carbofuran         | 6E-07     | foliar spray          | fog         | 0.56      | 0.39  | 0.35                   | 1           | 0.846            |
| Chloroneb          | 0.003     | spray                 | wp          | 0.35      | 0.25  | 0.58                   | 17          | 12.148           |
| Chlorothalonil     | 1E-03     | crop spray            | gas         | 0.8       | 0.29  | 0.58                   | 368         | 640.320          |
| Chlorpyrifos       | 1.7E-05   | soil                  | gas         | 0.15      | 0.29  | 0.021                  | 36          | 2.598            |
| Clomazone          | 1.4E-04   | incorporation<br>soil | ec          | 0.3       | 0.56  | 0.052                  | 3           | 0.876            |
| Clopyralid         | 0         | foliar spray          | gas         | 0.8       | 0.29  | 0.35                   | 1           | 1.510            |
| Cyanazine          | 1.6E-09   | crop spray            | dust        | 0.8       | 0.21  | 0.35                   | 31          | 36.890           |
| Cyfluthrin         | 1.6E-08   | crop spray            | wp          | 0.3       | 0.25  | 0.35                   | 153         | 69.943           |
| Cypermethrin       | 1.4E-09   | crop spray            | wp          | 0.3       | 0.25  | 0.35                   | 5           | 2.286            |
| Diazinon           | 6E-05     | crop spray            | pellet      | 0.143     | 0.27  | 0.35                   | 21          | 8.296            |
| Dicamba            | 0         | spray                 | gas         | 0.8       | 0.29  | 0.35                   | 126         | 190.260          |
| Dichlobenil        | 1E-03     | crop spray            | wp          | 0.8       | 0.25  | 0.58                   | 3           | 4.740            |
| Dicofol            | 4E-07     | crop spray            | wp          | 0.3       | 0.25  | 0.35                   | 25          | 11.429           |
| Diflubenzuron      | 9E-10     | crop spray            | wp          | 0.25      | 0.25  | 0.35                   | 80          | 34.667           |
| Dimethenamid       | > 1.0     | soil spray            | gas         | 0.468     | 0.29  | 0.35                   | 5           | 3.026            |
| Diuron             | 6.9E-08   | soil surface          | wp          | 0.8       | 0.25  | 0.35                   | 310         | 418.500          |
| Endosulfan         | 1.7E-07   | crop spray            | gas         | 0.5       | 0.29  | 0.35                   | 2           | 1.280            |
| Esfenvalerate      | 1.1E-08   | crop spray            | dust        | 0.3       | 0.21  | 0.35                   | 7           | 3.080            |
| Fenarimol          | 2.2E-07   | crop spray            | wp          | 0.3       | 0.25  | 0.35                   | 1           | 0.457            |
| Flumetsulam        | ND        | spray                 | aq          | 0.18      | 0.21  | 0.35                   | 12          | 4.753            |
| Fluvalinate        | 1E-07     | crop spray            | rtu         | 0.8       | 0.2   | 0.35                   | 69          | 79.350           |
| Fosamine Ammonium  | 4E-06     | foliar spray          | aq          | 0.8       | 0.21  | 0.35                   | 8           | 9.520            |
| Glyphosate         | 0         | foliar spray          | aq          | 0.8       | 0.21  | 0.35                   | 2,610       | 3105.900         |
| Hydroprene         | ?         | ?                     | gr          | 0.09      | 0.25  |                        | 2           | 0.049            |
| Imidacloprid       | 1.50E-09  | spray                 | aq          | 0.786     | 0.21  | 0.35                   | 1,426       | 1598.986         |
| Iprodione          | 1E-07     | crop spray            | wp          | 0.8       | 0.25  | 0.35                   | 24          | 32.400           |
| Lambda-cyhalothrin | 1.50E-09  | spray                 | ec          | 0.87      | 0.56  | 0.35                   | 8           | 32.782           |
| MCPP               | 0         | foliar spray          | aq          | 0.5       | 0.21  | 0.35                   | 49          | 27.440           |
| Malathion          | 8E-06     | contact spray         | ec          | 0.3       | 0.56  | 0.35                   | 7           | 4.130            |
| Mancozeb           | 0         | crop spray            | Fl aq conc  | 0.8       | 0.21  | 0.35                   | 165         | 196.350          |
| Maneb              | 0         | crop spray            | wp          | 0.8       | 0.25  | 0.35                   | 26          | 35.100           |
| Metalaxyl          | 5.62E-06  | soil spray            | wp          | 0.25      | 0.25  | 0.35                   | 7           | 3.033            |
| Metam-Sodium       | 20        | soil spray            | aq          | 0.8       | 0.21  | 0.58                   | 334         | 474.280          |
| Methoprene         | 17.5      | spray                 | aq          | 0.8       | 0.21  | 0.58                   | 26          | 36.920           |
| Methoxychlor       | 0         | spray                 | wp          |           | 0.25  | 0.35                   | 3           | 1.050            |
| Methyl Bromide     | 1824      | release of gas        | Fl aq conc  | 0.8       | 0.21  | 0.58                   | 58          | 82.360           |
| Metolachlor        | 3.135E-05 | soil spray            | ec          | 0.3       | 0.56  | 0.35                   | 488         | 287.920          |
| Metribuzin         | 1E-05     | soil surface          | Fl aq conc  | 0.75      | 0.21  | 0.35                   | 3           | 2.940            |
| Metsulfuron Methyl | 2.5E-12   | foliar spray          | gr          | 0.2       | 0.25  | 0.35                   | 1           | 0.413            |
| Nicosulfuron       | 1.20E-16  | grass spray           | gr          | 0.162     | 0.25  | 0.35                   | 2           | 0.797            |
| Oryzalin           | 1E-08     | soil spray            | wp          | 0.75      | 0.25  | 0.35                   | 77          | 84.700           |
| PCNB               | 1.1E-04   | soil spray            | wp          | 0.6       | 0.25  | 0.58                   | 88          | 84.040           |
| Paclobutrazol      | 6.00E-10  | spray                 | wp          | 0.5       | 0.25  | 0.35                   | 13          | 7.800            |
| Paraquat           | 0         | target spray          | aq          | 0.8       | 0.21  | 0.35                   | 124         | 147.560          |
| Pendimethalin      | 9.4E-06   | soil spray            | ec          | 0.6       | 0.56  | 0.35                   | 1,257       | 1495.830         |
| Permethrin         | 1.3E-08   | crop spray            | ec          | 0.3       | 0.56  | 0.35                   | 9,455       | 5578.450         |

| Pesticide             | V. Press | Application           | Formulation | Formula   | % VOC | EF                     | Alleg.       | VOC              |
|-----------------------|----------|-----------------------|-------------|-----------|-------|------------------------|--------------|------------------|
|                       | mm Hg    |                       | Type        | (% Inert) | Inert | lbs. VOC/<br>lbs. A.I. | lbs of A.I.  | Alleg.<br>Lbs/yr |
| Petroleum Oils        | 1.0E-03  | spray                 | ec          |           | 0.56  | 0.58                   | 1,503        | 871.740          |
| Phosmet               | 4.9E-07  | crop spray            | wp          | 0.5       | 0.25  | 0.35                   | 26           | 15.600           |
| Picloram              | Neg      | foliar spray          | aq          | 0.8       | 0.21  | 0.35                   | 252          | 299.880          |
| Primisulfuron-methyl  | 1.50E-05 | crop spray            | gr          | 0.49      | 0.25  | 0.35                   | 2            | 1.180            |
| Propachlor            | 7.90E-05 | spray                 | gr          | 0.35      | 0.25  | 0.35                   | 2            | 0.969            |
| Propoxur              | 9.7E-06  | crop spray            | ec          | 0.3       | 0.56  | 0.35                   | 2            | 1.180            |
| Quizalofop-ethyl      | 3E-07    | foliar spray          | ec          | 0.2       | 0.56  | 0.35                   | 1            | 0.490            |
| Sethoxydim            | 1.6E-07  | foliar spray          | ec          | 0.3       | 0.56  | 0.35                   | 1            | 0.590            |
| Simazine              | 2.21E-08 | soil spray            | wp          | 0.8       | 0.25  | 0.35                   | 776          | 1047.600         |
| Sulfentrazone         |          | spray                 | gr          | 0.25      | 0.25  | 0.56                   | 1            | 0.643            |
| Sulfometuron Methyl   | 6E-16    | soil spray            | gr          | 0.2       | 0.25  | 0.35                   | 7            | 2.888            |
| Sulfur                | 0        | dust                  | dust        | 0.2       | 0.21  | 0                      | 96           | 5.040            |
| Terbacil              | 3.1E-07  | soil spray            | wp          | 0.8       | 0.25  | 0.35                   | 4            | 5.400            |
| Thifensulfuron methyl | 1.3E-10  | foliar spray          | gr          | 0.2       | 0.25  | 0.35                   | 1            | 0.413            |
| Thiophanate-methyl    | 1E-07    | crop spray            | wp          | 0.5       | 0.25  | 0.35                   | 37           | 22.200           |
| Triadimefon           | 1.5E-08  | crop spray            | wp          | 0.8       | 0.25  | 0.35                   | 7            | 9.450            |
| Trichlorfon           | 2E-06    | crop spray            | sp          | 0.8       | 0.12  | 0.35                   | 36           | 29.880           |
| Triclopyr             | 1.26E-06 | foliar spray          | ec          | 0.8       | 0.56  | 0.35                   | 454          | 1175.860         |
| Trifluralin           | 1.1E-04  | soil<br>incorporation | ec          | 0.015     | 0.56  | 0.052                  | 3            | 0.182            |
| Vinclozolin           | 120.0099 | spray                 | ec          | 0.5       | 0.56  | 0.58                   | 16           | 18.240           |
| Zinc Phosphide        | 0        | powder                | pellet      | 0.8       | 0.27  | 0                      | 1            | 1.080            |
| <b>County Total</b>   |          |                       |             |           |       |                        | <b>24529</b> | <b>23472.544</b> |

Emissions are calculated for each pesticide active ingredient per county and then summed.

Example calculation for the emissions from Pendimethalin pesticide used in Allegany county.

$$\text{Emis Pendimethalin} = 1257 \frac{\text{Lbs}}{\text{year}} \times \frac{0 \text{ lbs. VOC}}{\text{lbs. AI}} + \frac{1257}{(1-0.6)} \times 0.6 \times 0.56$$

$$\text{Emis Pendimethalin} = 1495.83 \text{ lbs. VOC / year}$$

$$\text{Emis Pendimethalin} = 1495.83 / 2000 = 0.7479 \text{ tons VOC / year}$$

$$\text{Emis Pendimethalin} = \mathbf{0.7479} \text{ tons VOC / year}$$

The remaining pesticides used in Allegany County are calculated in a similar manner.

### Results:

Since the EPA has released new guidance on the calculation of agricultural pesticide application, the new methodology vastly differs from the method used in 1990. In the Maryland Ozone Precursor Inventory for 1990, Air and Radiation Management, MDE, September 1993, pesticide

application for the state totaled 42 tons per day. This method assumed 90% volatilization of the AI. The method also assumed the inert carrier content to be 145% by weight of the AI. Another major assumption is 100% volatilization of the inert carrier.

Since publication, the accuracy of the old pesticide methodology has been debated by different groups. General thoughts from scholars and private industry is that the old methodology over predicts the volatility of the organics in the pesticide. The new methodology, presented here requires many assumptions and uses data that takes account for the different vapor pressures of individual active ingredients. This method, along with some general assumptions, estimated pesticide emissions at 8.7 tons per day for the state. The decrease is due to the change in method, along with a decline in pounds of pesticides applied in the state. (While the state amount of overall pesticide used in 2011 was similar to 2008, the amount used in each county for 2011 varied base on the number of harvested acres in each county).

### 3.1.2.12 Commercial/Consumer Solvent Use

SCC: 24 60 100 000 (Personal Care)  
24 60 200 000 (Household)  
24 60 400 000 (Automotive Aftermarket)  
24 60 500 000 (Coatings and Related)  
24 60 600 000 (Adhesives and Sealants)  
24 60 800 000 (FIFRA - Regulated)  
24 60 900 000 (Miscellaneous Products)

#### Description

Certain commercial/consumer uses of products containing volatile organics cannot easily be identified by questionnaires, surveys or other inventory procedures yielding locale-specific emission estimates. This category includes the following sources: household products, toiletries, aerosol products, rubbing compounds, windshield washing fluid, polishes, waxes, non-industrial adhesives, space deodorants, moth control agents and laundry detergents.

#### Pollutants

VOC and HAPs

#### Method and Data Sources

The recommended emission factor that combines emissions from all these sources is 7.84 pounds VOC per person per year, from EIIP Volume III, Area Sources, Preferred and Alternate Methods (July, 1997). This emission factor excludes non-reactive VOC and takes into account more recent volatility levels based on product reformulation, than does AP-42, Fifth Edition. MDE used an activity level of 7 days a week and no seasonal adjustment factor as suggested in Table 5.8-1 in Procedures.

#### *Activity*

The U.S. Census Bureau reports and collects population statistics for the counties of Maryland. U.S. Census Bureau Internet address: (<http://www.census.gov>).

**Emission Factors:**

Commercial and Consumer Products (All) 7.84 lbs. VOC/person/year

| <b>Original EPA Per Capita VOC Emission Factors</b> <sup>36, 37</sup> |            |   |
|---|------------|---|
| <b>Industry</b>   | <b>SCC</b> | <b>1996 Per Capita<br/>VOC Emission Factor<br/>(lbs. VOC/person/year)</b> |
| Personal Care Products  | 2460100000 | 2.32  |
| Household Products  | 2460200000 | 0.79  |
| Automotive Aftermarket Products                                       | 2460400000 | 1.36  |
| Coatings and Related Products   | 2460500000 | 0.95  |
| Adhesives and Sealants  | 2460600000 | 0.57  |
| FIFRA - Regulated Products  | 2460800000 | 178   |
| Miscellaneous Products  | 2460900000 | 0.07  |
| Total (All Commercial & Consumer Products) =                          |            | 7.84  |

**Point Source  
Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustment for  
Controls**

Federal regulations provide a 20 percent reduction in emissions from a 3.9 lbs. VOC/person subset of the total commercial and consumer products category.

Commercial and consumer products are regulated by three separate category measures. The three control measures are; the original Federal regulations, effective, OTC Phase I controls, effective, and OTC Phase II controls effective. Each of the control measures are discussed briefly below:

**Control Set 1:** Federal regulations provide a 20 percent reduction in emissions from 3.9 lbs. VOC/person subset of the total commercial and consumer products category. This results in following controls per commercial and consumer solvent subcategory:

<sup>36</sup> Source: Adapted from EPA, 1995

<sup>37</sup> Emission factors are based on usage and population data for 1990.



**Per Capita VOC Emission Factors After Federal Rule**

| <b>Product Category</b>                      | <b>SCC</b>  | <b>Emission Factor<br/>(lbs. VOC/person/year)c</b> |
|--|-------------|--|
| Personal Care Products                       | 24601000000 | 2.08   |
| Household Products                           | 24602000000 | 0.63   |
| Automotive Aftermarket Products              | 24604000000 | 1.13   |
| Adhesives and Sealants                       | 24606000000 | 0.51   |
| FIFRA-Regulated Products                     | 24608000000 | 1.68   |
| Coatings and Related Products                | 24605000000 | 0.95   |
| Miscellaneous Products                       | 24609000000 | 0.07   |
| Total (All Commercial & Consumer Products) = |             | 7.06   |

**Control Set 2:** OTC Phase I rule was based on the five CARB consumer products rules and further emission reductions of 14.20 % beyond federal regulation provided in control set one above. This results in the following controls per commercial and consumer solvent subcategory:

**Per Capita VOC Emission Factors After OCT Phase 1**

| <b>Product Category</b>                      | <b>SCC</b>  | <b>Emission Factor<br/>(lbs. VOC/person/year)c</b> |
|--|-------------|--|
| Personal Care Products                       | 24601000000 | 1.79   |
| Household Products                           | 24602000000 | 0.54   |
| Automotive Aftermarket Products              | 24604000000 | 0.98   |
| Adhesives and Sealants                       | 24606000000 | 0.43   |
| FIFRA-Regulated Products                     | 24608000000 | 1.44   |
| Coatings and Related Products                | 24605000000 | 0.82   |
| Miscellaneous Products                       | 24609000000 | 0.07   |
| Total (All Commercial & Consumer Products) = |             | 6.06   |

**Control Set 3 :** OTC Phase II rule was based on the five CARB consumer products rules and further emission reductions of 2.0 % beyond federal regulation provided in control set one above. This results in the following controls per commercial and consumer solvent subcategory:

**Per Capita VOC Emission Factors After OCT Phase 2**

| <b>Product Category</b> | <b>SCC</b>  | <b>Emission Factor<br/>(lbs. VOC/person/year)c</b> |
|-------------------------|-------------|--|
| Personal Care Products  | 24601000000 | 1.7529695  |

|  |             |           |
|--|-------------|-----------|
| Household Products                           | 24602000000 | 0.5268063 |
| Automotive Aftermarket Products              | 24604000000 | 0.9571004 |
| Adhesives and Sealants                       | 24606000000 | 0.4269687 |
| FIFRA-Regulated Products                     | 24608000000 | 1.4084942 |
| Coatings and Related Products                | 24605000000 | 0.8047066 |
| Miscellaneous Products                       | 24609000000 | 0.0581146 |
| Total (All Commercial & Consumer Products) = |             | 5.9351604 |

### Spatial and Temporal Allocations

#### *Spatial*

Data for spatial allocation is not available for this source.

#### *Temporal*

Data for temporal allocation is not available for this source.

### Emissions Calculation

The per capita equation used to estimate emissions from commercial and consumer solvents is:

$$E_{CC} = \frac{[POP_i \times EF_{CC}] - [(POP_i \times CS_{CC}) \times CE_{CC}]}{2000}$$

Where:

$E_{CC}$  = VOC emissions in tons per day from commercial and consumer solvents

$POP_i$  = 2011 population of county i (Appendix A)

$EF_{CC}$  = VOC emission factor for commercial and consumer solvents (7.84 lbs.  $voc$ /person)

$CS_{CC}$  = Controlled subset of commercial and consumer solvents (3.9 lbs.  $voc$ /person)

$CE_{CC}$  = Control efficiency for controlled subset of commercial and consumer solvents (20%)

#### 2011 Sample Calculation All Commercial/Consumer Solvent Use (Anne Arundel County)

$$E_{CC} = \frac{[(544,403^{38}) \times (7.84^{39})] - [(544,403 \times 3.9^{40}) \times (0.20)^{41}]}{2000}$$

$$E_{CC} = 1,615.560 \text{ tons } voc \text{ per year}$$

<sup>38</sup> 2011 Population data from U.S. Bureau of Census, Population Estimates Branch (see Appendices)

<sup>39</sup> Emission factor from EIIP Chapter 5 Commercial and Consumer Solvent Use

<sup>40</sup> EPA memo from John Sietz

<sup>41</sup> EPA memo from John Sietz

### **3.1.2.12.1 Barge, Tank, Tank Truck, Rail Car and Drum Cleaning**

**SCC: 24 61 160 000**

The EPA explained to MDE staff that the agency has not developed an emission factor for this category. The EPA also stated that most barge, tank truck, rail car and drum cleaning is done by steam cleaning and the residue goes to industrial and public waste disposal treatment plants. It is impossible to separate this category's portion of the treatment plant emissions. EPA considers the emissions from this category to be insignificant. Emissions from this category are calculated for the appropriate facilities in the point source inventory.

### **3.1.3 BIOPROCESS EMISSIONS SOURCES**

#### **3.1.3.1 Bakeries**

**SCC: 23 02 050 000**

#### **Description**

Bakeries emit VOC, primarily ethanol formed by yeast fermentation of bread or dough, during the baking process. Ethanol is emitted through a vent, along with combustion product gases. Large commercial bakeries are inventoried as point sources. In-store and neighborhood bakeries have lower emissions, and thus are considered area sources.

#### **Pollutants**

VOC

#### **Method and Data Sources**

MDE staff followed methodology described in an EIIP Area Source Category Method Abstract – Bakeries, dated June 1999 and an emission factor of 0.11 tons<sub>VOC</sub> per employee cited in an April 24, 1992 Technical Memorandum prepared by Radian Corporation for EPA. Applicable point source emissions (those within the same NAICS) taken from the MDE/ARMA registration files have been subtracted from the emissions calculated on a per employee basis; and are presented below.

#### ***Activity***

Employee numbers were taken from County Business Patterns 2010 - Maryland, NAICS 311812, Bakery Products and 311811, Retail Bakeries (see Appendices). Some county employment data is represented by a letter code indicating a range for the number of employees for that NAICS. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a NAICS matched the sum of the number of employees reported per county.

***Emission Factor***

An emission factor of 0.11 tons<sub>VOC</sub> per employee cited in an April 24, 1992 Technical Memorandum prepared by Radian Corporation for EPA was utilized.

**Point Source  
Adjustments**

Bakery emissions from facilities identified as point sources (NAICS 311812 and 311811) were subtracted from the area source inventory to avoid double counting.

**Adjustment for  
Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

***Spatial***

Data for spatial allocation is not available for this source.

***Temporal***

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate emissions from bakeries is:

Equation:

$$E_{BAK} = EF_{BAK} \times EMP_j$$

Where:

- $E_{BAK}$  = VOC emissions from small bakeries in tons per year
- $EF_{BAK}$  = per employee emission factor for bakeries
- $EMP_j$  = number of employees at small (less than 20 employees), bakeries in county j

### Point Source Adjustments

$$E_{\text{BAK-ADJ}} = EF_{\text{BAK}} \times \text{EMP}_{\text{j Pt. Sources}}^{42}$$

Where:

$E_{\text{BAK-ADJ}}$  = Point source adjusted bakery emissions

$EF_{\text{BAK}}$  = Calculated area source bakery emissions

$\text{EMP}_{\text{j Pt. Sources}}$  = Point Source Adjustment was done by subtracting employment for Baltimore City related sources before calculating emissions.

### 2011 Sample Calculation for Bakery VOC Emissions (Baltimore City):

Employees in NAICS 311811 and 311812 in Baltimore City: 1,362 emp

Employees in Baltimore City Bakeries: 947.16

$$\text{EMP}_{\text{j Pt. Sources}} = 1,362 - 947.16 \text{ emp}$$

$$E_{\text{BAK}} = 220 \times 510.82 \text{ lb.s VOC per person per year}$$

$$E_{\text{BAK}} = 112,380 \text{ lb.s VOC per person per year}$$

$$E_{\text{BAK}} = (112,380 / 2000) \text{ tons VOC per year}$$

$$E_{\text{BAK}} = 56.19 \text{ tons VOC per year}$$

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<sup>42</sup> Point Source Reduction from MDE ARMA registration files

### 3.1.3.2 Breweries

SCC: 23 02 070 001

#### **Description**

During the fermentation process, breweries emit ethanol and other VOCs. Although large-scale commercial breweries have been inventoried as point sources, there are microbreweries and brewpubs that emit lower levels of VOCs and therefore must be inventoried as area sources. These smaller breweries emit most of their VOCs from the fermentation room, not the brew kettle as is the case with the large breweries.

#### **Pollutants**

VOC

#### **Method and Data Sources**

MDE/ARMA staff surveyed small brewpubs and microbreweries in Maryland.

#### *Activity*

The survey questionnaire asked the brewing facilities to provide MDE/ARMA with the amount of barrels brewed per month for the calendar year 2011. For those facilities that reported only annual production amounts, an average monthly value was used.

#### *Emission Factor*

Emissions from the small breweries were calculated using an emission factor cited in a February 5, 1992 Technical Memorandum prepared by Radian Corporation for EPA. This emission factor is 56.743 lbs. VOC per 1000 barrels produced. One barrel equals 31 gallons. Note: Emf conversion is: 56.743 lb VOC/1000 barrels = 0.05674 lb/barrel = 0.0018303 lb/gal.

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

No controls are available for this source category.

#### **Spatial and Temporal Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate emissions from bakeries is:

$$E_{\text{BREW}} = \frac{EF_{\text{BREW}} \times BP_j}{2000}$$

Where:

$E_{\text{BREW}}$  = VOC emissions from small bakeries in tons per year

$EF_{\text{BREW}}$  = emission factor for small breweries

$BP_j$  = 2011 beer production in barrels

2011 Sample Calculation for Small Brewery VOC Emissions (Baltimore City):

Number barrels produced by microbreweries in Baltimore City = 40,394.85

$$E_{\text{BREW}} = \frac{0.05674 \times 40,394.85}{2000}$$

$E_{\text{BREW}} = 1.146\text{E-}00$  tons  $\text{v}_{\text{OC}}$  per year

### 3.1.3.3 Wineries

SCC: 23 02 070 005

#### Description

Ethanol emissions from wineries occur during the fermentation process. The emissions vary, depending upon the type of wine (red vs. white), the fermentation temperature and the sugar content of the grapes used.

#### Pollutants

VOC

#### Method and Data Sources

MDE used the methods and procedures documented in AP-42<sup>43</sup>, Chapter 12, Beverages, Section 2, Wines and Brandies dated September 1995. AP42 Chapter 9.12.2

#### *Activity*

The U.S. Department of the Treasury's Alcohol and Tobacco Tax and Trade Bureau, State of Maryland Comptrollers Office, and direct survey of most of Maryland's wineries revealed that approximately 351,819 gallons of wine was produced in 2011. The survey suggests that 191,088 gallons of white and 160,731 gallons of red wine were actually produced.

#### *Emission Factor*

Table 9.12.2-1 of AP-42 shows that ethanol emissions are 1.8 lbs. VOC per 1000 gallons of white wine fermented and 4.6 lbs. VOC per 1000 gallons of red wine fermented.

#### Point Source Adjustments

No subtraction of emissions from point sources is necessary.

#### Adjustment for Controls

No controls are available for this source category.

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<sup>43</sup> AP42, Chapter 9.12.2: Food and Agricultural Industries, Beverages, Wines and Brandies



## Spatial and Temporal Allocations

### *Spatial*

Data for spatial allocation is not available for this source.

### *Temporal*

Data for temporal allocation is not available for this source.

## Emissions Calculation

**Emission Factors:**      **red =      0.0046 lb.voc/gal.**  
   **white =      0.0018 lb.voc/gal.**

White wine  
**lb.voc/gal.) / 2000**

$$EM_{\text{total}} = (191,088 \text{ gal.} \times \mathbf{0.0018})$$

White wine  $EM_{\text{total}} = 0.172$  tons of ethanol

Red wine  $EM_{\text{total}} = (160,731 \text{ gal.} \times \mathbf{0.0046 \text{ lb.voc/gal.}}) / \mathbf{2000}$

Red wine  $EM_{\text{total}} = 0.370$  tons of ethanol

Using the above figures, the production of wine by all Maryland wineries in 2011 resulted in the production of 0.542 tons of ethanol.

### 3.1.3.4 Distilleries

#### Description

Ethanol emissions are the largest component of the VOCs emitted from distilleries. Distilleries produce both grain alcohol for industrial and fuel purposes, and distilled spirits such as whiskey and brandy for consumption purposes. The emissions points in the distilled spirits manufacturing process are likely to be the same as in breweries and wineries, with the aging process as an additional source of emissions. During the aging process, ethanol and water seep through the wooden barrels used to age whiskey and evaporate into the air. Aging and barrel emptying are the major sources of VOC emissions from whiskey production.

#### Pollutants

VOC

#### Method and Data Sources

MDE staff indicated that no distilleries below the 10 ton per year point source cutoff operated in the inventory area during 2011. Fugitive VOC emissions from the aging process at large distillery operations can be substantial and will be included in the point source inventory.

### 3.1.4 CATASTROPHIC/ACCIDENTAL RELEASES

#### 3.1.4.1 Oil Spills

SCC: 28 30 000 000

##### **Description**

Oil spills involve oil tanker accidents, tanker truck accidents, and spills and blowouts from oil rigs or pipelines in coastal and inland areas. Because a wide range of fuel types may be spilled, the nature and quantity of emissions can vary. Emissions are also influenced by the clean-up procedure and by dispersion and weathering processes.

Oil spill evaporation produces local VOC emissions. If spills catch fire, additional SO<sub>2</sub>, CO, CO<sub>2</sub>, PM, NO<sub>x</sub> and VOC emissions may result. Other potentially toxic chemical compounds may also be released as a result of chemical cleanup

##### **Pollutants**

VOC

##### **Method and Data Sources**

###### *Activity*

Data on oil spills in Maryland were obtained from MDE's Oil Control Program. They provided MDE/ARMA staff a yearly report of all oil spills that occurred in Maryland during 2011. Spills around Maryland totaled to about 54,373 gallons.

###### *Emission Factor*

MDE staff used an emission factor recommended to the Metropolitan Washington Council of Governments by E.H. PECHAN and Associates, Inc., the contractor used by MWCOG to prepare their 1990 base year inventory. This emission factor was based on a California Air Resources Board (CARB), study of air emissions from large oil spills (over 10 million gallons of oil). Based on this study, a range of evaporation estimates for reactive organic gases was found to be between 5,500 and 13,000 tons. Using this information, an average emission factor was calculated to be 0.0000925 tons VOC per gallon of oil spilled.

##### **Point Source Adjustments**

No point source adjustments were made.

##### **Adjustment for Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate emissions from oil spills:

$$E_{\text{Oil Spills}} = EF_{\text{Oil Spills}} \times \text{GOS}_j$$

Where:

$E_{\text{Oil Spills}}$  = VOC emissions from oil spills in tons VOC per year

$EF_{\text{Oil Spills}}$  = tons of pollutant per gallon of oil spilled

$\text{GOS}_i$  = gallons of oil spilled in county I

2011 Sample Calculation for Oil Spill VOC Emissions (Prince George's County):

Annual Emissions:

Number gallons oil spilled in Prince George's County 2011: **5,958** gallons

$$E_{\text{Oil Spills}} = (0.0000925) \times (5,958)$$

$$E_{\text{Oil Spills}} = 0.5511 \text{ tons VOC per year}$$

### 3.1.4.2 Leaking Underground Storage Tanks / Soil Remediation

SCC: 26 60 000 000

#### Description

Many underground storage tanks (USTs) are over 15 years old and are constructed of steel, which may rust over time. The underground piping connected to these tanks also has the potential to leak. Leaking USTs (leaking underground storage tank sites or LUST sites) are of concern because they may result in the contamination of drinking water, subsurface soils, and ground and surface water, and may emit toxic and/or explosive vapors. The contaminated soil and water may also emit VOC.

#### Pollutants

VOC

#### Method and Data Sources

##### *Activity*

Emission calculation methods were taken from EIIP, AREA SOURCE CATEGORY METHOD ABSTRACT - REMEDIATION OF LEAKING UNDERGROUND STORAGE TANKS, 2001. The numbers of LUST sites by county were obtained from MDE's Oil Control Program. No seasonal variation was assumed. Each remediation event takes an average of 30 days; during this period emissions are released.

##### *Emission Factor*

An emissions factor of 28 lbs of VOC per day per site was used.

#### Point Source Adjustments

No point source adjustments were made.

#### Adjustment for Controls

No controls are available for this source category.

#### Spatial and Temporal Allocations

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

$$E_{LUST} = \frac{LS1_j \times EF \times 30 \text{ day}}{2000 \text{ lb./ton}}$$

Where:

$E_{LUST}$  = VOC emissions in tons per year from leaking underground storage tanks

$LS1_j$  = number of remediation site(s) in county j

EF = emissions factor

2011 Sample Calculation for Leaking Underground Storage Tanks (Anne Arundel County)

No seasonal variation assumed

$$E_{LUST-AA} = \frac{2 \times 28 \text{ VOC lbs./day} \times 30 \text{ day}}{2000 \text{ lb./ton}}$$

$E_{LUST-AA} = 0.84 \text{ tons VOC per year}$

### **3.1.5 SOLID WASTE DISPOSAL, TREATMENT, AND RECOVERY**

#### **3.1.5.1 On-site Incineration**

**SCC: 2601020000**

##### **Description**

On-site incineration is the confined burning of waste on a small scale by institutions such as hospitals, nursing homes, veterinary offices, funeral homes and laboratories. Large-scale incineration is included in the point source inventory.

##### **Pollutants**

VOC, NO<sub>x</sub>, SO<sub>x</sub>, CO, PM<sub>10</sub>, PM<sub>2.5</sub>, and HAPS,

##### **Method and Data Sources**

In Maryland incinerators are regulated under COMAR 26.11.08. Maryland began regulating incinerators for control of particulates in the 1970's. In AQCRs III and IV single chamber incinerators, the type that would be used for on-site residential incineration, were banned. All such incinerators were rendered inoperative under the direction of the Maryland Department of the Environment (MDE). Over 1700 small incinerators were eliminated under this requirement.

In the other Maryland counties included in the Washington, D.C. nonattainment area, incineration of trash in on-site incinerators is prohibited except in areas where public trash collection is not provided.

COMAR 26.11.08.09 now requires all incinerators to obtain a permit to operate and any person who owns or operates an incinerator must obtain certification from MDE and renew the certification annually.

MDE/ARMA maintains a registry of all incinerators within the State. Because of the requirements prohibiting single chamber incinerators, the requirement for a permit to operate, and the operator certification requirements, staff used the sum of the incinerators in the registry as representing the total area source emissions from incinerators of all types emitting less than 10 tons/VOC, 100 tons/yr CO and 50 tons per year NO<sub>x</sub>. Incinerators from the registry with emissions above these thresholds are included in the point source inventory.

No seasonality is applied. The emission factor is chosen by type of incinerator: waste, pathological, hazardous, industrial, special medical, sewage sludge and municipal waste combustors. The burn rate is determined by stack test or AP-42. Hours of operation and tons of waste per day are supplied by the operator.

### 3.1.5.2 Publicly Owned Treatment Works (POTWs)

SCC: 26 30 020 000

#### **Description**

Wastewater is usually collected and treated at a public waterworks facility to be filtered and reused or discharged into surrounding waterways. While the wastewater is held and being treated VOCs are released into the air due to contaminants and byproducts in the water.

#### **Pollutants**

VOC

#### **Method and Data Sources**

The emissions from these facilities were calculated based on the method described in EPA EIIP II Chapter 5 Section 5.1.

#### *Activity*

The amount of actual flow for each POTW in Maryland was supplied by the MDE's Wastewater Management Administration (see Appendices). MDE staff multiplied this amount by the emission factor listed to get VOC emissions from each POTW. The individual POTW emissions were then totaled by county.

#### *Emission Factor*

EPA and ERTAC supplied MDE with a new emission factor of 0.44 pounds VOC per million gallons of actual flow of wastewater discharged.

#### **Point Source Adjustments**

VOC stack emissions in the Air Management registration files from the Patapsco, Western Branch, and Back River Wastewater Treatment Plants were subtracted from the totals below.

#### **Adjustment for Controls**

A seasonal adjustment factor of 1.4 was used when calculating ozone season or daily emissions not yearly.

#### **Spatial and Temporal Allocations**

***Spatial***

Data for spatial allocation is not available for this source.

***Temporal***

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate yearly emissions from POTWs is:

$$E_{\text{POTWY}} = \frac{\text{ADF}_{\text{IJ}} \times \text{EF}_{\text{POTW}} \times 365 \text{ days}}{2000}$$

For seasonal emissions:

$$E_{\text{POTWS}} = \frac{\text{ADF}_{\text{IJ}} \times \text{EF}_{\text{POTW}} \times \text{SAF}_{\text{POTW}}}{2000}$$

Where:

- $E_{\text{POTWY}}$  = VOC emissions in tons<sub>VOC</sub> per year from POTWs
- $\text{ADF}_{\text{IJ}}$  = Actual daily flow into POTW i in county j
- $\text{EF}_{\text{POTW}}$  = VOC emission factor<sup>44</sup> for POTWs
- $\text{SAF}_{\text{POTW}}$  = Seasonal adjustment factor<sup>45</sup> for peak ozone season which is 1.4  
Plant operation is 365 days a year

2011 Sample Calculation for POTW VOC Emissions (Howard County):

Little Patuxent Treatment Plant statistics<sup>46</sup>:

Actual daily flow (MGD)<sup>47</sup>: 15.755

$$E_{\text{POTWY}} = \frac{(15.755) \times (0.44 \text{ lbs.}_{\text{VOC}} / \text{gal}) \times 365 \text{ days}}{2000}$$

$$E_{\text{POTWY}} = 1.27 \text{ tons}_{\text{VOC}} / \text{year}$$

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<sup>44</sup> Emission factor taken from Procedures, Section 3.5.1

<sup>45</sup> Seasonal adjustment factor taken from Procedures, Table 5.8.1

<sup>46</sup> Supplied by the Maryland Water Management Administration (see Appendices)

<sup>47</sup> MGD : Million Gallons per Day



### 3.1.5.3 Open Burning – Land Clearing Debris

SCC: 26 10 000 500

#### Description

Open burning of land clearing debris refers to the clearing of land for new construction and the burning of organic material (i.e., trees, shrubs and other vegetation). The clearing of land for the construction of new buildings and highways often results in debris consisting of trees, shrubs, and brush. This debris may be burned in place but it is usually collected in piles for burning. The burning of land clearing wastes may be practiced by private individuals, corporations, and government agencies (e.g., highway construction department). There are no federal laws restricting the open burning of land clearing wastes, although state or local laws may exist.

Residential open burning without a permit is prohibited under Maryland law (COMAR 26.11.07), where trash and leaf collection is available. The basic difference between the regulation as it applies to counties in AQCRs III and IV and the rest of the state is the requirements under which the burn takes place, i.e., minimum setbacks from property lines, etc. In the more rural counties, areas with no available trash collection are more prevalent. MDE adopted a regulation that prohibits open burning during the peak ozone period (June to August). The seasonal prohibition only affects those counties that lie within serious and severe ozone nonattainment areas. Certain exemptions must be in place however so as not to adversely affect agriculture or restrict fire training and recreational activities. Commercial open burning without a permit is prohibited in Maryland.

#### Pollutants

VOC, NO<sub>x</sub>, SO<sub>x</sub>, CO, PM<sub>10</sub> and PM<sub>2.5</sub>

#### Method and Data Sources

The method used to calculate emissions, is presented in EIIP<sup>48</sup>, Chapter 16, Open Burning (Revised Final 2001).

#### *Activity*

The number of acres disturbed by residential, non-residential and roadway construction are estimated and then these values are added together to obtain a county-level estimate of total acres disturbed by land-clearing. County-level emissions from land clearing debris are then calculated by multiplying the total acres disturbed by construction by a weighted loading factor and emission factor.

The BELD database in BEIS was used to determine the number of acres of hardwoods, softwoods, and grasses in each county. Average loading factors were weighted according to the percent contribution of each type of vegetation class to the total land area for each county. The loading factors for slash hardwood and slash softwood were further adjusted

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<sup>48</sup> Emission Inventory Improvement Program

by a factor of 1.5 to account for the mass of tree that is below the soil surface that would also be subject to burning once the land is cleared.

Fuel loading factors are as follows:

| Fuel Type | Fuel Load Factor<br>(tons/acre) | Adjusted Load Factor<br>(tons/acre) |
|-----------|---------------------------------|-------------------------------------|
| Hardwood  | 99                              | 148.5                               |
| Softwood  | 57                              | 85.5                                |
| Grass     | 4.5                             | 4.5                                 |

Average fuel loading factors were calculated as follows:

$$LF_{OB-LCD-CO_i} = \frac{(\text{Acres}_{HW-CO_i} \times LF_{Adj-HW}) + (\text{Acres}_{SW-CO_i} \times LF_{Adj-SW}) + (\text{Acres}_{GR-CO_i} \times LF_{Adj-GR})}{\text{Acres}_{TOT-CO_i}}$$

- $LF_{OB-LCD-CO_i}$  = Average Load Factor in County i
- $\text{Acres}_{HW-CO_i}$  = Acres of hardwood in County i from BELD database
- $LF_{Adj-HW}$  = Adjusted Load Factor for Hardwood
- $\text{Acres}_{SW-CO_i}$  = Acres of softwood in County i from BELD database
- $LF_{Adj-SW}$  = Adjusted Load Factor for Softwood
- $\text{Acres}_{GR-CO_i}$  = Acres of grasses in County i from BELD database
- $LF_{Adj-GR}$  = Adjusted Load Factor for Grasses
- $\text{Acres}_{TOT-CO_i}$  = Total Land Acres in County i

**Emission Factors**<sup>49</sup>

Emission factors in lbs. /ton were taken from AP-42 Table 2.5-1, Emission Factors for Open Burning of Municipal Refuse and are listed below:

|                   |      |  |
|-------------------|------|--|
| VOC               | 11.6 | Lbs. VOC/ ton                          |
| SO <sub>x</sub>   | 0.0  | Lbs. SO <sub>x</sub> / ton             |
| CO                | 169  | Lbs. CO/ ton                           |
| PM <sub>10</sub>  | 17   | Lbs. PM <sub>10</sub> / ton            |
| PM <sub>2.5</sub> | 17   | Lbs. PM <sub>2.5</sub> / ton           |
| NO <sub>x</sub>   | 5    | Lbs. N <sub>NO<sub>x</sub></sub> / ton |

Ozone Season Daily (OSD) emissions calculated by multiplying annual emissions by 0.25 then dividing by 92.

**Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

<sup>49</sup> Emissions factors for VOC NO<sub>x</sub>, CO, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> were obtained from AP-42 Table 2.5-1.

**Adjustments  
for Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Emissions are temporally allocated to months or seasons by the number of permits issued per month per county.

**Emissions  
Calculation**

*Annual Emissions*

$$E_{OB-LCD-Ann} = \frac{AD_{R-NR-Road} \times LF_{OB-LCD-CO_i} \times EF_{OB_i}}{2000}$$

- $E_{OB-LCD-Ann}$  = Annual emissions from open burning of land clearing debris
- $AD_{R-NR-Road}$  = Acres disturbed from Residential, Non-residential and Roadway construction in the county
- $LF_{OB-LCD-CO_i}$  = Average Load Factor in County i
- $FL_{HW-SW-G}$  = Fuel loading factor for hardwoods, softwoods, and grasses
- $EF_{OB_i}$  = Open burning emission factor for pollutant i in lbs. / ton

*Ozone Season Daily Emissions*

$$E_{OB-LCD-Day} = \frac{E_{OB-LCD-Ann}}{4 \times 92}$$

- $E_{OB-LCD-Day}$  = Ozone Season Daily emissions from open burning
- $E_{OB-LCD-Ann}$  = Annual emissions from open burning of land clearing debris
- 4 = Number of seasons in the year
- 92 = Days in the season

### 3.1.5.4 Open Burning – Residential Municipal Solid Waste

SCC: 26 10 030 000

#### **Description**

Open burning is the unconfined burning of wood, leaves, land clearing debris, household waste, and agricultural crop waste. Household waste is often referred to as residential municipal solid waste (MSW); a term for nonhazardous refuse produced by households (e.g., paper, plastics, metals, wood, glass, rubber, leather, textiles, and food wastes).

Open burning without a permit is prohibited in Maryland where trash and leaf collection is available, (COMAR 26.11.07). The basic difference between the regulation as it applies to counties in AQCRs III and IV and the rest of the state is the requirements under which the burn takes place, i.e., minimum setbacks from property lines, etc. In the more rural counties, areas with no available trash collection are more prevalent. MDE adopted a regulation that prohibits open burning during the peak ozone period (June to August). The seasonal prohibition only affects those counties that lie within serious and severe ozone nonattainment areas. Certain exemptions must be in place however so as not to adversely affect agriculture or restrict fire training and recreational activities.

#### **Pollutants**

VOC, NO<sub>x</sub>, SO<sub>x</sub>, CO, PM<sub>10</sub>, PM<sub>2.5</sub>, and HAPs

#### **Method and Data Sources**

The method used to calculate emissions is presented in a study/survey conducted by the Mid-Atlantic/Northeast Visibility Union (MANE-VU), titled “Open Burning in Residential Areas Emissions Inventory Development Report.”<sup>50</sup>

#### *Activity*

The purpose of the survey was to obtain data for developing activity estimates and control information (e.g., bans on burning) that would form the basis of an improved open burning emission inventory for Mid-Atlantic/Northeast Visibility Union (MANE-VU) states and tribes for the year 2002. But for 2011, the percentages used to calculate emissions are the same; the emissions increase or decrease due to the estimated number of households that burn and the amount of material burned.

A rule effectiveness (RE) survey was also taken to estimate controlled emissions for areas under restriction. Household waste burning surveys were completed for 72 respondents or jurisdictions, while yard waste surveys were conducted for 181 respondents. The respondents for this survey were typically local fire wardens or chiefs. Rule effectiveness surveys related to residential MSW rules were conducted for 49 respondents, while RE

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<sup>50</sup> Open Burning in Residential Areas Emissions Inventory Development Report, Prepared by E.H. PECHAN & Associates, Inc. for the Mid-Atlantic/Northeast Visibility Union, dated January 31, 2004.

surveys for yard waste burning rules were performed for 51 respondents. In obtaining survey responses, PECHAN collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census). PECHAN also developed a control database for each open burning category that describes the recommended control efficiency (CE) and rule penetration (RP) values by state and county, and by sub-county, where applicable.

Open burning activity estimates recorded from the survey were used directly to estimate emissions for the surveyed jurisdictions. For the non-surveyed areas, including tribal lands, the default activity data derived from all survey responses were applied. Households are defined as detached single-family unit dwellings, and were updated by using the 2011 U.S. Census.

***Emission Factors***

Emission factors in lbs/ton total mass were taken from AP-42 Table 2.5-1 Emission Factors for Open Burning of Municipal Refuse and from a 1997 EPA research paper on open burning<sup>51</sup> are listed below:

| SCC        | Type of Waste | PM2.5<br>lb/ton | PM10<br>lb/ton | VOC<br>lb/ton | NOX<br>lb/ton | SO2<br>lb/ton | CO<br>lb/ton |
|------------|---------------|-----------------|----------------|---------------|---------------|---------------|--------------|
| 2610030000 | <b>HH MSW</b> | <b>34.8</b>     | <b>38</b>      | <b>8.56</b>   | <b>6</b>      | <b>1</b>      | <b>85</b>    |
| 2610000100 | Leaf Waste    | 22              | 22             | 28            | 6.2           | 0.76          | 112          |
| 2610000400 | Brush Waste   | 15.21           | 19.73          | 19            | 5             | 1.66          | 140          |

**Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustments for Controls**

If an area has controls or prohibitions on residential burning, controlled emissions were calculated from uncontrolled emissions using the following equation:

$$E_c = E_{uc} * [(1-(CE)(RP)(RE)]$$

<sup>51</sup> EPA. 1997. Evaluation of Emissions from the Open Burning Of Household Waste in Barrels. EPA-600/R-97-134a. U.S. Environmental Protection Agency, Control Technologies Center./ Research Triangle Park, North Carolina.

Where:

|          |   |                                       |
|----------|---|---------------------------------------|
| $E_c$    | = | Controlled area source emissions      |
| $E_{uc}$ | = | Uncontrolled area source emissions    |
| CE       | = | % Control efficiency varied 0 to 100% |
| RP       | = | % Rule penetration varied 0 to 100%   |
| RE       | = | % Rule effectiveness was 96.8%        |

The following sections describe how values for CE, RP and RE were derived from surveys.

### **Rule Effectiveness**

PECHAN evaluated differences in RE between rural/suburban and urban areas, as well as differences in RE for MSW and yard waste burning. Although one may expect that RE would be higher for urban than for suburban or rural areas, ANOVA of the survey results from these geographic subdivisions, as well as for the different open burning categories, did not show that RE values were drawn from distinct populations. Therefore, the final selection of RE reflects a value for all areas and all burning categories.

There were a total of 26 RE survey responses that included information on the number of violating households. To calculate RE, PECHAN used the number of households violating the rule, and the number of households expected to perform open burning for areas in the region where there is no rule (i.e., # households x fraction of open burning households by region from survey).

The RE values obtained from the survey responses will be used for the specific State or jurisdiction surveyed. Non-surveyed areas could not be assigned a jurisdiction-specific RE because no responses were obtained. PECHAN did not develop state specific RE value. They believed that local jurisdictions in individual states implemented their rules the same as local jurisdictions in the MANE-VU region. To estimate a default RE value for the remaining areas, the survey data were statistically analyzed. After evaluating the data using the Census 2000 data, a mean value of 96.8 percent reflected the best estimator of central tendency. As such, PECHAN applied a rule effectiveness of 96.8 percent to all areas and for both MSW and yard waste burning (PECHAN, 2002b).

### **Control Efficiency and Rule Penetration**

For those areas identified to have a control, CE is assumed to be 100 percent (since the control is typically a ban on burning activity). For MSW burning, with the exception of Pennsylvania, PECHAN assigned 100 percent CE and 100 percent RP to urban and suburban areas in the MANE-VU region (i.e., even if the state did not have a statewide ban on burning). In Pennsylvania, unless a jurisdiction or county (e.g., Allegheny County) was determined via survey to have a ban, it will be assumed that suburban and rural areas allow open burning. For yard waste burning, PECHAN assigned 100 percent CE and RP to all urban areas in the MANE-VU region. Yard waste emissions calculated for suburban and urban areas were assumed to be uncontrolled, unless the survey data or other statewide or local control information indicated otherwise. For municipal yard waste burning areas were assumed to either perform this activity

and have associated emissions, or did not conduct burns and therefore were assigned zero emissions.

In determining annual emissions for those areas with a seasonal ban, PECHAN adjusted the RP by the length of the seasonal ban relative to the entire year. The RP value also depends on how the time period of the ban overlaps with the activity profile for the specific category of burning. For example, for brush waste burning, the survey data revealed an average activity profile as follows: Winter–20%; Spring–46%; Summer–6%; and Fall–28%. So, for an area that has a brush burning ban in the summer, although some percentage of burning is likely to be prevented during this season, we assume that 2 percent of the summer season brush burning in August is delayed until September when burning is permitted, resulting in an RP of 4 percent to apply to annual brush waste burning emissions. As mentioned in the discussion of temporal allocation profiles, this also has an affect on the monthly activity profile. A summer RP value of 4 percent would result in a revised temporal allocation profile to be: Winter–20%; Spring–46%; Summer–4%; and Fall–30%.

Control Percentages used for each county:

| STATE CO | SCC        | RE     | RP     | CE     |
|----------|------------|--------|--------|--------|
| 24001    | 2610030000 | 96.80% | 82.61% | 82.61% |
| 24003    | 2610030000 | 96.80% | 93.62% | 100%   |
| 24005    | 2610030000 | 96.80% | 94.80% | 100%   |
| 24009    | 2610030000 | 96.80% | 60.29% | 100%   |
| 24011    | 2610030000 | 96.80% | 28.57% | 28.57% |
| 24013    | 2610030000 | 96.80% | 100%   | 100%   |
| 24015    | 2610030000 | 96.80% | 62.50% | 100%   |
| 24017    | 2610030000 | 96.80% | 68.75% | 100%   |
| 24019    | 2610030000 | 96.80% | 33.33% | 33.33% |
| 24021    | 2610030000 | 96.80% | 71.88% | 100%   |
| 24023    | 2610030000 | 96.80% | 14.29% | 14.29% |
| 24025    | 2610030000 | 96.80% | 80%    | 100%   |
| 24027    | 2610030000 | 96.80% | 92.68% | 100%   |
| 24029    | 2610030000 | 96.80% | 40%    | 40%    |
| 24031    | 2610030000 | 96.80% | 98.31% | 100%   |
| 24033    | 2610030000 | 96.80% | 100%   | 100%   |
| 24035    | 2610030000 | 96.80% | 25%    | 100%   |
| 24037    | 2610030000 | 96.80% | 40%    | 40%    |
| 24039    | 2610030000 | 96.80% | 50%    | 50%    |
| 24041    | 2610030000 | 96.80% | 33.33% | 33.33% |
| 24043    | 2610030000 | 96.80% | 0%     | 0%     |
| 24045    | 2610030000 | 96.80% | 94.12% | 94.12% |
| 24047    | 2610030000 | 96.80% | 75%    | 75%    |
| 24510    | 2610030000 | 96.80% | 0%     | 0%     |

## Spatial and Temporal Allocations

### *Spatial*

PECHAN collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census).

### *Temporal*

Activity estimates and associated emissions are calculated on an annual basis. PECHAN proposes the following temporal allocation profiles to represent monthly, weekly, and daily activity profiles by SCC (see Tables II-2 through II-5). The monthly activity profiles were developed based on data obtained from the survey. The weekly and weekday/weekend profiles were developed based on engineering judgment. These profiles will be applied to annual activity for all areas of MANE-VU (i.e., variations in regional, State, or tribal areas are not accounted for).

Temporal Allocation Profile Formats (monthly)

| SCC        | Month |       |       |       |       |       |       |       |       |       |       |       |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|            | Jan   | Feb   | Mar   | Apr   | May   | Jun   | Jul   | Aug   | Sep   | Oct   | Nov   | Dec   |
| 2610030000 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 |
| 2610000400 | 0.067 | 0.067 | 0.153 | 0.153 | 0.153 | 0.020 | 0.020 | 0.020 | 0.093 | 0.093 | 0.093 | 0.067 |
| 2610040400 | 0.067 | 0.067 | 0.153 | 0.153 | 0.153 | 0.020 | 0.020 | 0.020 | 0.093 | 0.093 | 0.093 | 0.067 |
| 2610000100 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.333 | 0.333 | 0.333 | 0.000 |

Temporal Allocation Profile Formats (weekly)

| SCC        | Day of Week |       |       |       |       |       |       |
|------------|-------------|-------|-------|-------|-------|-------|-------|
|            | Mon         | Tue   | Wed   | Thu   | Fri   | Sat   | Sun   |
| 2610030000 | 0.111       | 0.111 | 0.111 | 0.111 | 0.111 | 0.222 | 0.222 |
| 2610000400 | 0.111       | 0.111 | 0.111 | 0.111 | 0.111 | 0.222 | 0.222 |
| 2610040400 | 0.200       | 0.200 | 0.200 | 0.200 | 0.200 | 0.000 | 0.000 |
| 2610000100 | 0.111       | 0.111 | 0.111 | 0.111 | 0.111 | 0.222 | 0.222 |

Temporal Allocation Profile Formats (daily; weekday)

| SCC        | Weekday Hour |      |      |      |      |      |       |       |       |       |       |       |
|------------|--------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|
|            | 0100         | 0200 | 0300 | 0400 | 0500 | 0600 | 0700  | 0800  | 0900  | 1000  | 1100  | 1200  |
| 2610030000 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000400 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610040400 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000100 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |

| SCC        | Weekday Hour |       |       |       |       |       |       |       |      |      |      |      |
|------------|--------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|
|            | 1300         | 1400  | 1500  | 1600  | 1700  | 1800  | 1900  | 2000  | 2100 | 2200 | 2300 | 0000 |
| 2610030000 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000400 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610040400 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000100 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |



### Temporal Allocation Profile Formats (daily; weekend day)

| SCC        | Weekend Day Hour |      |      |      |      |      |       |       |       |       |       |       |
|------------|------------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|
|            | 0100             | 0200 | 0300 | 0400 | 0500 | 0600 | 0700  | 0800  | 0900  | 1000  | 1100  | 1200  |
| 2610030000 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000400 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610040400 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000100 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |

| SCC        | Weekend Day Hour |       |       |       |       |       |       |       |      |      |      |      |
|------------|------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|
|            | 1300             | 1400  | 1500  | 1600  | 1700  | 1800  | 1900  | 2000  | 2100 | 2200 | 2300 | 0000 |
| 2610030000 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000400 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610040400 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000100 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |

### Emissions Calculation

Emissions were calculated at a census tract level and summed over a county for county level emissions. A county level sample emission calculation will not be presented here, however the equations for a particular census tract are presented below. All of the census tracts in a county would then be summed for county level emission estimates.

The equation for estimating the mass of waste burned is:

$$W_{msw} = HH * Bt * M$$

Where:

- Wt<sub>MSW</sub> = Mass of waste burned per time period
- HH = Number of households that burn (Question 1, Part 2 of survey)
- Bt = Number of burns per time period (Question 3, Part 2)
- M = Mass of waste per burn (Question 5, Part 3)

Uncontrolled emissions were then calculated using the following equation:

$$E_{UNC} = W_{MSW} * EF$$

Where:

- E<sub>UNC</sub> = Uncontrolled area source emissions
- W<sub>MSW</sub> = Mass of waste burned per time period
- EF = Emission factor per pollutant

Controlled emissions were then calculated using the following equation:

$$E_C = E_{UNC} * [(1-(CE)(RP)(RE)]$$

- where: E<sub>C</sub> = Controlled area source emissions
- E<sub>UNC</sub> = Uncontrolled area source emissions

### 3.1.5.5 Open Burning – Residential Yard Waste

SCC: 26 10 000 100 (Leaf Debris)

SCC: 26 10 000 400 (Brush Debris)

#### **Description**

Open burning is the unconfined burning of wood, leaves, land clearing debris, household waste, and agricultural crop waste. Household waste often referred to as residential municipal solid waste (MSW), is a term for nonhazardous refuse produced by households (e.g., paper, plastics, metals, wood, glass, rubber, leather, textiles, and food wastes).

Open burning without a permit is prohibited in Maryland where trash and leaf collection is available, COMAR 26.11.07. The basic difference between the regulation as it applies to counties in AQCRs III and IV and the rest of the state is the requirements under which the burn takes place, i.e., minimum setbacks from property lines, etc. In the more rural counties, areas with no available trash collection are more prevalent. MDE adopted a regulation that prohibits open burning during the peak ozone period (June to August). The seasonal prohibition only affects those counties that lie within serious and severe ozone nonattainment areas. Certain exemptions must be in place however so as not to adversely affect agriculture or restrict fire training and recreational activities.

#### **Pollutants**

VOC, NO<sub>x</sub>, SO<sub>x</sub>, CO, PM<sub>10</sub>, PM<sub>2.5</sub>, and HAPs

#### **Method and Data Sources**

The method used to calculate emissions is presented in a study/survey conducted by the Mid-Atlantic/Northeast Visibility Union (MANE-VU), titled “Open Burning in Residential Areas Emissions Inventory Development Report.”<sup>52</sup>

#### *Activity*

The purpose of the survey was to obtain data for developing activity estimates and control information (e.g., bans on burning) that would form the basis of an improved open burning emission inventory for Mid-Atlantic/Northeast Visibility Union (MANE-VU) states and tribes for the year 2002. But for 2011, the percentages used to calculate emissions are the same; the emissions increase or decrease due to the estimated number of households that burn and the amount of material burned.

A rule effectiveness (RE) survey was also taken to estimate controlled emissions for areas under restriction. Household waste burning surveys were completed for 72 respondents or jurisdictions, while yard waste surveys were conducted for 181 respondents. The respondents for this survey were typically local fire wardens or chiefs. Rule effectiveness surveys related to residential MSW rules were conducted for 49 respondents, while RE

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<sup>52</sup> Open Burning in Residential Areas Emissions Inventory Development Report, Prepared by E.H. PECHAN & Associates, Inc. for the Mid-Atlantic/Northeast Visibility Union, dated January 31, 2004.

surveys for yard waste burning rules were performed for 51 respondents. In obtaining survey responses, PECHAN collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census). PECHAN also developed a control database for each open burning category that describes the recommended control efficiency (CE), rule penetration (RP) values by state per county, and by sub-county, where applicable.

Open burning activity estimates recorded from the survey were used directly to estimate emissions for the surveyed jurisdictions. For the non-surveyed areas, including tribal lands, the default activity data derived from all survey responses were applied. Households are defined as detached single-family unit dwellings, and were updated by using the 2011 U.S. Census.

***Emission Factors***

Emission factors in lbs/ton total mass were taken from AP-42 Table 2.5-1 Emission Factors for Open Burning of Municipal Refuse and from a 1997 EPA research paper on open burning<sup>53</sup> are listed below:

| SCC        | Type of Waste | PM2.5<br>lb/ton | PM10<br>lb/ton | VOC<br>lb/ton | NOX<br>lb/ton | SO2<br>lb/ton | CO<br>lb/ton |
|------------|---------------|-----------------|----------------|---------------|---------------|---------------|--------------|
| 2610030000 | HH MSW        | 34.8            | 38             | 8.56          | 6             | 1             | 85           |
| 2610000100 | Leaf Waste    | 22              | 22             | 28            | 6.2           | 0.76          | 112          |
| 2610000400 | Brush Waste   | 15.21           | 19.73          | 19            | 5             | 1.66          | 140          |

**Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustments for Controls**

If an area has controls or prohibitions on residential burning, controlled emissions were calculated from uncontrolled emissions using the following equation:

$$E_c = E_{uc} * [(1-(CE)(RP)(RE)]$$

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<sup>53</sup> EPA. 1997. Evaluation of Emissions from the Open Burning Of Household Waste in Barrels. EPA-600/R-97-134a. U.S. Environmental Protection Agency, Control Technologies Center / Research Triangle Park, North Carolina

Where:

|          |   |  |
|----------|---|--|
| $E_c$    | = | Controlled area source emissions       |
| $E_{uc}$ | = | Uncontrolled area source emissions     |
| CE       | = | % Control efficiency varied 0% to 100% |
| RP       | = | % Rule penetration varied 0% to 100%   |
| RE       | = | % Rule effectiveness 96.8%             |

The following sections describe how values for CE, RP, and RE were derived from surveys.

### **Rule Effectiveness**

PECHAN evaluated differences in RE between rural/suburban and urban areas, as well as differences in RE for MSW and yard waste burning. Although one may expect that RE would be higher for urban than for suburban or rural areas, ANOVA of the survey results from these geographic subdivisions, as well as for the different open burning categories, did not show that RE values were drawn from distinct populations. Therefore, the final selection of RE reflects a value for all areas and all burning categories.

There were a total of 26 RE survey responses that included information on the number of violating households. To calculate RE, PECHAN used the number of households violating the rule, and the number of households expected to perform open burning for areas in the region where there is no rule (i.e., # households x fraction of open burning households by region from survey).

The RE values obtained from the survey responses will be used for the specific State or jurisdiction surveyed. Non-surveyed areas could not be assigned a jurisdiction-specific RE because no responses were obtained. PECHAN did not develop state specific RE value. They believed that local jurisdictions in individual states implemented their rules the same as local jurisdictions in the MANE-VU region. To estimate a default RE value for the remaining areas, the survey data were statistically analyzed. After evaluating the data using the Census 2000 data, a mean value of 96.8 percent reflected the best estimator of central tendency. As such, PECHAN applied a rule effectiveness of 96.8 percent to all areas and for both MSW and yard waste burning (PECHAN, 2002b).

### **Control Efficiency and Rule Penetration**

For those areas identified to have a control, CE is assumed to be 100 percent (since the control is typically a ban on burning activity). For MSW burning, with the exception of Pennsylvania, PECHAN assigned 100 percent CE and 100 percent RP to urban and suburban areas in the MANE-VU region (i.e., even if the state did not have a statewide ban on burning). In Pennsylvania, unless a jurisdiction or county (e.g., Allegheny County) was determined via survey to have a ban, it will be assumed that suburban and rural areas allow open burning. For yard waste burning, PECHAN assigned 100 percent CE and RP to all urban areas in the MANE-VU region. Yard waste emissions calculated for suburban and urban areas were assumed to be uncontrolled, unless the survey data or other statewide or local control information indicated otherwise. For the municipal yard waste burning category, areas that performed this activity had associated emissions, or did not conduct burns and therefore were assigned zero emissions.

In determining annual emissions for those areas with a seasonal ban, PECHAN adjusted the RP by the length of the seasonal ban relative to the entire year. The RP value also depends on how the time period of the ban overlaps with the activity profile for the specific category of burning. For example, for brush waste burning, the survey data revealed an average activity profile as follows: Winter–20%; Spring–46%; Summer–6%; and Fall–28%. So, for an area that has a brush burning ban in the summer, although some percentage of burning is likely to be prevented during this season, we assume that 2 percent of the summer season brush burning in August is delayed until September when burning is permitted, resulting in an RP of 4 percent to apply to annual brush waste burning emissions. As mentioned in the discussion of temporal allocation profiles, this also has an affect on the monthly activity profile. A summer RP value of 4 percent would result in a revised temporal allocation profile to be: Winter–20%; Spring–46%; Summer– 4%; and Fall–30%.

**Spatial and Temporal Allocations**

*Spatial*

PECHAN collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census).

*Temporal*

Activity estimates and associated emissions are calculated on an annual basis. PECHAN proposes the following temporal allocation profiles to represent monthly, weekly, and daily activity profiles by SCC (see Tables II-2 through II-5). The monthly activity profiles were developed based on data obtained from the survey. The weekly and weekday/weekend profiles were developed based on engineering judgment. These profiles will be applied to annual activity for all areas of MANE-VU (i.e., variations in regional, State, or tribal areas are not accounted for).

Temporal Allocation Profile Formats (monthly)

| SCC        | Month |       |       |       |       |       |       |       |       |       |       |       |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|            | Jan   | Feb   | Mar   | Apr   | May   | Jun   | Jul   | Aug   | Sep   | Oct   | Nov   | Dec   |
| 2610030000 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 |
| 2610000400 | 0.067 | 0.067 | 0.153 | 0.153 | 0.153 | 0.020 | 0.020 | 0.020 | 0.093 | 0.093 | 0.093 | 0.067 |
| 2610040400 | 0.067 | 0.067 | 0.153 | 0.153 | 0.153 | 0.020 | 0.020 | 0.020 | 0.093 | 0.093 | 0.093 | 0.067 |
| 2610000100 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.333 | 0.333 | 0.333 | 0.000 |

Temporal Allocation Profile Formats (weekly)

| SCC        | Day of Week |       |       |       |       |       |       |
|------------|-------------|-------|-------|-------|-------|-------|-------|
|            | Mon         | Tue   | Wed   | Thu   | Fri   | Sat   | Sun   |
| 2610030000 | 0.111       | 0.111 | 0.111 | 0.111 | 0.111 | 0.222 | 0.222 |
| 2610000400 | 0.111       | 0.111 | 0.111 | 0.111 | 0.111 | 0.222 | 0.222 |
| 2610040400 | 0.200       | 0.200 | 0.200 | 0.200 | 0.200 | 0.000 | 0.000 |
| 2610000100 | 0.111       | 0.111 | 0.111 | 0.111 | 0.111 | 0.222 | 0.222 |

Temporal Allocation Profile Formats (daily; weekday)

| SCC        | Weekday Hour |      |      |      |      |      |       |       |       |       |       |       |
|------------|--------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|
|            | 0100         | 0200 | 0300 | 0400 | 0500 | 0600 | 0700  | 0800  | 0900  | 1000  | 1100  | 1200  |
| 2610030000 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000400 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610040400 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000100 | 0            | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |

| SCC        | Weekday Hour |       |       |       |       |       |       |       |      |      |      |      |
|------------|--------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|
|            | 1300         | 1400  | 1500  | 1600  | 1700  | 1800  | 1900  | 2000  | 2100 | 2200 | 2300 | 0000 |
| 2610030000 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000400 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610040400 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000100 | 0.071        | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |

Temporal Allocation Profile Formats (daily; weekend day)

| SCC        | Weekend Day Hour |      |      |      |      |      |       |       |       |       |       |       |
|------------|------------------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|
|            | 0100             | 0200 | 0300 | 0400 | 0500 | 0600 | 0700  | 0800  | 0900  | 1000  | 1100  | 1200  |
| 2610030000 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000400 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610040400 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |
| 2610000100 | 0                | 0    | 0    | 0    | 0    | 0    | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 |

| SCC        | Weekend Day Hour |       |       |       |       |       |       |       |      |      |      |      |
|------------|------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|
|            | 1300             | 1400  | 1500  | 1600  | 1700  | 1800  | 1900  | 2000  | 2100 | 2200 | 2300 | 0000 |
| 2610030000 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000400 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610040400 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |
| 2610000100 | 0.071            | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0    | 0    | 0    | 0    |

**Emissions Calculation**

Emissions were calculated at a census tract level and summed over a county for county level emissions. A county level sample emission calculation will not be presented here, however the equations for a particular census tract are presented below. All of the census tracts in a county would then be summed for county level emission estimates.

The equation for estimating the mass of waste burned is:

$$W_{tmsw} = HH * B_t * M$$

Where:

- $W_{tmsw}$  = Mass of waste burned per time period
- HH = Number of households that burn (Question 1, Part 2 of survey)
- $B_t$  = Number of burns per time period (Question 3, Part 2)
- M = Mass of waste per burn (Question 5, Part 3)

Uncontrolled emissions were then calculated using the following equation:

$$E_{UNC} = Wt_{MSW} * EF$$

Where:

$E_{UNC}$  = Uncontrolled area source emissions

$Wt_{MSW}$  = Mass of waste burned per time period

$EF$  = Emission factor per pollutant

Controlled emissions were then calculated using the following equation:

$$E_C = E_{UNC} * [(1-(CE)(RP)(RE)]$$

Where:

$E_C$  = Controlled area source emissions

$E_{UNC}$  = Uncontrolled area source emissions

$CE$  = % Control efficiency/100

$RP$  = % Rule penetration/100

$RE$  = % Rule effectiveness/100

### 3.1.5.6 Cremation – Animal and Human

SCC: 28 10 060 100 (Humans)  
28 10 060 200 (Animals)

#### **Description**

Propane-fired burners (afterburner and ignition) are typically used at cemeteries for human body and animal cremation. Burners are usually rated at 2,115,000 Btu per hour capacity. Newer units installed in the late 1980's are equipped with a modulating ignition burner. When afterburner temperatures reach about 1800 F (980 C), the ignition burner modulates to a low-fire mode that will reduce the Btu per hour usage.

When the crematory reaches an operating temperature of 1,250 F (680 C) the body container is placed on the combustion chamber grate and the ignition burner is fired to attain a target combustion temperature sufficient for the proper reduction of human remains. The chamber preheats by the afterburner reaches 1,250 F (680 C) in about 30 to 45 minutes prior to ash removal. When the body container is introduced into the combustion chamber, and the burner is ignited, cremation begins at about 1600 to 1800 F (870 to 980 C). Flame impingement on the body takes two to three minutes; cremation occurs for about two hours. The remains are then raked towards the ignition burner for about two minutes. Cool-down follows for 45 minutes to 1.5 hours.

#### **Pollutants**

HAPs (Criteria Pollutants were not calculated)

#### **Method and Data Sources**

The method used to calculate emissions, is presented in “Documentation for the 1996 Base Year National Toxics Inventory for Area Sources” prepared by Eastern Research Group, Inc. (May 31, 2001) and distributed by U.S. EPA Emissions, Monitoring and Analysis Division, Emission Factor and Inventory Group.

#### ***Activity***

In Maryland crematories are regulated under COMAR. COMAR now requires all crematories to obtain a permit to operate and any person who owns or operates an crematory must obtain certification from MDE and renew the certification annually.

MDE/ARMA maintains a registry of all crematories within the State. Because of the requirement for a permit to operate, and the operator certification requirements, staff used the sum of the crematories in the registry as representing the total area source emissions from crematories of all types emitting less than 10 tons/VOC, 100 tons/yr CO and 50 tons per year NO<sub>x</sub>.



### ***Emission Factors***

Emission factors these hazardous air pollutants, except formaldehyde, were taken from the State of California Air Resources Board Test Report No. C-90-004<sup>54</sup>. The emission factor used for formaldehyde was reported in the USEPA FIRE<sup>55</sup> system database.

Emission factors were converted to a pound per ton basis using the procedure provided by the Emission Standards Division<sup>56</sup>. National activity was provided by the Emissions Standards Division based on an assumed body weight of 150 pounds and information reported by the Cremation Association of North America<sup>57</sup> that 21.13 percent of bodies were cremated and that there were 2,322,265 deaths in the United States in 1996<sup>58</sup>.

| Pollutant     | Animal and Human Cremation    |  |
|---------------|-------------------------------|--|
|               | Emission Factor               |  |
|               | Lbs. pollutant / ton cremated |  |
| arsenic       | 4.00E-04                      |  |
| beryllium     | 1.84E-05                      |  |
| cadmium       | 1.48E-04                      |  |
| chromium      | 3.99E-04                      |  |
| formaldehyde  | 2.89E-09                      |  |
| nickel        | 5.09E-04                      |  |
| POM as 16-PAH | 9.63E-04                      |  |
| POM as 7-PAH  | 1.03E-09                      |  |
| Mercury       | 4.39E-02                      |  |

### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

### **Adjustments for Controls**

No controls are available for this source category.

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<sup>54</sup> State of California Air Resources Board, Engineering Evaluation Branch, Monitoring and Laboratory Division. "Evaluation Test on Two Propane Fired Crematories at Camellia Lawn Cemetary." Test Report No. C-90-004. October 29, 1992

<sup>55</sup> U.S. EPA. Factor Information Retrieval (FIRE) System Database, Version 5.1a. Research Triangle Park, NC. September 1995.

<sup>56</sup> Crume, Richard, U.S. EPA, Emission Standards Division. Note to Anne Pope, U.S. EPA/Emissions Monitoring and Analysis Division. Comments on Human and Animal Cremation information in the "Baseline Emission Inventory of HAP Emissions from MACT Sources – Interim Final Report," September 18, 1998. October 30, 1998.

<sup>57</sup> Cremation Association of North America. 1996 Statistics as found on the Internet Cremation Society, Cremation Stats Nationwide webpage: [www.cremation.org/stats.htm](http://www.cremation.org/stats.htm)

<sup>58</sup> Ventura, S. et al. "Births and Deaths: United States, 1996." Monthly Vital Statistics Report, Vol. 64, No. 1, Supplement 2. September 11, 1997. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health and Statistics.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation for estimating emissions from crematories is:

$$E_{CREM} = \frac{TON_{cty} * EF}{2000}$$

Where:

- E<sub>CREM</sub> = Annual emissions from crematories
- TON<sub>cty</sub> = Tons cremated per year in county
- EF = Emission Factor per pollutant (lbs/ton)

2011 Sample Calculation (Harford County)

Arsenic Annual Emissions:

$$E_{CREM} = \frac{TON_{cty} * EF}{2000}$$

- TON<sub>cty</sub> = 226.67
- EF = 0.0004 lbs Arsenic/Ton Cremated

$$E_{CREM} = \frac{(226.67) \times (0.0004)}{(2000 \text{ lbs/ton})}$$

$$E_{CREM} = 4.53E-05 \text{ tons Arsenic per year}$$

### 3.1.5.7 Municipal Solid Waste Landfills

SCC: 26 20 030 000

#### Description

Municipal solid waste landfills receive household and commercial trash. VOC emissions are produced from volatilization, chemical reaction and biological decomposition of waste. Methane and Carbon dioxide are the primary constituents of landfill gas, and are produced during anaerobic decomposition of cellulose and proteins in the land filled waste. 98.7 percent of landfill emissions are methane and carbon dioxide according to the Volatile Organic Compounds Species Data Manual, an EPA publication. In addition to methane and carbon dioxide, non-methane organic carbons (NMOCs) are produced as a small fraction of the landfill gas emissions (less than 1%). NMOCs include hazardous air pollutants and reactive VOCs.

#### Pollutants

VOC

#### Method and Data Sources

The method used to calculate emissions, is presented in AP-42, Chapter 2.4, Municipal Solid Waste Landfills and EIIP<sup>59</sup>, Volume III, Chapter 15, Landfills, dated September 1997.

Emission estimation assumptions were also made using supporting documents Standards of Performance for New Stationary Sources (NARA, 1991a) and Emission Guidelines for Control of Existing Sources (NARA, 1997b).

To estimate emissions for the various compounds present in landfill gas, total landfill gas emissions must first be estimated. Emissions of landfill gas were calculated using a computer program known as the Landfill Gas Emissions Model (LandGEM 3.02). The model equation is as follows:

$$Q_{CH_4} = \sum_{i=1}^n \sum_{j=0.1}^1 kL_o \left( \frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where:

$Q_{CH_4}$  = annual methane generation in the year of the calculation (m<sup>3</sup>/year)

$i$  = 1 year time increment

$n$  = (year of the calculation) - (initial year of waste acceptance)

$j$  = 0.1 year time increment

$k$  = methane generation rate (year<sup>-1</sup>)

$L_o$  = potential methane generation capacity (m<sup>3</sup>/Mg)

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<sup>59</sup> Emission Inventory Improvement Program

$M_i$  = mass of waste accepted in the  $i^{\text{th}}$  year (Mg)

$t_{ij}$  = age of the  $j^{\text{th}}$  section of waste mass  $M_i$  accepted in the  $i^{\text{th}}$  year (decimal years, e.g., 3.2 years)

Site-specific landfill information is generally available for variables  $M_i$ ,  $n$ , and  $t_{ij}$ . A more detailed explanation on how to run the model can be found in the LandGEM 3.02 Users Guide at <http://www.epa.gov/ttn/catc1/dir1/landgem-v302-guide.pdf>.

#### Landgem Model Parameters AP-42 Default Values

|                                    |                                  |
|------------------------------------|----------------------------------|
| $L_o$ : 100.00 m <sup>3</sup> / Mg | Methane Generation Potential     |
| $k$ : 0.0400 1/yr                  | Decay Rate/Rate of Decomposition |
| NMOC : 595.00 ppmv                 | Non-methane Concentration        |
| Methane : 50.00 % volume           |                                  |
| Carbon Dioxide : 50.00 % volume    |                                  |

#### *Activity*

Data was obtained from MDE's Solid Waste Program and from the landfill facilities directly.

#### *Emission Factors*

All factors are incorporated into the LandGEM model.

### Point Source Adjustments

Thirteen municipal solid waste landfills were considered point sources and LandGEM model runs for these landfills were done, but keep out of the Area source emission estimates. Emission reductions were calculated for landfills that used control technology to reduce emissions.

### Adjustments for Controls

Controlled emissions from landfills were calculated in the following manner:

#### Equation:

$$E_{\text{CON-LF}} = \{E_{\text{UNC-LF}} \times (1 - C_{\text{EFF}})\} + \{E_{\text{UNC-LF}} \times C_{\text{EFF}} \times [1 - (D_{\text{EFF}} \times \text{RE})]\}$$

Where:

- $E_{\text{CON-LF}}$  = Controlled emissions from landfills
- $E_{\text{UNC-LF}}$  = Uncontrolled emissions from landfills (generated from the LandGEM model)
- $C_{\text{EFF}}$  = Landfill collection efficiency (EPA default = 75%)
- $D_{\text{EFF}}$  = Control device destruction efficiency (98%)
- $\text{RE}$  = Rule effectiveness (EPA default 80%)

### Spatial and Temporal Allocations

Data for spatial and temporal allocation is not available for this source.

### **3.1.6 SMALL STATIONARY SOURCE FOSSIL FUEL USE**

#### **3.1.6.1 Small Electric Utility Boilers**

All small electric utility boilers are inventoried in the point source category. The list of small boilers from Inventory of Power Plants in the United States, DOE/EIA-0095(88) was obtained and indicated that all small electric boilers were included in the point source inventory.

#### **3.1.6.2 Other Fuel Consumption**

Coke and process gas emissions will be inventoried as point sources.

### 3.1.6.3 Fuel Oil Combustion

SCC: 21 04 011 000 (residential kerosene)  
 21 03 011 000 (commercial/institutional kerosene)  
 21 04 004 000 (residential distillate oil)  
 21 03 004 000 (commercial/institutional distillate oil)  
 21 03 005 000 (commercial/institutional residual oil)

#### Description

Data collection for fuel oil consumption covers the use of both distillate and residual oil. Distillate oil includes fuel oil grades 1,2 and 4. Diesel fuel and kerosene also can be considered as distillate oils. Residential and commercial/institutional sources are the largest consumers of distillate oil, nationwide. Residual oil includes fuel oil grades 5 and 6. In most areas residual oil is not used by residential sources, but industrial and commercial/institutional users may consume significant amounts.

#### Pollutants

PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub>, NO<sub>x</sub>, CO, VOC

#### Method and Data Sources

##### *Activity*

Total sales statistics of kerosene, distillate oil, and residual oil in the State of Maryland were obtained from the Annual Report on Sales of Fuel Oil and Kerosene, 2011, published by Energy Information Administration, U.S. Department of Energy<sup>60</sup>.

##### *Emission Factors*

**Uncontrolled Emission Factors – AP-42 Tables 1.3-1 and 1.3-3 (hand-fed units)**

|                  | Residential Distillate<br>lbs/Kgal | Residential Kerosene<br>lbs/Kgal | Commercial Distillate<br>lbs/Kgal | Commercial Kerosene<br>lbs/Kgal | Commercial Residual<br>lbs/Kgal | Commercial Residual 1% S<br>lbs/Kgal |
|------------------|------------------------------------|----------------------------------|-----------------------------------|---------------------------------|---------------------------------|--------------------------------------|
| <b>PM10-FIL</b>  | 1.080                              | 1.080                            | 1.080                             | 1.080                           | 13.494                          | 7.703                                |
| <b>PM2.5-FIL</b> | 0.830                              | 0.830                            | 0.830                             | 0.830                           | 5.011                           | 2.861                                |
| <b>PM-CON</b>    | 1.300                              | 1.300                            | 1.300                             | 1.300                           | 1.500                           | 1.500                                |
| <b>NH3</b>       | 1.000                              | 1.000                            | 0.800                             | 0.800                           | 0.800                           | 0.800                                |
| <b>SO2</b>       | 43.200                             | 41.657                           | 43.200                            | 41.657                          | 318.000                         | 159.000                              |
| <b>NOx</b>       | 18.000                             | 18.000                           | 20.000                            | 20.000                          | 55.000                          | 55.000                               |
| <b>CO</b>        | 5.000                              | 5.000                            | 5.000                             | 5.000                           | 5.000                           | 5.000                                |
| <b>VOC</b>       | 0.713                              | 0.713                            | 0.340                             | 0.340                           | 1.130                           | 1.130                                |

<sup>60</sup> Total residential distillate oil use in the State of Maryland in 2011 from U.S Department of Energy, Energy Information Administration, Office of Oil and Gas, Petroleum Marketing Monthly, "Annual Report on Sales of Fuel Oil and Kerosene, 2011".

## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

## Adjustments for Controls

No controls are available for this source category.

## Spatial and Temporal Allocations

### *Spatial*

This information on total sales of kerosene, distillate oil and residual oil was broken down to the county level using a spatial allocation factor documented and recommended by EIIP<sup>61</sup> in an Area Source Method Abstract for Residential and Commercial/Institutional Fuel Oil and Kerosene combustion.

MDE developed an allocation factor from local and state totals of annual heating-degree days and population with fuel oil to spatially allocate fuel oil consumption. The method is

A “heating-degree day” is a unit of measure used to indicate how cold it has been over a 24-hour period. Daily heating-degree days are calculated as the difference between the base value of 65°F and the mean temperature for the day (mean of the high and low temperatures for the day).

Annual heating degree days are the sum of the daily heating degree days. Heating degree data is available from the National Oceanographic and Atmospheric Administration (NOAA).<sup>62</sup>

$$SAF_{InventoryCounty} = \frac{HDD_{InventoryCounty} * POP_{InventoryCounty}}{\sum_{AllCountiesInState} (HDD_{County} * POP_{County})}$$

Where:

|                         |   |   |
|-------------------------|---|---|
| $SAF_{InventoryCounty}$ | = | Spatial apportioning factor for inventory county        |
| $HDD_{InventoryCounty}$ | = | Annual heating degree days for inventory county         |
| $POP_{InventoryCounty}$ | = | Population of the inventory county                      |
| $HDD_{County}$          | = | Annual heating degree days for each county in the state |
| $POP_{County}$          | = | Population for each county in the state                 |

---

<sup>61</sup> Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Residential and Commercial/Institutional Fuel Oil and Kerosene Combustion, dated April 2011.

<sup>62</sup> <http://www.noaa.gov> (home page) or <http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS> (for a list of available data)

The spatial apportioning factor is used to allocate the state fuel total to the county level using the following equation:

$$\text{Fuel}_{\text{INVENTORY COUNTY}} = \text{SAF}_{\text{INVENTORY COUNTY}} \times \text{Fuel}_{\text{TOTAL STATE}}$$

Where:

$$\begin{aligned} \text{Fuel}_{\text{INVENTORY COUNTY}} &= \text{Total Fuel consumed annually in the inventory county} \\ \text{Fuel}_{\text{TOTAL STATE}} &= \text{Total Fuel consumed annually in the state} \end{aligned}$$

### *Temporal*

Kerosene, distillate oil, and residual oil are almost entirely used for space heating. MDE made the assumption that the amount of fuel consumed in a county over the course of a month is proportional to the number of heat degree days in that county for the month.

The total amount of fuel consumed in the county annually is allocated from state totals using the following formula.

$$\text{Fuel}_{\text{InventoryCountyAnnual}} = \text{SAF}_{\text{InventoryCounty}} * \text{Fuel}_{\text{TotalState}}$$

Where:

$$\begin{aligned} \text{Fuel}_{\text{InventoryCountyAnnual}} &= \text{Total Fuel consumed annually in the inventory county} \\ \text{Fuel}_{\text{TotalState}} &= \text{Total Fuel consumed annually in the state} \end{aligned}$$

The amount of fuel consumed in a month per county is proportional to the number heat degree days for the month in the county divided by the total number heat degree days for the year in the county.

$$\text{Fuel}_{\text{InventoryCountyPerMonth}} = \text{Fuel}_{\text{InventoryCountyAnnual}} * \frac{\text{HDD}_{\text{InventoryCounty-Month}}}{\text{HDD}_{\text{InventoryCounty-Annual}}}$$

## **Emissions Calculation**

### *Activity Data Gathered*

- Total amount of fuel (kerosene, distillate oil, and residual oil) consumed in the state.
- Number of heat degree days per county per month for the year of the inventory.

### *Calculate Spatial Apportioning Factor*

$$\text{SAF}_{\text{InventoryCounty}} = \frac{\text{HDD}_{\text{InventoryCounty}} * \text{POP}_{\text{InventoryCounty}}}{\sum_{\text{AllCountiesInState}} (\text{HDD}_{\text{County}} * \text{POP}_{\text{County}})}$$



***Apportion State Fuel Consumption to the County Level***

$$F_{I-CTY} = SAF_{CTY} \times F_{ST} \text{ (see Appendices)}$$

Where

$F_{I-CTY}$  = Fuel type I consumed in county

$SAF_{CTY}$  = Spatial apportioning factor for inventory county

$F_{ST}$  = Total fuel consumed in the state.

***Calculate Annual Emissions***

Emissions were calculated in tons/year for residential, commercial and industrial categories from each type of fuel combustion using following equations.

$$EM_R = (F_{I-CTY} \times EF_R) / 2000$$

Where

$EM_R$  = Emissions from residential category.

$F_{I-CTY}$  = Total annual residential sales of fuel i in the county.

$EF_R$  = Residential emission factor for fuel i from AP-42

$$EM_C = (F_{I-CTY} \times EF_C) / 2000$$

Where

$EM_C$  = Emissions from commercial/institutional category.

$F_{I-CTY}$  = Total annual commercial/institutional sales of fuel i in the county.

$EF_C$  = Commercial emission factor for fuel i from AP-42.

**Residential Distillate Oil Combustion Sample Calculation (Baltimore City)**

Residential Distillate Oil Consumed State of Maryland = **6,143**<sup>63</sup> kilogallons

Spatial apportioning factor for Baltimore City:

$$SAF_{\text{Baltimore City}} = \frac{HDD_{\text{Baltimore City}} \times POP_{\text{Units Heating Baltimore City}}^{64}}{\sum_{\text{ALL COUNTIES IN STATE}} (HDD_{\text{COUNTY}} \times POP_{\text{Units Heating State}})}$$

$$SAF_{\text{Baltimore City}} = \mathbf{0.089899}$$

To calculate the total annual kilogallons of distillate oil used in city of Baltimore for residential space heating:

$$Fuel_{\text{Baltimore City}} = SAF_{\text{Baltimore City}} \times Fuel_{\text{TOTAL STATE}}$$

$$Fuel_{\text{Baltimore City}} = \mathbf{0.089899} \times \mathbf{6,143,000}$$

<sup>63</sup> From EIA: Adjusted Sales for Residential End Use: Distillate Fuel Oil and Kerosene, 2011 (Thousand Barrels)

<sup>64</sup> Population data from the U.S. Bureau of the Census, The Maryland Department of Planning.

$$\text{Fuel}_{\text{Baltimore City}} = 552.25 \text{ kilogallons}$$

#### Annual Emissions Calculation

$$E_{\text{Baltimore City - Res - VOC}} = \text{Fuel}_{\text{Baltimore City}} \times EF_{\text{VOC}}$$

$$E_{\text{Baltimore City - Res - VOC}} = 552.25 \times 0.713$$

$$E_{\text{Baltimore City - Res - VOC}} = 393.75 \text{ lbs}_{\text{VOC}} / \text{year}$$

$$E_{\text{Baltimore City - Res - VOC}} = 0.1969 \text{ tons}_{\text{VOC}} / \text{year}$$

All pollutants (PM, SO<sub>x</sub>, NO<sub>x</sub>, VOC, and CO) are calculated in a similar manner.

Commercial and industrial emissions from this source category are calculated in a similar manner with the exception that the number of days in an ozone season changes from 214 for residential to 168 for commercial and industrial. Residential ozone season days are based on 7 days per week activity. Commercial and industrial ozone season days are based on 6 days per week activity.

### 3.1.6.4 Coal Combustion

SCC: 21 04 002 000 (Residential Coal)

SCC: 21 03 002 000 (Commercial/Institutional Coal)

#### **Description Residential Coal**

This source category covers air emissions from coal combustion in the residential sector. Bituminous coal, mined here in Maryland, represents the bulk of the coal used residentially for space heating in the State. Although mined nearby in Pennsylvania, readily available, and cleaner burning, anthracite coal is not used much in Maryland because of its expense.

#### **Pollutants**

PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub>, NO<sub>x</sub>, CO, VOC

#### **Method and Data Sources**

##### *Activity*

The following assumptions were made in the computation of emissions from coal combustion from the residential sources.

(i) Number of Dwelling Units using Coal

The number of dwelling units using coal for space heating for 2011 was obtained from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing; the number of new housing units authorized for construction between 1990 and 2011 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (<http://www.op.state.md.us>). MDE estimated that no new housing units would be equipped to burn coal as a home heating fuel.

COMAR 26.11.09.04 prohibits the use of solid fuel-burning equipment that has a rated heat input of less than 35 million BTU per hour.

(ii) Residential Coal Activity Consumption Data

The State Energy Data Report, Consumption Estimates, by the Energy Information Administration, provided information on estimated coal consumption. The report indicates that in Maryland mostly bituminous coal was used in 2011. It was assumed, therefore, that bituminous coal was consumed by most of the hand-fired residential coal sources in the State of Maryland.

### *Emission Factors*

Emission factors were obtained from AP-42, Tables 1.1-3 and 1.1-4 (Residential-hand-fed units) and PM2.5 from ERTAC.

| <b>Coal Emission Factors</b> |  |                                |                                 |                                      |                                       |  |
|------------------------------|--|--------------------------------|---------------------------------|--------------------------------------|---------------------------------------|--|
|                              | <b>NO<sub>x</sub></b><br><b>(lbs./ton)</b> | <b>CO</b><br><b>(lbs./ton)</b> | <b>VOC</b><br><b>(lbs./ton)</b> | <b>PM10-PRI</b><br><b>(lbs./ton)</b> | <b>PM2.5-PRI</b><br><b>(lbs./ton)</b> | <b>SO<sub>2</sub></b><br><b>(lbs./ton)</b> |
| Residential                  | 9.1  | 275                            | 10                              | 6.2                                  | 3.84                                  | 37.2                                       |

Maryland's 2008 average sulfur content in coal = 1.2% Sulfur DOE/EIA State Electricity Profiles 2008, March 2010 **Table 6. page 124**  
AP42 Table 1.1-19 (hand fed units) Emission factor SO<sub>2</sub> = 31S  
In formula  $S = 1.2$ , such that  $SO_2 \text{ EF} = 31 * 1.2 = 37.2 \text{ lb/ton}$

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustments for Controls**

No controls are available for this source category.

#### **Spatial and Temporal Allocations**

##### *Spatial*

MDE developed an allocation factor from local and state totals of annual heating-degree days and housing units heating with coal to spatially allocated coal consumption. The method is documented and recommended by EIIP<sup>65</sup> in an Area Source Method Abstract for natural gas and LPG combustion. Because the emission factor was specifically adjusted to reflect seasonal emissions through heating degree days, no further seasonal adjustment factor is necessary.

A "heating-degree day" is a unit of measure used to indicate how cold it has been over a 24-hour period. Daily heating-degree days are calculated as the difference between the base value of 65°F and the mean temperature for the day (mean of the high and low temperatures for the day).

Annual heating-degree days are the sum of the daily heating-degree days. Heating degree data is available from the National Oceanographic and Atmospheric Administration (NOAA).<sup>66</sup>

$$SAF_{InventoryCounty} = \frac{HDD_{InventoryCounty} * CHU_{InventoryCounty}}{\sum_{AllCountiesInState} (HDD_{County} * CHU_{County})}$$

Where:

- SAF<sub>INVENTORY COUNTY</sub> = Spatial apportioning factor for inventory county
- HDD<sub>INVENTORY COUNTY</sub> = Annual heating degree days for inventory county
- CHU<sub>INVENTORY COUNTY</sub> = Housing units using coal in inventory county
- HDD<sub>COUNTY</sub> = Annual heating degree days for each county in the state
- CHU<sub>COUNTY</sub> = Housing units using coal for each county in the state

The spatial apportioning factor is used to allocate the state fuel total to the county level using the following equation:

$$Coal_{INVENTORY COUNTY} = SAF_{INVENTORY COUNTY} \times Coal_{TOTAL STATE}$$

Where:

- Coal<sub>INVENTORY COUNTY</sub> = Total Coal fuel consumed in the inventory county
- Coal<sub>TOTAL STATE</sub> = Total Coal fuel consumed in the state.

### *Temporal*

MDE assumed that all residential coal combustion is used for space heating purposes. The total coal consumed in the county can be allocated by month or period using proportions of annual and monthly (or period) heating-degree days.

$$Residential\ Fuel_{MONTH} = Residential\ Fuel_{ANNUAL} \times \frac{HDD_{MONTH}}{HDD_{ANNUAL}}$$

Where:

- Residential Fuel<sub>MONTH</sub> = Space heating fuel use for inventory month
- Residential Fuel<sub>ANNUAL</sub> = Space heating fuel use for inventory year
- HDD<sub>MONTH</sub> = Heating degree days for inventory month
- HDD<sub>ANNUAL</sub> = Heating degree days for inventory year

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<sup>66</sup> <http://www.noaa.gov> (home page) or <http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS> (for a list of available data)

**Emissions  
Calculation**

Equation:

$$E_{\text{COALR}} = \frac{(EF_{\text{COAL}i} \times \text{Coal}_{\text{INVENTORY COUNTY}})}{2000}$$

$E_{\text{COALR}}$  = Yearly emissions from residential coal combustion  
 $EF_{\text{COAL}i}$  = Emission factor for coal combustion for pollutant i

Residential Coal Combustion Sample Calculation (Allegheny County) (tons / year)

Total Residential Coal Consumption – State of Maryland 2,000 tons

To calculate spatial apportioning factor for Allegheny County:

$$SAF_{\text{ALLEGANY COUNTY}} = \frac{HDD_{\text{INVENTORY COUNTY}} \times CHU_{\text{INVENTORY COUNTY}}}{\sum \text{ALL COUNTIES IN STATE } (HDD_{\text{COUNTY}} \times CHU_{\text{COUNTY}})}$$

$$SAF_{\text{ALLEGANY COUNTY}} = \mathbf{0.2013417}$$

To calculate tons of coal used in Allegheny County:

$$\begin{aligned} \text{Residential Coal}_{\text{ALLEGANY COUNTY}} &= SAF_{\text{ALLEGANY COUNTY}} \times \text{Coal}_{\text{TOTAL STATE}} \\ \text{Residential Coal}_{\text{ALLEGANY COUNTY}} &= \mathbf{0.2013417} \times 2,000 \\ \text{Residential Coal}_{\text{ALLEGANY COUNTY}} &= 402.68 \text{ tons} \end{aligned}$$

Equation:

Residential Coal SO<sub>2</sub> Emission Calculation for Allegheny County

$$E_{\text{COALR}} = \frac{(EF_{\text{COAL SO}_2} \times \text{Coal}_{\text{ALLEGANY COUNTY}})}{2000}$$

$$E_{\text{COALR}} = \frac{(37.2 \times 402.68)}{2000}$$

$$E_{\text{COALR}} = 7.490 \text{ tons SO}_2 \text{ year}$$

**Description -  
Commercial and  
Institutional Coal**

Commercial and Institutional sources of coal combustion above the point source threshold are included in the point source portion of the inventory. The following table lists area source emissions from commercial and institutional sources smaller than the threshold values.

**Methods and  
Data Sources**

The following assumptions were made in the computation of emissions from coal combustion from the commercial and institutional sources not included in the point source inventory.

*Activity*

- (i) Coal Consumption Data

The State Energy Data Report (SEDR) estimated that approximately 31,000 tons/year of total coal was used commercially by Maryland in 2011.

- (ii) Number of Dwelling Units using Coal

The number of dwelling units using coal for space heating for 2011 was developed from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2011 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (<http://www.op.state.md.us>). MDE estimated that no new housing units would be equipped to burn coal as a home heating fuel.

COMAR 26.11.09.04 prohibits the use of solid fuel-burning equipment that has a rated heat input of less than 35 million BTU per hour.

*Emission Factors*

EMISSION FACTORS WERE OBTAINED FROM AP-42, TABLES 1.1-3 AND VOCS (TNMOC) TABLE 1.1-19 (AVERAGE OF OVERFEED AND UNDERFEED STOKER). PM10 AND PM2.5 EF ON TABLES 1.1-10 AND 1.1-11

| <b>Coal Emission Factors</b>  |  |                                |                                 |                                      |                                       |  |
|-------------------------------|--|--------------------------------|---------------------------------|--------------------------------------|---------------------------------------|--|
|                               | <b>NO<sub>x</sub></b><br><b>(lbs./ton)</b> | <b>CO</b><br><b>(lbs./ton)</b> | <b>VOC</b><br><b>(lbs./ton)</b> | <b>PM10-PRI</b><br><b>(lbs./ton)</b> | <b>PM2.5-PRI</b><br><b>(lbs./ton)</b> | <b>SO<sub>2</sub></b><br><b>(lbs./ton)</b> |
| Commercial /<br>Institutional | 8.5  | 8.5                            | 0.675                           | 6.1                                  | 3                                     | 41.4                                       |

## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

## Adjustments for Controls

No controls are available for this source category.

## Spatial and Temporal Allocations

### *Spatial*

Spatial temporal allocations to this source category were calculated in the same manner as the residential coal combustion category.

### *Temporal*

Spatial and temporal allocations to this source category were calculated in the same manner as the residential coal combustion category.

## Emissions Calculation

### Commercial Coal Combustion Sample Calculation (Allegheny County) (tons / year)

Total Commercial Coal Consumption – State of Maryland 16,000 tons

To calculate spatial apportioning factor for Allegheny County:

$$SAF_{\text{ALLEGANY COUNTY}} = \frac{HDD_{\text{INVENTORY COUNTY}} \times CHU_{\text{INVENTORY COUNTY}}}{\sum_{\text{ALL COUNTIES IN STATE}} (HDD_{\text{COUNTY}} \times CHU_{\text{COUNTY}})}$$

$$SAF_{\text{ALLEGANY COUNTY}} = \mathbf{0.351336}$$

To calculate tons of coal used in Allegheny County:

$$\begin{aligned} \text{Commercial Coal}_{\text{ALLEGANY COUNTY}} &= SAF_{\text{ALLEGANY COUNTY}} \times \text{Coal}_{\text{TOTAL STATE}} \\ \text{Commercial Coal}_{\text{ALLEGANY COUNTY}} &= 0.351336 \times 16,000 \\ \text{Commercial Coal}_{\text{ALLEGANY COUNTY}} &= 5,621.38 \text{ tons} \end{aligned}$$



Equation:

Commercial Coal VOC Emission Calculation for Allegany County

$$E_{\text{COALC}} = \frac{(\text{EF}_{\text{COAL VOC}} \times \text{Coal}_{\text{ALLEGANY COUNTY}})}{2000}$$

$$E_{\text{COALC}} = \frac{(0.675 \times 5,621.38)}{2000}$$

$$E_{\text{COALC}} = 1.897 \text{ tons}_{\text{VOC}} \text{ year}$$

### 3.1.6.5 Natural Gas Combustion

SCC: 21 04 060 000 (Residential Natural Gas)

SCC: 21 03 060 000 (Commercial/Institutional Natural Gas)

#### Description

This source category covers air emissions from natural gas combustion in the residential and commercial/institutional sectors for space heating, water heating, and cooking. This category includes small boilers, furnaces, heaters and other heating units that are not inventoried as point sources. Residential and commercial sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and Federal, state and local government institutions (e.g., military installations, prisons, office buildings). Natural gas is one of the major fuels used throughout the country. It is used mainly for power generation, for industrial process steam and heat production, and for domestic and commercial space heating. It is also used for domestic cooking and hot water heating.

#### Pollutants

PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub>, NO<sub>x</sub>, CO, NH<sub>3</sub>, VOC

#### Method and Data Sources

The following assumptions were made in the computation of the emissions from natural gas combustion.

##### *Activity*

##### (i) Number of Dwelling Units using Natural Gas

The number of dwelling units using natural gas for space heating for 2011 was developed from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2011 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (<http://www.op.state.md.us>). The total number of additional housing units constructed in the county was apportioned to type of home heating fuel by the same ratio as the 1990 Census figures.

##### (ii) Residential and Commercial/Institutional Natural Gas Consumption Data

Total residential and commercial/institutional natural gas consumption data in the State of Maryland for 2011 was obtained from surveying the following companies: Baltimore Gas and Electric (*Constellation Energy Group*), Washington Gas Energy Services (Maryland

Division), Chesapeake Utilities Corporation, Columbia Gas of Maryland, Easton Utility Commission, and Elkton Gas Company. The companies provided natural gas sales statistics for the year 2011 in therms or cubic feet for all counties in their service area for the residential, commercial, and industrial categories. These statistics were then converted into million cubic feet using a conversion factor of 1 therm equals 100 cubic feet.

***Emission Factors***

(iii) Emission Factors – Natural Gas

Emission factors for residential natural gas came from 2008 Emission Inventory Data & Documentation (<http://www.epa.gov/ttn/chief/net/2008inventory.html> ) Nonpoint section for Residential Heating: Natural Gas factors for combustion of natural gas in commercial boilers are presented in Table 1.4-1 and 1.4-2 of Section 1.4 of AP-42. Commercial factors came from the ICI Workbook on the same website created by EPA and ERTAC committee through a joint study.

| <b>Natural Gas Emission Factors</b> |  |   |  |  |   |  |             |
|-------------------------------------|--|---|--|--|---|--|-------------|
|                                     | <b>Nox</b><br><b>(lbs./10<sup>6</sup> scf)</b> | <b>CO</b><br><b>(lbs./10<sup>6</sup> scf)</b> | <b>VOC</b><br><b>(lbs./10<sup>6</sup> scf)</b> | <b>PM 10</b><br><b>(lbs./10<sup>6</sup> scf)</b> | <b>PM 2.5</b><br><b>(lbs./10<sup>6</sup> scf)</b> | <b>NH3</b><br><b>(lbs./10<sup>6</sup> scf)</b> | <b>(lbs</b> |
| Residential                         | 94   | 40  | 5.5  | 0.2  | 0.11  | 20   |             |
| Commercial                          | 100  | 84  | 5.5  | 0.2  | 0.11  | 0.49   |             |

**Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustments for Controls**

No controls are available for this source category.

**Spatial and Temporal Allocations**

***Spatial***

The natural gas survey of suppliers provided MDE with county totals for natural gas consumption. Therefore MDE did not have to use an allocation factor derived from local and state totals of annual heating degree days and housing units heating with natural gas to spatially allocated natural gas consumption to the county level for most of the counties.

*Temporal*

In addition to space heating, natural gas is often used for cooking and water heating. For ozone and other seasonal inventories, consumption for cooking and water heating may be assumed to be constant through the year, but fuel used for space heating must be apportioned according to heating needs.

To separate residential space heating natural gas usage from cooking and water heating, MDE used data from the State Energy Data Report, Consumption Estimates, Energy Information Administration, Office of Energy Markets and End Use, U.S. Department of Energy. Specifically data was collected from Table 15 – Natural Gas Deliveries to Residential Customers, by State, 1998-2011. The residential deliveries for the month with the lowest deliveries can be assumed to be only for cooking and water heating. The percentage of residential natural gas consumption for cooking and water heating may then be calculated:

$$\begin{aligned} \text{Annual Non-Space Heating Percent} &= \frac{12 * \text{Lowest Monthly Fuel Use}}{\text{Annual Fuel Use}} * 100 \\ \text{Annual Non-Space Heating Percent} &= \frac{12 * 1635}{80,447} * 100 \\ \text{Annual Non-Space Heating Percent} &= 24.389 \% \end{aligned}$$

The annual non-space heating percent can be calculated in a similar manner for commercial/institutional natural gas usage. The percentage of commercial/institutional natural gas consumption for non-space heating may then be calculated:

$$\begin{aligned} \text{Annual Non-Space Heating Percent} &= \frac{12 * \text{Lowest Monthly Fuel Use}}{\text{Annual Fuel Use}} * 100 \\ \text{Annual Non-Space Heating Percent} &= \frac{12 * 2440}{65323} * 100 \\ \text{Annual Non-Space Heating Percent} &= 44.823 \% \end{aligned}$$

This percentage may be applied to the inventory area’s total residential and/or commercial/institutional natural gas consumption to calculate the non-space heating portion of usage. This portion can be subtracted from the annual total, and the remaining consumption, which is being used for space heating, can be allocated by month or period using proportions of annual and monthly or period heating degree days.

$$\text{Space Heat Fuel}_{\text{MONTH}} = \text{Space Heat Fuel}_{\text{ANNUAL}} \times \frac{\text{HDD}_{\text{MONTH}}}{\text{HDD}_{\text{ANNUAL}}}$$

Where:

$$\begin{aligned} \text{Space Heat Fuel}_{\text{MONTH}} &= \text{Space heating fuel use for inventory month} \\ \text{Space Heat Fuel}_{\text{ANNUAL}} &= \text{Space heating fuel use for inventory year} \end{aligned}$$

HDD<sub>MONTH</sub> = Heating degree days for inventory month  
HDD<sub>ANNUAL</sub> = Heating degree days for inventory year

**Emissions  
Calculation**

Emission Calculation – Residential Emissions

Equation:

$$E_{\text{NatGas}} = \frac{(EF_{\text{NatGas-P}} \times NG_i)}{2000}$$

$E_{\text{NatGas}}$  = Yearly emissions from natural gas combustion  
 $EF_{\text{NatGas-P}}$  = Emission factor for natural gas combustion for pollutant i  
 $NG_i$  = Natural gas consumed for county i

Total Residential Natural Gas Consumption – Baltimore City<sup>67</sup> 13,700.31 M ft<sup>3</sup>

|                   | <b>Total Natural Gas Delivered (M ft<sup>3</sup>)</b> |                   |
|-------------------|---|-------------------|
|                   | <b>Residential</b>                                    | <b>Commercial</b> |
| State of Maryland | <b>77,411.73</b>                                      | <b>61,737.32</b>  |

$$E_{\text{NatGas}} = \frac{(EF_{\text{NatGas-voc}} \times NG_{\text{Bato.City}})}{2000}$$

$$E_{\text{NatGas}} = \frac{(5.5 \times 13,700.31)}{2000}$$

$$E_{\text{NatGas}} = 37.68 \text{ tons VOC year}$$

The same equation and methodology can be used to estimate emission of various pollutants.

<sup>3</sup> Natural gas consumption data gathered from MDE survey – Baltimore County data from BGE

### 3.1.6.6 Liquefied Petroleum Gas Combustion

SCC: 21 04 007 000 (Residential LPG)

SCC: 21 03 007 000 (Commercial/Institutional LPG)

#### Description

This source category covers air emissions from liquefied petroleum gas (LPG) combustion in the residential and commercial sectors for space heating, water heating, or cooking. LPG includes propane, propylene, butane, and butylenes. The product used for domestic heating is composed primarily of propane. This category includes small boilers, furnaces, heaters and other heating units that are not inventoried as point sources. Residential and commercial sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and Federal, state and local government institutions (e.g., military installations, prisons, office buildings).

#### Pollutants

PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub>, NO<sub>x</sub>, CO, NH<sub>3</sub>, VOC

#### Method and Data Sources

The following assumptions were made in the computation of the emissions from liquefied petroleum gas (LPG) combustion.

##### *Activity*

##### 1. Number of Dwelling Units using LPG

The number of dwelling units using LPG for space heating for 2011 was developed from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2011 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (<http://www.op.state.md.us>). The total number of additional housing units constructed in the county was apportioned to type of home heating fuel by the same ratio as the 1990 Census figures.

##### 2. Residential and Commercial LPG Activity Consumption Data

Total residential and commercial LPG consumption data for space heating in the State of Maryland (LPG<sub>ST</sub>) for 2011 were obtained from State Energy Data Report, Consumption Estimates, Energy Information Administration, Office of Energy Markets, and End Use, U.S. Department of Energy.

### *Emission Factors*

Emission factors for LPG came from 2008 Emission Inventory Data & Documentation (<http://www.epa.gov/ttn/chief/net/2008inventory.html>) Nonpoint section for Residential Heating: LPG Combustion Table 1. Commercial factors came from the ICI Workbook on the same website created by EPA and ERTAC committee through a joint study. Factors have been rounded to one and two decimal places.

| <b>LPG Emission Factors</b> |                           |                          |                           |                                |                                 |                           |                           |
|-----------------------------|---------------------------|--------------------------|---------------------------|--------------------------------|---------------------------------|---------------------------|---------------------------|
|                             | <b>NOx</b><br>(lbs./kbbl) | <b>CO</b><br>(lbs./kbbl) | <b>VOC</b><br>(lbs./kbbl) | <b>PM10-FIL</b><br>(lbs./kbbl) | <b>PM2.5-FIL</b><br>(lbs./kbbl) | <b>NH3</b><br>(lbs./kbbl) | <b>SO2</b><br>(lbs./kbbl) |
| Residential                 | 562.8                     | 159.6                    | 21.91                     | 0.8                            | 0.44                            | 1.95                      | 2.39                      |
| Commercial                  | 597.66                    | 334.74                   | 21.84                     | 0.84                           | 0.42                            | 2.1                       | 2.52                      |

### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

### **Adjustments for Controls**

No controls are available for this source category.

### **Spatial and Temporal Allocations**

#### *Spatial*

MDE developed factors from local and state totals of annual heating degree days and housing units that heat with liquid propane gas; to spatially allocate liquid propane gas consumption. The method is documented and recommended by EIIP<sup>68</sup> in an Area Source Method Abstract for natural gas and LPG combustion.

A “heating degree day” is a unit of measure used to indicate how cold it has been over a 24-hour period. Daily heating degree days are calculated as the difference between the base value of 65°F and the mean temperature for the day (mean of the high and low temperatures for the day).

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<sup>68</sup> Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Natural Gas and LPG Combustion, dated 2011

Annual heating degree days are the sum of the daily heating degree days. Heating degree data is available from the National Oceanographic and Atmospheric Administration (NOAA).<sup>69</sup>

$$SAF_{INVENTORY\ COUNTY} = \frac{HDD_{INVENTORY\ COUNTY} \times LP-HU_{INVENTORY\ COUNTY}}{\sum_{ALL\ COUNTIES\ IN\ STATE} (HDD_{COUNTY} \times LP-HU_{COUNTY})}$$

Where:

- $SAF_{INVENTORY\ COUNTY}$  = Spatial apportioning factor for inventory county
- $HDD_{INVENTORY\ COUNTY}$  = Annual heating degree days for inventory county
- $LP-HU_{INVENTORY\ COUNTY}$  = Housing units using LP gas for inventory county
- $HDD_{COUNTY}$  = Annual heating degree days for each county in the state
- $LP-HU_{COUNTY}$  = Housing units using LP gas for each county in the state

The spatial apportioning factor is used to allocate the state fuel total to the county level using the following equation:

$$LPG_{INVENTORY\ COUNTY} = SAF_{INVENTORY\ COUNTY} \times LPG_{TOTAL\ STATE}$$

Where:

- $LPG_{INVENTORY\ COUNTY}$  = Total LPG fuel consumed in the inventory county
- $LPG_{TOTAL\ STATE}$  = Total LPG fuel consumed in the inventory county

### *Temporal*

In addition to space heating, liquid propane gas is often used for cooking and water heating. For ozone and other seasonal inventories, consumption for cooking and water heating may be assumed to be constant through the year, but fuel used for space heating must be apportioned according to heating needs.

## **Emissions Calculation**

### Emission Calculation

$$E_{LPGi} = \frac{(EF_{LPG\ p} \times LPG_{County\ i})}{2000}$$

- $E_{LPGi}$  = Yearly emissions from liquid propane gas combustion in county i
- $EF_{LPG\ p}$  = Emission factor for LPG combustion for pollutant p
- $LPG_{County\ i}$  = LPG consumed for space heating in county i

<sup>69</sup> <http://www.noaa.gov> (home page) or <http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS> (for a list of available data)



2011 Residential LPG Combustion Sample Calculation (Baltimore City) (tons/year)

Total Residential LPG Consumption – State of Maryland 2,023 thousand barrels (kbbbl)

To calculate spatial apportioning factor for Baltimore City:

$$\text{SAF}_{\text{BALTIMORE CITY}} = \frac{\text{HDD}_{\text{INVENTORY COUNTY}} \times \text{LP-HU}_{\text{INVENTORY COUNTY}}}{\sum_{\text{ALL COUNTIES IN STATE}} (\text{HDD}_{\text{COUNTY}} \times \text{LP-HU}_{\text{COUNTY}})}$$

$$\text{SAF}_{\text{BALTIMORE CITY}} = \frac{4,705 \times 2,080}{300,519,851}$$

$$\text{SAF}_{\text{BALTIMORE CITY}} = 0.032565$$

To calculate thousand barrels of liquefied petroleum gas (LPG) used in Baltimore City:

$$\text{Residential LPG}_{\text{BALTIMORE CITY}} = \text{SAF}_{\text{BALTIMORE CITY}} \times \text{LPG}_{\text{TOTAL STATE}}$$

$$\text{Residential LPG}_{\text{BALTIMORE CITY}} = 0.032565 \times 2,023$$

$$\text{Residential LPG}_{\text{BALTIMORE CITY}} = \mathbf{65.88 \text{ kbbbl}}$$

Equation:

$$E_{\text{LPG}i} = \frac{(\text{EF}_{\text{LPG voc}} \times \text{LPG}_{\text{County } i})}{2000}$$

$$E_{\text{LPG}i} = \frac{(21.91 \times \mathbf{65.88})}{2000}$$

$$E_{\text{LPG}i} = 0.7217 \text{ tons}_{\text{VOC}} \text{ per year}$$

### 3.1.6.7 Wood Combustion

SCC: 21 04 008 000 (Residential Wood Combustion)

#### Description

This source category covers air emissions from wood combustion in the residential sectors primarily for space heating and aesthetics. The inventory includes emission estimates for indoor wood-burning equipment (e.g. fireplaces, woodstoves, pellet stoves, furnaces/boilers) and outdoor wood burning equipment (e.g. outdoor fireplaces, fire pits, wood-fired barbecues, chimneys).

#### Pollutants

NO<sub>x</sub>, CO, VOC, PM<sub>10</sub>, PM<sub>2.5</sub>, NH<sub>3</sub>, SO<sub>2</sub>, and HAPs

#### Method and Data Sources

Maryland's Residential Wood Combustion Emission Inventory was calculated using a new EPA emissions estimation tool called the, RWC TOOL. A detailed explanation of how activity data and emission factors were developed in order to predict emissions for several states can be read in Appendix X. A collection of surveyed, census, housing tract, equipment use, and wood burned data was used in the tool along with EPA's estimation methodologies and statistics to create an emissions profile for Maryland that can be used repeatedly with a few periodic updates.

#### Point Source Adjustments

No subtraction of emissions from point sources is necessary.

#### Adjustments for Controls

No controls are available for this source category.

#### Spatial and Temporal Allocations

##### *Spatial*

To produce county-level temporal profiles, the same process used to go from response level profiles to group-level profiles was used to go from group profiles to county profiles. Activity or emissions for each census tract were assigned to each temporal unit based on

the tract level temporal profiles. These values were then summed across all tracts in the county and normalized to give activity fractions.

### ***Temporal***

Temporal allocation profiles were also developed for this project using the residential wood survey data. Profiles were first developed for each sample group. Activity (for outdoor equipment) or emissions (for indoor equipment) for each respondent was divided.

The following RWC methodology comes directly from E.H. PECHAN memo on how emission calculations were made for the category.

## **CALCULATION METHODOLOGY AND UPDATES**

The emissions from RWC are calculated using the Equation 1 below.

$$E_y = u \times EF_y \times (1 - CF_y) \quad (\text{Eq. 1})$$

Where  $y$  is a specific pollutant and:

- $E_y$  = annual emissions (ton/year) for a specific appliance (or SCC);
- $u$  = annual activity (tons of fuel burned);
- $EF_y$  = emission factor (tons of pollutant emitted/mass of fuel used); and
- $CF_y$  = control factor.

Each of the terms in Equation 1 and their sources are explained further below.

**Activity (u):** Methodologies for determining the activity varied by the type of RWC appliance. Activity for the majority of appliance types was derived from census data.

### ***Fireplaces, Inserts, and Woodstoves***

For the first method, which applies to fireplaces, fireplace inserts, and woodstoves, activity in terms of tons of fuel burned was calculated based on several factors as shown in Equation 2 below.

$$u = P \times AP \times WBP \times CP \times UR \times BR \times D \quad (\text{Eq. 2})$$

Where:

- $P$  = Number of occupied housing units in a county in 2011;
- $AP$  = Percentage of occupied housing units for a specific appliance category (e.g., woodstoves used as main heating equipment, fireplaces without inserts used for other heating, etc.);
- $WBP$  = Wood-burning percentage – percentage of wood burned for each purpose from AHS;
- $CP$  = Certification Profile - percentage of a specific appliance category per SCC (e.g., for woodstoves: uncertified, certified catalytic, certified non-catalytic);
- $UR$  = Urban or Rural adjustment – Profile adjustment based on county population density;
- $BR$  = Burn rate (cords/year); and
- $D$  = average density of the wood fuel burned.

### 3.1.6.8 Commercial Cooking

SCC: 2302002100 (Conveyorized Charbroiling)  
2302002200 (Under-fired Charbroiling)  
2302003000 (Deep Fat Frying)  
2302003100 (Flat Griddle Frying)  
2302003200 (Clamshell Griddle Frying)

#### Description

This source category covers air emissions from commercial cooking in the Maryland area(s). These emissions (i.e. emissions from commercial cooking of meats) represent the “greatest sources of commercial cooking emissions. In particular, emissions of particulate matter (PM) and volatile organic compounds (VOCs) are the most significant. Of the cooking processes that have been identified, charbroiling is the most important air pollutant emissions contributor”<sup>70</sup>. It follows that this category includes the following meat sources: hamburger, steak, fish, pork, and chicken. And the five equipment types: chain-driven (conveyorized) charbroilers, under-fired charbroilers, deep fat fryers, griddles, and clam shell griddles.

#### Pollutants

PM, PM<sub>10</sub>, PM<sub>2.5</sub>, CO, VOC, HAPs

#### Method and Data Sources

The recommended methods for calculating emissions and emission factors to commercial cooking possessing sources was obtain from PECHAN Technical Memorandum (December 2003) and EIIP Web site Volume III, Area Sources document series methods and web link: [http://www.epa.gov/ttnchie1/eiip/techreport/volume03/charbroilingtechmemo\\_122303.pdf](http://www.epa.gov/ttnchie1/eiip/techreport/volume03/charbroilingtechmemo_122303.pdf). <http://www.epa.gov/ttnchie1/conference/ei13/pointarea/roe.pdf>.

#### Activity

Total number of restaurants came from County Business Patterns 2010 - Maryland, NAICS: 7221, Full-Service Restaurants and 72213, Limited Service Restaurants. Base year 2010 Restaurants statistics for Maryland’s counties were collected from the U.S. Census Bureau Internet Website address (<http://www.census.gov/epcd/cbp/view/cbpview.html>). Table 3.7.1.8-a shows CBP total number of Maryland county restaurants. MDE staff calculated the percent of county restaurant types (i.e. Ethnic Food, Fast Food, Family Food, and Seafood) reported in the PECHAN Technical Memorandum. Table 3.7.1.8-b shows the percent of each restaurant type per county calculated from the PECHAN Technical Memorandum. This percentage was applied to the total number of restaurants collected from the County Business Patterns to determine the number of each type of restaurant facility in each county<sup>1,71</sup>. Table

<sup>70</sup> Source: Adapted from PECHAN December 2003 Commercial Cooking Processes Technical Memorandum.

<sup>71</sup> Source: Adapted from County Business Patterns (CBP) and U.S. Census Bureau 2010 reports.

3.7.1.8-c gives average number of equipment pieces by restaurant type. Table 3.7.1.8-d shows average pounds of meat cooked on each type of equipment per week (lbs/week). And Table 3.7.1.8-e gives emission factors (lb/ton meat).

**Table 3.7.1.8-a 2010 CBPs'  
Total Number of County  
Rest.**

| County Name     | NAICS Code<br>7221 & 72213 |
|-----------------|----------------------------|
| Allegany        | 57                         |
| Anne Arundel    | 423                        |
| Baltimore CO    | 500                        |
| Calvert         | 66                         |
| Caroline        | 13                         |
| Carroll         | 116                        |
| Cecil           | 66                         |
| Charles         | 90                         |
| Dorchester      | 20                         |
| Frederick       | 166                        |
| Garrett         | 30                         |
| Harford         | 150                        |
| Howard          | 210                        |
| Kent            | 34                         |
| Montgomery      | 733                        |
| Prince George's | 324                        |
| Queen Anne's    | 45                         |
| St Mary's       | 69                         |
| Somerset        | 14                         |
| Talbot          | 59                         |
| Washington      | 111                        |
| Wicomico        | 80                         |
| Worcester       | 189                        |
| Baltimore City  | 415                        |

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<sup>3</sup> Total may not be multiplier and divisional because of rounding.

**Table 3.7.1.8-b Percent of Each County Restaurant Type<sup>3</sup>**

| County Name     | Ethnic | Fast Food | Family | Seafood | Steak & Barbeque |
|-----------------|--------|-----------|--------|---------|------------------|
| Allegany        | 17     | 27        | 8      | 0       | 5                |
| Anne Arundel    | 115    | 202       | 49     | 42      | 14               |
| Baltimore CO    | 148    | 240       | 58     | 39      | 14               |
| Calvert         | 15     | 27        | 10     | 10      | 3                |
| Caroline        | 2      | 9         | 1      | 1       | 13               |
| Carroll         | 23     | 69        | 17     | 4       | 3                |
| Cecil           | 15     | 34        | 8      | 5       | 3                |
| Charles         | 25     | 45        | 14     | 9       | 5                |
| Dorchester      | 3      | 13        | 4      | 8       | 1                |
| Frederick       | 44     | 79        | 29     | 11      | 3                |
| Garrett         | 3      | 16        | 10     | 0       | 1                |
| Harford         | 35     | 80        | 13     | 15      | 7                |
| Howard          | 71     | 110       | 16     | 8       | 5                |
| Kent            | 3      | 14        | 10     | 7       | 0                |
| Montgomery      | 332    | 314       | 50     | 16      | 22               |
| Prince George's | 97     | 168       | 24     | 20      | 16               |
| Queen Anne's    | 3      | 21        | 1      | 17      | 2                |
| St Mary's       | 12     | 28        | 11     | 11      | 7                |
| Somerset        | 0      | 6         | 3      | 5       | 0                |
| Talbot          | 11     | 27        | 6      | 13      | 2                |
| Washington      | 27     | 56        | 16     | 10      | 1                |
| Wicomico        | 22     | 34        | 8      | 12      | 3                |
| Worcester       | 46     | 80        | 19     | 35      | 9                |
| Baltimore City  | 109    | 238       | 29     | 32      | 9                |

**Note: Divide decimal numbers in Table 3.7.1.8-b by 100 to change % into fraction values.**

**Table 3.7.1.8-c Percent of Restaurants with each type of cooking equipment<sup>1, 2</sup>**

| Restaurant Category | Chain-Driven<br>Charbroilers<br>(ufc) Rest | Underfired<br>Charbroilers<br>(ufc) Rest. | Deep-Fat Fryers (dff)<br>Rest. | Flat<br>Griddles<br>(fg) Rest. | Clamshell Griddles<br>(cg) Rest. |
|---------------------|--|---|--------------------------------|--------------------------------|----------------------------------|
| Ethnic              | 3.5  | 47.5                                      | 81.9                           | 62.7                           | 4                                |
| Fast Food           | 18.6                                       | 30.8                                      | 96.8                           | 51.9                           | 14.7                             |
| Family              | 10.1                                       | 60.9                                      | 91.4                           | 82.9                           | 1.4                              |
| Seafood             | 0  | 52.6                                      | 100                            | 36.8                           | 10.5                             |
| Steak & Barbeque    | 6.9  | 55.2                                      | 82.8                           | 89.7                           | 0                                |

Table 3.7.1.8-d Average Number of Equipment Pieces by Restaurant Type<sup>1, 2</sup>

| Restaurant Category | Chain-Driven Charbroilers (ufc) Rest | Underfired Charbroilers (ufc) Rest. | Deep-Fat Fryers (dff) Rest. | Flat Griddles (fg) Rest. | Clamshell Griddles (cg) Rest. |
|---------------------|--------------------------------------|-------------------------------------|-----------------------------|--------------------------|-------------------------------|
| Ethnic              | 1.62                                 | 1.54                                | 1.63                        | 1.88                     | 1.8                           |
| Fast Food           | 1.07                                 | 1.58                                | 3.1                         | 1.43                     | 2.09                          |
| Family              | 1.71                                 | 1.29                                | 2.34                        | 2.03                     | 0                             |
| Seafood             | 0                                    | 1.1                                 | 2.47                        | 1.11                     | 1.5                           |
| Steak & Barbecue    | 0                                    | 1.63                                | 2.42                        | 1.35                     | 0                             |

Table 3.7.1.8-e Average Pounds of Meat Cooked on Each Type of Equipment Per Week<sup>1, 2</sup>  
(lbs/week)

| Type of Meat       | Chain-Driven Charbroilers (ufc) Rest | Underfired Charbroilers (ufc) Rest. | Deep-Fat Fryers (dff) Rest. | Flat Griddles (fg) Rest. | Clamshell Griddles (cg) Rest. |
|--------------------|--------------------------------------|-------------------------------------|-----------------------------|--------------------------|-------------------------------|
| Steak              | 236                                  | 180                                 | 181                         | 166                      | 94                            |
| Hamburger          | 798                                  | 270                                 | 274                         | 362                      | 1314                          |
| Poultry, with Skin | 147                                  | 144                                 | 365                         | 88                       | 113                           |
| Poultry, Skinless  | 266                                  | 179                                 | 208                         | 111                      | 108                           |
| Pork               | 57.6                                 | 148                                 | 58.6                        | 112                      | 118                           |
| Seafood            | 119                                  | 143                                 | 159                         | 92.1                     | 632                           |
| Other              | 0                                    | 41.5                                | 274                         | 57.5                     | 0                             |

***Emission Factors***

Table 3.7.1.8-f Emission Factor (lb/ton meat)<sup>1, 2</sup>

| Equipment Type (fuel)                              | SCC        | Meat/Food           | PM   | PM10 | PM2.5 | CO    | NOX | VOC  |
|--|------------|---------------------|------|------|-------|-------|-----|------|
| Under fired-charbroiler (charcoal) (ufc) Rest.     | 2302002200 | Beef                | 16.2 | 15   | 14.2  | 327   | 4.8 | 9.4  |
|  |            | Beef (marinated)    | 19   | 18.4 | 17.4  | 335.2 | 7.2 | 11.6 |
|  |            | Chicken (marinated) | 19.6 | 18.8 | 18.2  | 315.8 | 8.4 | 9    |
|  |            | Hamburger (25%fat)  | 65.4 | 65.4 | 63.8  | 27.44 | 0   | 7.88 |
| Under fired-charbroiler (natural gas) (ufc) Rest.  | 2302002200 | Steak               | 34.4 | 34.4 | 33.6  | 9.94  | 0   | 1.72 |
|  |            | Chicken (whole)     | 21.0 | 21.0 | 19.8  | 9.68  | 0   | 3.64 |
|  |            | Seafood             | 6.6  | 6.6  | 6.4   | 0     | 0   | 0.76 |
| Conveyorized Charbroiler (natural gas) (cdc) Rest. | 2302002100 | Hamburger (21%fat)  | 14.8 | 14.8 | 14.6  | 16.58 | 0   | 4.54 |

|  |            |                           |     |     |      |      |   |             |
|--|------------|---------------------------|-----|-----|------|------|---|-------------|
|  |            | Shoestring potatoes       | 0   | 0   | 0    | 0    | 0 | 0.42        |
|  |            | Breaded chicken           | 0   | 0   | 0    | 0    | 0 | 0.24        |
| Deep fat fryer (natural gas) (dff) Rest.               | 2302003000 | Breaded fish              | 0   | 0   | 0    | 0    | 0 | 0.28        |
|  |            | Hamburger (24% fat)       | 10  | 10  | 7.6  | 0.76 | 0 | 0.14        |
|  |            | Chicken (boneless breast) | 0   | 0   | 0    | 0.9  | 0 | 0.8         |
| Griddle (electric) (fg) Rest.                          | 2302003100 | Seafood                   | 0   | 0   | 0    | 0    | 0 | 0.22        |
|  |            | Hamburger (24% fat)       | 1.7 | 1.7 | 1.44 | 0    | 0 | 0.02        |
| Double-sided (clamshell) Griddle (electric) (cg) Rest. | 2302003200 | Chicken                   | 0   | 0   | 0    | 0    | 0 | 0.114285714 |
|  |            | Seafood                   | 0   | 0   | 0    | 0    | 0 | 0.031428571 |

## Point Source Adjustments

No point source subtraction of emissions.

## Adjustments for Controls

No adjustments for controls in Maryland for this source.

### *Spatial*

## Spatial and Temporal Allocations

Data for spatial allocation is the number of restaurant per county from CBPs'.

### *Temporal*

Data for temporal allocation is not available for this source.

## Emissions Calculation

The following steps were used to calculate commercial cooking emissions for Maryland:

- i. Multiply total restaurants in a county (i.e. from CBPs' data source) by percent (%) type of restaurant (i.e. from PECHAN document) Table 3.2.6.8-a, and Table 3.2.6.8-b.
- ii. Multiply county-level facility counts by the fraction (i.e. percent) of restaurants with each type of cooking equipment (Table 3.2.6.8-c).
- iii. Multiply number of restaurants with each type of cooking equipment by number of pieces of equipment (Table 3.2.6.8-d).
- iv. Sum number of pieces of cooking equipment across restaurant types.
- v. Multiply total summed number of pieces of cooking equipment per restaurant types by average pounds of meat cooked on each type of equipment per week (Table 3.2.6.8-e).



- vi. Finally, multiply results from v by emission factor (lb/ton meat) (Table 3.2.6.8-f) and divided emission values by 2000 by 365 for daily lbs/ton unit.

$$B_{poe}$$

$$E_{CC} = (N * (\text{Frac}_n / 100)) * D_{tn} * \text{Sum}_{all} * \text{Meat}_{type} * EF_{\text{meat type}} / 2000$$

Where:

- $E_{CC}$  = Commercial Cooking Emissions in pound (lbs) per tons (i.e. Activity data times  $EF_{\text{meat type}}$ ) for county per restaurant food type and equipment type SCC.
- $N$  = Total number of food restaurants in county (see CBP report 2004).
- $\text{Frac}_n$  = Fraction of restaurant type for that type of cooking equipment.
- $B_{poe}$  = Number of food restaurants for SCC with restaurants type of equipment.
- $D_{tn}$  = Total number of restaurants type of equipment at food restaurant.
- $\text{Sum}_{all}$  = Total number of summed of pieces of cooking equipment across restaurant type.
- $\text{Meat}_{type}$  = Total pounds per week of meat type cooked on restaurants equipment in county.
- $EF_{\text{meat type}}$  = Meat type emission factor (lb/ton meat).

Example 2011 Commercial Cooking Emission Calculation for Baltimore County, Fast Food Restaurant Type, SCC 2302002100, Chain-Driven Charbroiler (Conveyorized). **Note:** Emissions are calculated for only a particular county, restaurant, food equipment, and food type. In order to determine emission for a particular county, all emission for meat types must be summed at the equipment level and multiply by the appropriate meat type emission factor.

**Step i.**

$$E^3_{BC,cde, FFood,PM} = 500 * (48/100) = 240.00$$

**Step ii.**

$$E^3_{BC,cde, FFood,PM} = 240.00 * (18.6/100) = 44.64$$

**Step iii.**

$$E^3_{BC,cde, Fast food, PM} = 44.64 * 1.07 = 47.7648$$

**Step iv.**

$$\text{Sum}_{all, E^3_{BC,cde, Fast food, PM}} = 47.7648$$

**Step v.**

$$E^3_{\text{BC,cdc, Fast food, PM}} = 47.76 * 240.00 = 11,262.40$$

**Step vi.**

$$E^3_{\text{BC,cdc, Fast food, PM}} = (11,462.40 * 3.891)/2000 = 22.30$$

$$E^3_{\text{BC,cdc, Fast Food, PM10-PRI}} = 22.30 \text{ tons per year}$$

### 3.1.7 FUGITIVE SOURCES

Other area sources include forest fires, slash and prescribed burning, agricultural burning, structure fires, orchard heaters, leaking underground storage tanks and natural organic sources. Although often intermittent in nature, many of these sources can produce large quantities of air pollutant emissions.

#### 3.1.7.1 Residential Construction Activity

SCC: 23 11 010 000

#### Description

This source category covers fugitive dust emissions from residential construction activities.

#### Pollutants

PM<sub>10</sub>, PM<sub>2.5</sub>, and HAPs

#### Method and Data Sources

##### *Activity*

For residential construction, housing permit data for single-family units, two-family units, and apartments were obtained at the county level from the U.S. Department of Commerce's (DOC) Bureau of the Census.

Estimated the number of buildings in each category, and then estimated the total acres disturbed by construction by applying conversion factors to the housing start data for each category as follows:

- Single-family ¼ acre/building
- Two-family ⅓ acre/building
- Apartment ½ acre/building

Housing construction PM10 emissions are calculated using an emission factor of 0.032 tons PM10/acre/month, the number of housing units created a units-to-acres conversion factor, and the duration of construction activity. The duration of construction activity for houses is assumed to be 6 months.

Apartment construction emissions are calculated separately using an emission factor of 0.11 tons PM10/acre/month; with a 12 months period assumed for apartment construction.

For areas in which basements are constructed to estimate the cubic yards of dirt moved per house, an average value of 2000 square feet is assumed for both single family and two-family homes. Multiplying the average total square feet by an average basement depth of 8 feet and adding in 10 percent of the cubic feet calculated for peripheral dirt removed produces an estimate of the cubic yards of earth moved during residential construction. The percentage of one-family houses with basements was obtained from the DOC. The percentage of houses per Census region (Northeast, Midwest, South, and West) that contain full or partial basements is applied to the housing start estimates for each of these respective regions. The best available control measures (BACM) Level 2 equation (emission factor of 0.011 tons PM10/acre/month plus 0.059 tons PM10/1000 cubic yards of on-site cut/fill) is applied once the number of acres disturbed due to the estimated number of houses built with basements is determined.

*Emission Factors*

|                                  | <b>Single-family Construction</b><br>ton PM <sub>10</sub> /acre/month | <b>Two-family Construction</b><br>ton PM <sub>10</sub> /acre/month | <b>Multi-family Construction</b><br>ton PM <sub>10</sub> /acre/month |
|----------------------------------|---|--|--|
| PM <sub>10</sub> Emission Factor | 0.032   | 0.032  | 0.11   |
| Duration of Activity             | 6 months  | 6 months   | 12 months  |

**Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustments for Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

$$E_{RCi} = E_{RC-SFH} + E_{RC-2FAM} + E_{RC-MF}$$

Where:

$E_{RCi}$  = Emissions of pollutant i in tons per year from residential construction activity

$E_{RC-SFH}$  = Emissions of pollutant i in tons per year from residential single-family home construction activity

$E_{RC-2FAM}$  = Emissions of pollutant i in tons per year from residential two-family home construction activity

$E_{RC-MF}$  = Emissions of pollutant i in tons per year from residential multi-family construction activity

and:

$$E_{RC-SFH} = E_{RC-SFH, w BM} + E_{RC-SFH, w/o BM}$$

Where:

$E_{RC-SFH, w BM}$  = Emissions of pollutant i in tons per year from residential single-family home construction activity of homes with basements

$E_{RC-SFH, w/o BM}$  = Emissions of pollutant i in tons per year from residential single-family home construction activity of homes without basements

$$E_{RC-SFH, w/o BM} = \frac{HS_{SFH} \times (1 - HS_{SFH, w BM}) \times (AD_{RC-SFH}) \times (PD_{RC-SFH}) \times EF_{RC-SFH}}{2000}$$

Where:

- $E_{RC-SFH, w/o BM}$  = Emissions of pollutant i in tons per year from residential single-family home construction activity  
 $HS_{SFH}$  = Residential single-family housing starts  
 $HS_{SFH, w BM}$  = Percent of residential single-family housing starts with basements  
 $AD_{RC-SFH}$  = Acres disturbed per housing type (residential single-family)  
 $PD_{RC-SFH}$  = Average project duration in months  
 $EF_{RC-SFH i}$  = Emissions factor in tons PM10/acre/month for pollutant i

$E_{RC-SFH, w BM}$  = Emissions from residential construction + Emissions from basement excavation

$$E_{RC-SFH, w BM} = \frac{[HS_{SFH} \times HS_{SFH, w BM} \times (AD_{RC-SFH}) \times (PD_{RC-SFH}) \times EF_{RC-SFH}] + [HS_{SFH} \times HS_{SFH, w BM} \times AHS_{RC-SFH} \times ABD_{RC-SFH} \times PDE_{RC-SFH} \times EF_{Acres-Disturb}]}{2000}$$

Where:

- $E_{RC-SFH, w BM}$  = Emissions of pollutant i in tons per year from residential single-family home construction activity  
 $HS_{SFH}$  = Residential single-family housing starts  
 $HS_{SFH, w BM}$  = Percent of residential single-family housing starts with basements  
 $AD_{RC-SFH}$  = Acres disturbed per housing type (residential single-family)  
 $PD_{RC-SFH}$  = Average project duration in months  
 $EF_{RC-SFH i}$  = Emissions factor in tons PM10/acre/month for pollutant i  
 $AHS_{RC-SFH}$  = Average residential single-family house size (national default = 2000 ft<sup>2</sup>)  
 $ABD_{RC-SFH}$  = Average basement depth for residential single-family homes (national default = 8 ft)  
 $PDE_{RC-SFH}$  = Peripheral dirt excavated for residential single-family homes (national default = 10 percent)  
 $EF_{Acres-Disturb}$  = Emissions factor for the acres disturbed during basement excavation activities during residential single-family home construction in tons PM<sub>10</sub>/1000 cubic yards

### 3.1.7.2 Heavy Construction Activity

SCC: 28 10 001 000

#### Description

Emissions produced from the construction of nonresidential buildings are estimated using the value of construction put in place. The national value of construction put in place is obtained from the Bureau of the Census<sup>72</sup>. The national value of construction put in place is allocated to the state level using non-residential building construction employment data within NAIC Code 2362 obtained from 2010 County Business Patterns<sup>73</sup>. The state value of construction put in place is allocated to the county level using non-residential building construction employment data within NAIC Code 2362 obtained from the 2010 County Business Patterns for the State of Maryland.

#### Pollutants

PM<sub>10</sub> and PM<sub>2.5</sub>

#### Method and Data Sources

##### *Activity*

ARMA used data from the U.S. Census Bureau on the national value of construction put in place- Not Seasonally Adjusted. The national value of construction put in place is allocated to the state level and then to the county level using non-residential building construction employment data within NAIC 2362 obtained from 2010 County Business Patterns.

A conversion factor of 1.301 acres/10<sup>6</sup> dollars (\$) is applied to the construction valuation data. This conversion factor is developed by adjusting the 1999 value of 2 acres/\$10<sup>6</sup> to 1999 - 2010 constant dollars using The Bureau of Labor Statistics *Producer Price Index*<sup>74</sup> for Construction. The duration of construction activity for nonresidential construction is estimated to be 11 months.

Employee numbers were taken from County Business Patterns 2010 - Maryland, NAIC 2362, Non-residential Building Construction (see Appendices). Some county employment data is represented by a letter code indicating a range for the number of employees for that

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<sup>72</sup> Bureau of Census, Annual Value of Construction Put in Place - Not Seasonally Adjusted in the United States: 2010; <http://www.census.gov/const/C30/priv2008.pdf>

<sup>73</sup> U.S. Census Bureau, County Business Patterns, NAIC Code 2362, Industry Nonresidential Building Construction 2010 <http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl>

<sup>74</sup> U.S. Census Bureau, County Business Patterns, 2010 <http://quickfacts.census.gov/qfd/states/24000.html> Select county then "Browse more data sets" then County Business Patterns Economic Profile for 2007 – Repeat for each county.

SIC. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a NAIC matched the sum of the number of employees reported per county.

***Emission Factors***

|                     | PM <sub>10</sub><br>(tons/acre/month) | PM <sub>2.5</sub><br>(tons/acre/month) |
|---------------------|---------------------------------------|--|
| Emissions           | 0.11                                  | 20% of PM <sub>10</sub>                |
| Duration of Project | 11 months                             |  |

**Point Source  
Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustments  
for Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

***Spatial***

Data for spatial allocation is not available for this source.

***Temporal***

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

|  |                   |
|--|-------------------|
| Value of Construction Work<br>in the U.S. - HC <sub>J</sub>                | \$261,776,000,000 |
| Number of Employees<br>within NAIC 2362 in the<br>U.S. - EMP <sub>us</sub> | 766,961           |
| Number of Employees  | 13936             |

within NAIC 2362 in  
Maryland

$$E_{HC\ i} = HC_j \times (EMP_j / EMP_{us}) \times CF_{HC} \times AEF_{HC\ i} \times DC_{HC}$$

Where:

- $E_{HC\ i}$  = Emissions of pollutant i in tons per year from heavy construction
- $HC_j$  = Value of Heavy construction in US j in 2010
- $EMP_{us}$  = Employment NAICS 2362 US in 2010
- $EMP_j$  = Employment NAICS 2362 County j in 2010
- $CF_{HC}$  = Conversion factor (acres/million dollars) for heavy construction (1.262)
- $AEF_{HC\ i}$  = Adjusted Emissions factor in tons per acre per month for pollutant i
- $DC_{HC}$  = Duration of construction activity (11 months)

2011 Sample Calculation Heavy Construction (Anne Arundel County)

Number of Employees within NAIC 2362 in Anne Arundel County 904

- PE = precipitation-evaporation value for each State,
- S = % dry silt content in soil for area being inventoried

$$AEF_{HC\ i} = \text{Initial } EF_{HC\ i} \times (24/PE) \times (S/9\%)$$

$$AEF_{HC\ i} = 0.19(PM_{10}) \times (24/114.1) \times (33/9\%)$$

$$AEF_{HC\ i} = 0.771253287$$

$$E_{HC\ i} = HC_j \times (EMP_j / EMP_{us}) \times CF_{HC} \times EF_{HC\ i} \times DC_{HC}$$

$$E_{HC\ i} = 261,776,000,000 \times (904 / 766,961) \times 1.264 \times 0.19(PM_{10}) \times 11$$

$$E_{HC\ i} = 628.614 \text{ tons/year } PM_{10}$$



### 3.1.7.3 Road Construction Activity

SCC: 23 11 030 000

#### Description

This source category covers fugitive dust emissions from road construction activity. PM<sub>10</sub> emissions produced by road construction are estimated using an emission factor for heavy construction and the State capital outlay for new road construction.

#### Pollutants

PM<sub>10</sub> and PM<sub>25</sub>

#### Method and Data Sources

##### *Activity*

To estimate the acres disturbed by road construction, the Federal Highway Administration (FHWA) has *Highway Statistics, Section IV - Highway Finance, Table SF-12A, State Highway Agency Capital Outlay*<sup>1</sup> for 2011 which outlines spending by state in several different categories. For this SCC, the following columns are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. These columns are also differentiated according to the following six classifications:

- Interstate, urban
- Interstate, rural
- Other arterial, urban
- Other arterial, rural
- Collectors, urban
- Collectors, rural

Dollar expenditures are converted to miles constructed using data obtained from the North Carolina Department of Transportation (NCDOT) in 2000. A conversion of \$4 million/mile is applied to the interstate expenditures. For expenditures on other arterial and collectors, a conversion factor of \$1.9 million/mile is applied, which corresponds to all other projects.

Miles are converted to acres for each of the 6 road type areas using the following estimate of acres disturbed per mile:

- Interstates: Urban, Rural, and Urban Other Arterial - 15.2 Acres Disturbed/mile
- Rural, Other Arterials - 12.7 Acres Disturbed/mile
- Urban, Collectors - 9.8 Acres Disturbed/mile
- Rural, Collectors - 7.9 Acres Disturbed/mile

### *Emission Factors*

A PM<sub>10</sub> emission factor of 0.42 tons/acre/month is used to account for the large amount of dirt moved during the construction of roadways. The duration of construction activity for road construction is estimated to be 12 months.

PM<sub>25</sub> emissions are estimated by applying a particle size multiplier of 0.10 to PM<sub>10</sub> emissions.

### *Soil Moisture Level*

To account for the soil moisture level, base emissions were multiplied by 24 divided by the precipitation-evaporation (PE) value. Precipitation-Evaporation (PE) values were obtained from Thornthwaite's PE Index. Average PE values for each State were estimated based on PE values for specific climatic divisions within a State. These values range from 7 to 41.

### *Silt Content*

To account for the silt content, base emissions were multiplied by percent dry silt content in soil divided by 9 percent. A data base containing county-level dry silt values were applied to PM<sub>10</sub> emissions for each county. These values were derived by applying a correction factor developed by the California Air Resources Board to convert wet silt values to dry silt values.

## **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

## **Adjustments for Controls**

For construction emissions, a control efficiency of 50 percent is used for both PM<sub>10</sub> and PM<sub>2.5</sub> for PM nonattainment areas.

## **Spatial and Temporal Allocations**

### *Spatial*

State-level estimates of acres disturbed are distributed to counties according to the housing starts per county, estimated for the residential construction category.

### *Temporal*

Data for temporal allocation is not available for this source.

## Emissions Calculation

$$E_{RC,i} = \frac{Exp \times MC_i \times AD_i \times EF_{RC,i} \times DUR}{2000}$$

where:

- $E_{RC,i}$  = Emissions of pollutant i in tons per year from road construction
- $Exp_{RC,i}$  = Expenditures per road type i
- $MC_{RC,i}$  = Miles constructed per road type i
- $AD_i$  = Acres disturbed per road type i
- $EF_{RC,i}$  = Emissions factor (tons per acre per month for pollutant i)
- $DUR$  = Duration of project (months)

This calculation would have to be made for each road classification in a county and then summed to get total for that pollutant for that county.

### 3.1.7.4 Agricultural Land Preparation

SCC: 28 01 000 003

#### Description

The land preparation source category includes estimates of the airborne soil particulate emissions produced during the preparation of agricultural lands for planting and after harvest activities. Operations included in this methodology are dicing, tilling, leveling, chiseling, plowing, and other mechanical operations used to prepare the soil. Dust emissions are produced by the mechanical disturbance of the soil by the implement used and the tractor pulling it. Soil preparation activities tend to be performed in the early spring and fall months.

Particulate emissions from land preparation operations are computed by multiplying an emission factor (EF) by an activity factor. The agricultural tilling emission factor provided in the 4th edition of U.S. EPA's AP-42 document is used to estimate soil preparation emissions. The activity factor is based on the number of acres of each crop in production for each county in the State. Because different crops need different operations to prepare the soil, each crop also has its own acre-pass value. Acre-passes are the number of passes, per acre, that are typically needed to prepare a field for planting a particular crop. By combining the crop acreage, crop specific acre-pass data, and the agricultural tilling emission factor, we estimate the particulate matter produced by agricultural land preparation operations.

Agricultural soil preparation particulate dust emissions are estimated *for each crop* in each county in Maryland using the following equation:

$$\text{Emissions}_{\text{CROP}} = \text{Emission Factor} \times \text{Acres}_{\text{CROP}} \times \text{Acre-passes/acre}_{\text{CROP}}$$

The crop emissions for each county are summed to produce the county and statewide particulate matter (PM) and PM emission estimates.

#### Pollutants

PM<sub>10</sub> and PM<sub>2.5</sub>

#### Method and Data Sources

##### *Activity*

The acreages used for estimating soil preparation emissions were collected from the Maryland Cooperative Extension Service and the Maryland Agricultural Statistics Service. A summary of crop acreage harvested in 2010 thru 2011 from individual county agricultural commissioner reports was used to calculate emissions.

In computing land preparation PM emissions, acre-passes are the number of passes typically performed to prepare a crop for planting. These operations may occur following harvest or closer to planting, and can include dicing, tilling, land leveling, and other operations. Each crop is different in the type of soil operations performed and when they occur. MDE used acre-pass estimates compiled by the California Air Resources Board (CARB). For the crops that were not explicitly updated, we either applied an updated crop profile from a similar crop, or used one of the existing CARB profiles.

***Emission Factors***

The emission factor used to estimate the dust emissions from agricultural land preparations is from U.S. EPA’s AP-42<sup>1</sup>. This emission factor was developed in 1981 based on test data measured in California and Kansas by Midwest Research Institute. Because of a lack of more detailed estimates, this single emission factor is used for all land preparation operations, all locations, and all seasons. The form of the emission factor is:

$$\text{Emission Factor (lbs PM/acre-pass)} = k (4.8) (s)^{0.6}$$

Where:

- k = particle size fraction of interest (EPA default = 0.042 for PM<sub>2.5</sub> or 0.21 for PM<sub>10</sub>)
- s = average percent soil silt content (EPA default = 18%)

For PM the value of ‘k’ used in California is 0.148. This is based on the EPA estimate that 33% of the total particulate entrained to the air during agricultural operations is 30 microns or less. Of this, analysis of California soil samples indicates that about 45% of the 30 micron or less sized particles are 10 microns or less in aerodynamic size (i.e., PM<sub>10</sub>). So, the California PM particle size multiplier is 0.148 (i.e., 0.33 x 0.45 = 0.148). Maryland decided to use the EPA default values listed above for the particle size fraction. For the percent soil silt value, the EPA default value of 18% soil silt is used for most counties.

| Emission Factor | PM <sub>2.5</sub>                   | PM <sub>10</sub>                   |
|-----------------|-------------------------------------|------------------------------------|
|                 | (Lbs. PM <sub>2.5</sub> /acre-pass) | (Lbs. PM <sub>10</sub> /acre-pass) |
|                 | 1.141968254                         | 5.709841268                        |

The EPA emission factor does not include an association between soil moisture and emissions. Because it is known that dust emissions are reduced when soil moisture is higher, California ARB staff has incorporated an emission correction during the wettest months of the year. The correction was based on some limited agricultural dust source test data, as well as the control factor used for watering at construction sites and their best judgment. During December and March, California ARB reduced the emission factor by 25% from the standard uncorrected value. In January and February, often the wettest

<sup>1</sup> U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, AP-42, Section 11.2.2, Fourth Edition. September 1985.

months, the emission factor is reduced by 50%. This produces a seasonal emissions profile that is more consistent with California’s actual ambient air dust levels, and also better reflects that soil preparation operations typically do not occur while the soil is excessively wet or muddy.

**Point Source  
Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustments  
for Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Crop acreages are collected on a county basis.

*Temporal*

Data for temporal allocation is not available for this source in Maryland.

In collecting updated acre-pass data, California also collected detailed information on when agricultural operations occur. Using these data, it was possible to create detailed temporal profiles that help to indicate when PM emissions from land preparations may be highest. The more detailed background document includes detailed crop calendars for each crop with updated information. For all of the acre-pass and crop calendar information, the farmers and other agricultural experts of the San Joaquin Valley were instrumental in helping us to update our crop information.

**Emissions  
Calculation**

$$E_{ALP_i} = \frac{EF_{ALP_i} \times A_i \times AP_i}{2000}$$

Where:

- $E_{ALP}$  = Annual PM emissions of pollutant i in tons per day from agricultural land preparations.
- $EF_{ALP_i}$  = Emissions factor in pounds per acre-pass for pollutant i
- $A_i$  = Acres of crop I harvested in county j in 2011
- $AP_i$  = Acre-passes per acres for crop i

2011 Sample Calculation Agricultural Land Preparation (Alleghany County):

$$E_{ALP\ PM2.5} = \frac{EF_{ALP\ PM2.5} \times [(A_{wheat} \times AP_{wheat}) + (A_{corn-gr} \times AP_{corn-gr}) + (A_{hay} \times AP_{hay}) + (A_{soy} \times AP_{soy}) + (A_{barley} \times AP_{barley})]}{2000}$$

$$E_{ALP\ PM2.5} = (1.141968254 \times [(0 \times 1) + (500 \times 4) + (7,500 \times 1) + (0 \times 6) + (0 \times 1)]) / 2000$$

$$E_{ALP\ PM2.5} = (1.141968254 \times 9,500) / 2000$$

$$E_{ALP\ PM2.5} = 5.42 \text{ tons per year of PM2.5}$$

### 3.1.7.5 Paved Roads

SCC: 22 94 000 000

#### Description

This source category covers fugitive dust emissions from activity on paved roads. ONLY A GENERAL OUTLINE OF HOW THIS SOURCE WAS CALCULATED WILL BE GIVEN DUE TO THE LARGE NUMBER OF CALCULATIONS NEEDED TO SHOW A SAMPLE CALCULATION FOR ANY ONE COUNTY.

#### Pollutants

PM<sub>10</sub> and PM<sub>2.5</sub>

#### Method and Data Sources

##### *Activity*

The basis for the activity data for fugitive dust emissions from paved roads is the state-level vehicle miles traveled per paved road type and the state-level vehicle miles traveled per unpaved road per road type.

##### *Emission Factors*

To calculate emissions for Paved Roads we used the The Predictive Emission Factor Equation 13.2.1.3 from AP-42, Fifth Edition, Vol. I Chapter 13: Miscellaneous Sources and the particle size multipliers, k from Table 13.2.1-1.

Several factors used for Paved Road emissions calculations came from 2008 Emission Inventory Data & Documentation (<http://www.epa.gov/ttn/chief/net/2008inventory.html>) Nonpoint section for Paved Roads. Such as, Silt Loading factors for Maryland from Table 2, factors below:

| Roadway Class                        | $sL$<br>(g/m <sup>2</sup> ) |
|--------------------------------------|-----------------------------|
| Rural Interstate                     | 0.015                       |
| Rural Other Principal Arterial       | 0.03                        |
| Rural Minor Arterial                 | 0.06                        |
| Rural Major Collector                | 0.2                         |
| Rural Minor Collector                | 0.2                         |
| Rural Local                          | 0.6                         |
| Urban Interstate                     | 0.015                       |
| Urban Other Freeways and Expressways | 0.015                       |
| Urban Other Principal Arterial       | 0.03                        |
| Urban Minor Arterial                 | 0.03                        |
| Urban Collector                      | 0.06                        |
| Urban Local                          | 0.2                         |



The old calculation equation is

$$EF_{CF} = k (sL/2)^{0.98} \times (W/3)^{0.53} \times (S/30)^{0.16} \times (CF)$$

The new calculation equation is

$$EF_{PAV} = [(k) \times (sL)^{0.91} \times (W)^{1.02}] \times (1-P/4N)$$

$EF_{CF}$  = A calculated emission factor for a given road type in a month having  $CF$  precipitation

$EF_{PAV}$  = A calculated emission factor for a given road type in a month

$k$  = particle size multiplier; particle size range and units used were 0.015 (lb/VMT) for PM10, and 0.0037 (lb/VMT) for PM2.5 from Table 13.2.1-1. PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

$sL$  = road surface silt loading (grams per square meter) ( $g/m^2$ ),

$W$  = average weight (tons) of the vehicles traveling the road (Maryland estimates the average wt. to be 6,360 pounds or 3.18 tons)

$P$  = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period

$N$  = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly)

$S$  = average speed (mph) of the vehicles traveling the road.

$CF$  = Correction factor for monthly rain/precipitation

2008 average with 2011 bold monthly rain/precipitation

| MONTH | P                                       |  |  | N<br>Days in<br>Averaging<br>Period | CF <sub>RAIN</sub> |
|-------|---|--|--|-------------------------------------|--------------------|
|       | No. of Days<br>of Rain > 0.01<br>inches | No. of Days<br>of Snow ><br>1.0 inches | No. of Days of<br>Rain & Snow ><br>0.01 inches |                                     |                    |
| Jan   | 7                                       | 0                                      | 9  | 31                                  | 0.9274             |
| Feb   | 9                                       | 1                                      | 9  | 28                                  | 0.9196             |
| Mar   | 12                                      | 0                                      | 11   | 31                                  | 0.9113             |
| Apr   | 20                                      | 0                                      | 12   | 30                                  | 0.9000             |
| May   | 14                                      | 0                                      | 9  | 31                                  | 0.9274             |
| Jun   | 12                                      | 0                                      | 9  | 30                                  | 0.9250             |
| Jul   | 9                                       | 0                                      | 11   | 31                                  | 0.9113             |
| Aug   | 15                                      | 0                                      | 4  | 31                                  | 0.9677             |
| Sep   | 15                                      | 0                                      | 9  | 30                                  | 0.9250             |
| Oct   | 14                                      | 0                                      | 4  | 31                                  | 0.9677             |
| Nov   | 10                                      | 0                                      | 7  | 30                                  | 0.9417             |
| Dec   | 9                                       | 1                                      | 14   | 31                                  | 0.8871             |

(Maryland estimates the average speed (S) to be:

| Road Type                            | Speed (mph) |
|--------------------------------------|-------------|
| Rural Interstate                     | 65.5        |
| Rural Other Principal Arterial       | 51.7        |
| Rural Minor Arterial                 | 46.2        |
| Rural Major Collector                | 41.7        |
| Rural Minor Collector                | 40          |
| Rural Local                          | 30.9        |
| Urban Interstate                     | 58.1        |
| Urban Other Freeways and Expressways | 55.5        |
| Urban Other Principal Arterial       | 28.7        |
| Urban Minor Arterial                 | 27.8        |
| Urban Collector                      | 24.6        |
| Urban Local                          | 21.1        |

A temporal VMT fraction factor was supplied by which was used to breakdown yearly VMT into seasonal and then monthly VMT (millions of miles by road type).

| LookUp      | RUR_URB | SEASON | VMTRAC |
|-------------|---------|--------|--------|
| RURALWINTER | RURAL   | WINTER | 0.2199 |
| RURALSPRING | RURAL   | SPRING | 0.2403 |
| RURALSUMMER | RURAL   | SUMMER | 0.2845 |
| RURALLFALL  | RURAL   | FALL   | 0.2553 |
| URBANWINTER | URBAN   | WINTER | 0.236  |
| URBANSRING  | URBAN   | SPRING | 0.2547 |
| URBANSUMMER | URBAN   | SUMMER | 0.264  |
| URBANFALL   | URBAN   | FALL   | 0.2453 |

A Transport factor (*TF*) also of 1, was used in estimation. The transport factor relates to the Modelers, and it is the fraction of Paved Road Dust PM that is transported more than a few yards.

An emission factor was created for each month, for each road type, and each county, almost 14,000 emission factors.

Annual Rural Traffic VMT (millions of miles)

| FUNCTIONAL CLASS    | State County FIPs | Rural             | Rural                          | Rural                | Rural                 | Rural                 | Rural       | TOTAL RURAL  |
|---------------------|-------------------|-------------------|--------------------------------|----------------------|-----------------------|-----------------------|-------------|--------------|
|                     |                   | Rural Inter-State | Rural Other Principal Arterial | Rural Minor Arterial | Rural Major Collector | Rural Minor Collector | Rural Local |              |
| ALLEGANY            | 24001             | 179               | 30                             | 51                   | 28                    | 50                    | 43          | 381          |
| ANNE ARUNDEL        | 24003             | 324               | 79                             | 174                  | 58                    | 32                    | 94          | 761          |
| BALTIMORE           | 24005             | 434               | 68                             | 104                  | 204                   | 44                    | 120         | 974          |
| CALVERT             | 24009             | 0                 | 331                            | 19                   | 48                    | 38                    | 59          | 495          |
| CAROLINE            | 24011             | 0                 | 101                            | 111                  | 73                    | 53                    | 42          | 380          |
| CARROLL             | 24013             | 0                 | 54                             | 247                  | 127                   | 62                    | 63          | 553          |
| CECIL               | 24015             | 455               | 52                             | 220                  | 57                    | 53                    | 116         | 953          |
| CHARLES             | 24017             | 0                 | 288                            | 82                   | 108                   | 55                    | 71          | 604          |
| DORCHESTER          | 24019             | 0                 | 122                            | 81                   | 33                    | 59                    | 35          | 330          |
| FREDERICK           | 24021             | 513               | 337                            | 129                  | 210                   | 127                   | 176         | 1492         |
| GARRETT             | 24023             | 179               | 70                             | 68                   | 70                    | 91                    | 57          | 535          |
| HARFORD             | 24025             | 466               | 80                             | 174                  | 128                   | 68                    | 125         | 1041         |
| HOWARD              | 24027             | 269               | 83                             | 87                   | 100                   | 28                    | 80          | 647          |
| KENT                | 24029             | 0                 | 30                             | 51                   | 56                    | 26                    | 20          | 183          |
| MONTGOMERY          | 24031             | 142               | 0                              | 106                  | 93                    | 40                    | 51          | 432          |
| PRINCE GEORGE'S     | 24033             | 39                | 159                            | 32                   | 88                    | 39                    | 47          | 404          |
| QUEEN ANNE'S        | 24035             | 0                 | 540                            | 79                   | 90                    | 56                    | 105         | 870          |
| ST. MARY'S          | 24037             | 0                 | 153                            | 175                  | 96                    | 63                    | 63          | 550          |
| SOMERSET            | 24039             | 0                 | 99                             | 36                   | 29                    | 31                    | 24          | 219          |
| TALBOT              | 24041             | 0                 | 245                            | 100                  | 33                    | 33                    | 56          | 467          |
| WASHINGTON          | 24043             | 512               | 24                             | 134                  | 122                   | 96                    | 117         | 1005         |
| WICOMICO            | 24045             | 0                 | 231                            | 19                   | 51                    | 50                    | 44          | 395          |
| WORCESTER           | 24047             | 0                 | 227                            | 37                   | 58                    | 33                    | 48          | 403          |
| BALTIMORE CITY      | 24510             | 0                 | 0                              | 0                    | 1                     | 1                     | 0           | 2            |
| <b>GRAND TOTALS</b> |                   | <b>3512</b>       | <b>3403</b>                    | <b>2316</b>          | <b>1961</b>           | <b>1228</b>           | <b>1656</b> | <b>14076</b> |

Annual Urban Traffic VMT (millions of miles)

| FUNCTIONAL CLASS    | State County FIPs | Urban             | Urban                         | Urban                          | Urban                | Urban           | Urban       | TOTAL URBAN  |
|---------------------|-------------------|-------------------|-------------------------------|--------------------------------|----------------------|-----------------|-------------|--------------|
|                     |                   | Urban Inter-state | Urban Freeways & Express-ways | Urban Other Principal Arterial | Urban Minor Arterial | Urban Collector | Urban Local |              |
| ALLEGANY            | 24001             | 162               | 0                             | 168                            | 65                   | 28              | 33          | 456          |
| ANNE ARUNDEL        | 24003             | 907               | 1532                          | 903                            | 762                  | 453             | 351         | 4908         |
| BALTIMORE           | 24005             | 3449              | 470                           | 1140                           | 1173                 | 477             | 517         | 7226         |
| CALVERT             | 24009             | 0                 | 31                            | 114                            | 34                   | 49              | 18          | 246          |
| CAROLINE            | 24011             | 0                 | 0                             | 0                              | 0                    | 0               | 0           | 0            |
| CARROLL             | 24013             | 39                | 0                             | 479                            | 77                   | 67              | 51          | 713          |
| CECIL               | 24015             | 127               | 13                            | 171                            | 37                   | 26              | 29          | 403          |
| CHARLES             | 24017             | 0                 | 0                             | 378                            | 141                  | 75              | 46          | 640          |
| DORCHESTER          | 24019             | 0                 | 0                             | 38                             | 11                   | 9               | 4           | 62           |
| FREDERICK           | 24021             | 549               | 306                           | 167                            | 163                  | 177             | 105         | 1467         |
| GARRETT             | 24023             | 0                 | 0                             | 1                              | 0                    | 0               | 0           | 1            |
| HARFORD             | 24025             | 283               | 135                           | 434                            | 252                  | 131             | 95          | 1330         |
| HOWARD              | 24027             | 1084              | 1069                          | 224                            | 448                  | 260             | 238         | 3323         |
| KENT                | 24029             | 0                 | 0                             | 12                             | 6                    | 2               | 2           | 22           |
| MONTGOMERY          | 24031             | 2473              | 227                           | 2134                           | 1047                 | 598             | 499         | 6978         |
| PRINCE GEORGE'S     | 24033             | 2879              | 1502                          | 1706                           | 970                  | 632             | 592         | 8281         |
| QUEEN ANNE'S        | 24035             | 0                 | 47                            | 2                              | 5                    | 0               | 4           | 58           |
| ST. MARY'S          | 24037             | 0                 | 8                             | 194                            | 33                   | 33              | 21          | 289          |
| SOMERSET            | 24039             | 0                 | 46                            | 0                              | 7                    | 8               | 5           | 66           |
| TALBOT              | 24041             | 0                 | 0                             | 110                            | 10                   | 11              | 10          | 141          |
| WASHINGTON          | 24043             | 457               | 0                             | 216                            | 153                  | 62              | 69          | 957          |
| WICOMICO            | 24045             | 0                 | 184                           | 155                            | 109                  | 88              | 41          | 577          |
| WORCESTER           | 24047             | 0                 | 26                            | 204                            | 36                   | 18              | 22          | 306          |
| BALTIMORE CITY      | 24510             | 1044              | 138                           | 1164                           | 690                  | 237             | 252         | 3525         |
| <b>GRAND TOTALS</b> |                   | <b>13453</b>      | <b>5734</b>                   | <b>10114</b>                   | <b>6229</b>          | <b>3441</b>     | <b>3004</b> | <b>41975</b> |

VMT should be converted into monthly totals by county by road type using seasonal fraction factors.

$$E_{rt} = EF_{CF} \times VMT \times TF$$

Where:

$E_{rt}$  = is the emissions for a particular road type

$VMT$  = the vehicle miles traveled in millions of miles on a particular road type

$$TF = 1$$

### 3.1.7.6 Unpaved Roads

SCC: 22 96 000 000

#### Description

This source category covers fugitive dust emissions from activity on unpaved roads.

#### Pollutants

PM<sub>10</sub>-PRI, PM<sub>10</sub>-FIL, PM<sub>25</sub>-PRI, PM<sub>25</sub>-FIL

#### Method and

#### Data Sources

##### *Activity*

The basis for the activity data for fugitive dust emissions from unpaved roads is the county-level miles of unpaved roads. The unpaved road mileage is converted to county-level vehicle miles traveled per unpaved road type by the following equation:

$$VMT_{UNPAVED(x, i)} = \frac{ADTV_{(i)} * MILES_{UNPAVED(x, i)} * DAYS_{YR}}{1,000,000}$$

Where:

|                           |  |
|---------------------------|--|
| $VMT_{UNPAVED(x, i)}$ :   | Annual vehicle miles traveled for county x and road type i (in millions) |
| $ADTV_{(i)}$ :            | Average Daily Traffic Volume for road type i                             |
| $MILES_{UNPAVED(x, i)}$ : | Miles of unpaved roads in county x and road type i                       |
| $DAYS_{YR}$ :             | Days per year (365) conversion of daily traffic to annual traffic        |

Maryland received unpaved road mileage by county from the Maryland State Highway Administration. The unpaved road mileage data was divided into two functional classes, (Rural Local and Urban Local). The Rural Local and Urban Local roads were further divided into Rural Unpaved and Urban Unpaved roads. The VMT for Unpaved and Unimproved urban and local roads was calculated and then summed by county.

Mileage on urban and rural local roads was broken down into two groups of average daily travel volume (ADTV) in the 1996 Highway Statistics publication (the last year that data was published). These groups are shown in Table 3.2.7.6.a. Maryland used a reasonable assumption that no more than 50 vehicles travel its urban and rural local unpaved roads daily. The assumed ADTV is 5 for both urban and rural groups (<50 Rural Local volume group).

**Table 3.8.1.6.a Assumed Values for Average Daily Traffic Volume by Volume Group**

| <b>Rural Roads</b>                          |       |         |          |         |
|---|-------|---------|----------|---------|
| Volume Category (vehicles per day per mile) | < 50  | 50-199  | 200-499  | > 500   |
| Assumed ADTV                                | 5*    | 125**   | 350**    | 550***  |
| <b>Urban Roads</b>                          |       |         |          |         |
| Volume Category (vehicles per day per mile) | < 200 | 200-499 | 500-1999 | > 2000  |
| Assumed ADTV                                | 20*   | 350**   | 1250**   | 2200*** |

Notes: \*10% or volume group's maximum range endpoint, \*\* Average of volume group's range endpoints, \*\*\* 110% or volume group's minimum

**Table 3.8.1.6.b Daily VMT by County and Road Class**

| <b>County Name</b> | <b>2011 Daily VMT Rural rt210</b> | <b>2011 Daily VMT Urban rt330</b> |
|--------------------|-----------------------------------|-----------------------------------|
| ALLEGANY           | 0.2076                            | 0.5947                            |
| ANNE ARUNDEL       | 0.0032                            | 0.0529                            |
| BALTIMORE          | 0.0024                            | 0.0368                            |
| CALVERT            | 0.1063                            | 0.1260                            |
| CAROLINE           | 0.4473                            | 0.0000                            |
| CARROLL            | 0.1949                            | 0.2587                            |
| CECIL              | 0.0467                            | 0.0424                            |
| CHARLES            | 0.0215                            | 0.0422                            |
| DORCHESTER         | 0.1420                            | 0.0983                            |
| FREDERICK          | 0.1695                            | 0.4235                            |
| GARRETT            | 0.1852                            | 0.0000                            |
| HARFORD            | 0.0896                            | 0.3122                            |
| HOWARD             | 0.0023                            | 0.0162                            |
| KENT               | 0.0031                            | 0.0011                            |
| MONTGOMERY         | 0.0076                            | 0.2619                            |
| PRINCE GEORGE'S    | 0.0041                            | 0.1557                            |
| QUEEN ANNE'S       | 0.0553                            | 0.0365                            |
| ST. MARY'S         | 0.0246                            | 0.0150                            |
| SOMERSET           | 0.0456                            | 0.0427                            |
| TALBOT             | 0.0086                            | 0.0051                            |
| WASHINGTON         | 0.0544                            | 0.1170                            |
| WICOMICO           | 0.0762                            | 0.1659                            |
| WORCESTER          | 0.0437                            | 0.0759                            |
| BALTIMORE CITY     | 0.0000                            | 0.0542                            |

Unpaved road VMT was calculated first by State and roadway class using temporally allocated NAPAP Inventory factors (seasonal temporal allocations factors or VMT fractions – VMTFRAC values). These factors are provided in the EPA publication, “Paved and Unpaved Road VMT temp factors.xls”. The seasonal VMT fractions were then multiplied by the ratio of the number of days in a month to the number of days in a season to adjust to monthly VMTFRAC. The emission factors were then applied to estimate emissions by month.

Below is Table 3.8.1.6.c and d

**Seasonal VMT Fractional Values by Road Class**

| Rural rt210 EPA |         | Urban rt330 EPA |         |
|-----------------|---------|-----------------|---------|
| SEASON          | VMTFRAC | SEASON          | VMTFRAC |
| WINTER          | 0.2199  | WINTER          | 0.2360  |
| SPRING          | 0.2403  | SPRING          | 0.2547  |
| SUMMER          | 0.2845  | SUMMER          | 0.2640  |
| FALL            | 0.2553  | FALL            | 0.2453  |

**Emission Factors:**

Re-entrained road dust emissions for unpaved roads were estimated using unpaved road VMT and the emission factor equation from AP-42 <sup>76</sup>:

$$EF = \frac{\left[ k * \left( \frac{s}{12} \right)^a * \left( \frac{SPD}{30} \right)^b \right]}{\left( \frac{M}{0.5} \right)^c} - C$$

where k, a, b, and c are empirical constants given in Table 1 and

- EF = size specific emission factor (lb/VMT)
- s = surface material silt content (%)
- SPD = mean vehicle speed (mph)
- M = surface material moisture content (%)
- C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

**Table 3.8.1.6.e Constants for Unpaved Roads Re-entrained Dust Emission Factor Equation**

| Constant   | PM <sub>25</sub> | PM <sub>10</sub> |
|------------|------------------|------------------|
| K (lb/VMT) | 0.18             | 1.8              |
| a          | 1                | 1                |
| b          | 0.5              | 0.5              |
| c          | 0.2              | 0.2              |

<sup>76</sup> United States Environmental Protection Agency, Office of Air Quality Planning and Standards. “Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2 Unpaved Roads.” Research Triangle Park, NC. 2003.

C                    0.00036                    0.00047  
 Source: AP-42

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Average State-level unpaved silt content values, developed as part of the 1985 National Acid Precipitation Assessment Program (NAPAP) Inventory, were obtained from the Illinois State Water Survey<sup>77</sup>. Silt contents of over 200 unpaved roads from over 30 States were obtained. Average silt contents of unpaved roads were calculated for each State that had three or more samples for that State. For States that did not have three or more samples, the average for all samples from all States was used. Samples and default values were provided by state. Silt content (%) from (AP-42 Table 13.2.2-1) of **3.9** was used for the Unpaved/Unimproved roads.

**Table 3.8.1.6.f** State-Level Unpaved Road Surface Material Silt Content Values used in MANE-VU Fugitive Dust Calculations

| State         | Unpaved Road<br>Surface Material Silt<br>Content (%) | Data Source      |
|---------------|--|------------------|
| Connecticut   | 3.9  | DEFAULT          |
| Delaware      | 0  | No Unpaved Roads |
| DC            | 0  | No Unpaved Roads |
| Maine         | 3.9  | DEFAULT          |
| Maryland      | 3.9  | DEFAULT          |
| Massachusetts | 3.9  | DEFAULT          |
| New Hampshire | 3.9  | DEFAULT          |
| New Jersey    | 3.9  | DEFAULT          |
| New York      | 4.7  | SAMPLES          |
| Pennsylvania  | 3.3  | SAMPLES          |
| Rhode Island  | 3.9  | DEFAULT          |
| Vermont       | 3.9  | DEFAULT          |

Table 3.8.1.6.g lists the speeds modeled on the unpaved roads by roadway type. These speeds were determined based on national average speeds modeled for onroad emission calculations and weighted to determine a single average speed for each of the roadway types. The value of 0.5 percent for M was chosen as the national default as sufficient resources were not available to determine more locally-specific values for this variable.

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<sup>77</sup> G. Stensland, Illinois State Water Survey, personal communication with W. Barnard of E.H. PECHAN & Associates, Inc., Durham, NC. 1989.



**Table 3.8.1.6.g** Speeds Modeled by Roadway Type on Unpaved Roads

| Unpaved Roadway Type           | Speed (mph) |
|--------------------------------|-------------|
| Rural Minor Arterial           | 39          |
| Rural Major Collector          | 34          |
| Rural Minor Collector          | 30          |
| Rural Local                    | 30          |
| Urban Other Principal Arterial | 20          |
| Urban Minor Arterial           | 20          |
| Urban Collector                | 20          |
| Urban Local                    | 20          |

The emission factor for paved roads is calculated from the empirical AP-42 formula and then is adjusted for precipitation. Correction factors were applied to the emission factors to account for the number of days with a sufficient amount of precipitation to prevent road dust resuspension. Monthly-corrected emission factors by State and roadway classification were calculated using the following equation:

$$EF_{CORR} = EF * \left[ \frac{(D - p)}{D} \right]$$

Where:

$EF_{CORR}$  = unpaved road dust emission factor corrected for precipitation effects

$EF$  = uncorrected emission factor

$D$  = number of days in the month

$p$  = number of days in the month with at least 0.01 inches of precipitation

The number of days in each county with at least 0.01 inches of precipitation in each month was obtained from the National Climatic Data Center<sup>78</sup>. For counties with more than one precipitation collection station with valid data from the NCDC data set, an average number of precipitation days were calculated for each month from all valid stations in the county. Counties with no precipitation collection station or no valid data were assigned the data from an adjacent county. The 2011 monthly precipitation data for MANE-VU counties were updated and are shown in Table 4. This method of assigning monthly precipitation days by county improves on the NEI approach of assigning monthly precipitation data by State. These are the same precipitation data used to calculate paved road emissions for the MANE-VU States.

**Table 3.8.1.6.h** 2011 Number of Days with at Least 0.01 Inches of Precipitation

| State | County          | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|-------|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| MD    | ALLEGANY        | 7   | 9   | 12  | 20  | 14  | 12  | 9   | 15  | 15  | 14  | 10  | 9   |
| MD    | ANNE ARUNDEL    | 9   | 9   | 12  | 14  | 12  | 10  | 8   | 16  | 16  | 11  | 9   | 7   |
| MD    | BALTIMORE       | 4   | 5   | 7   | 8   | 8   | 3   | 3   | 2   | 13  | 10  | 8   | 6   |
| MD    | CALVERT         | 9   | 4   | 14  | 12  | 11  | 12  | 9   | 10  | 12  | 9   | 11  | 9   |
| MD    | CAROLINE        | 11  | 10  | 11  | 12  | 11  | 11  | 8   | 14  | 12  | 15  | 11  | 6   |
| MD    | CARROLL         | 12  | 9   | 11  | 16  | 15  | 10  | 7   | 17  | 22  | 14  | 8   | 11  |
| MD    | CECIL           | 8   | 12  | 11  | 15  | 10  | 9   | 9   | 14  | 19  | 14  | 10  | 5   |
| MD    | CHARLES         | 9   | 4   | 14  | 12  | 11  | 12  | 9   | 10  | 12  | 9   | 11  | 9   |
| MD    | DORCHESTER      | 9   | 4   | 14  | 12  | 11  | 12  | 9   | 10  | 12  | 9   | 11  | 9   |
| MD    | FREDERICK       | 10  | 9   | 12  | 16  | 16  | 10  | 6   | 14  | 22  | 11  | 9   | 7   |
| MD    | GARRETT         | 20  | 16  | 18  | 20  | 17  | 12  | 11  | 13  | 14  | 18  | 11  | 15  |
| MD    | HARFORD         | 8   | 12  | 11  | 15  | 10  | 9   | 9   | 14  | 19  | 14  | 10  | 5   |
| MD    | HOWARD          | 7   | 6   | 14  | 14  | 10  | 2   | 7   | 8   | 10  | 11  | 8   | 8   |
| MD    | KENT            | 11  | 8   | 9   | 15  | 8   | 8   | 7   | 16  | 13  | 11  | 7   | 6   |
| MD    | MONTGOMERY      | 10  | 9   | 12  | 17  | 12  | 7   | 7   | 13  | 18  | 12  | 8   | 11  |
| MD    | PRINCE GEORGE'S | 9   | 10  | 12  | 15  | 13  | 8   | 6   | 11  | 14  | 16  | 9   | 9   |
| MD    | QUEEN ANNE'S    | 11  | 10  | 11  | 12  | 11  | 11  | 8   | 14  | 12  | 15  | 11  | 6   |
| MD    | ST. MARY'S      | 8   | 6   | 12  | 10  | 11  | 7   | 9   | 11  | 13  | 10  | 9   | 6   |
| MD    | SOMERSET        | 10  | 7   | 12  | 10  | 7   | 8   | 9   | 12  | 12  | 9   | 12  | 9   |
| MD    | TALBOT          | 9   | 7   | 11  | 12  | 11  | 11  | 9   | 14  | 12  | 13  | 9   | 10  |
| MD    | WASHINGTON      | 11  | 10  | 14  | 15  | 16  | 5   | 10  | 16  | 16  | 12  | 8   | 7   |
| MD    | WICOMICO        | 12  | 9   | 12  | 9   | 9   | 14  | 9   | 13  | 13  | 11  | 10  | 8   |
| MD    | WORCESTER       | 10  | 7   | 12  | 10  | 7   | 8   | 9   | 12  | 12  | 9   | 12  | 9   |
| MD    | BALTIMORE CITY  | 9   | 10  | 10  | 13  | 11  | 8   | 7   | 16  | 13  | 11  | 7   | 6   |

### Point Source Adjustments

No subtraction of emissions from point sources is necessary.

<sup>78</sup> U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Summary of the Day Element TD-3200, 2002 data provided on CD. National Climatic Data Center. 2003.

## Adjustment for Controls

No controls are available for this source category.

## Spatial and Temporal Allocations

### *Spatial*

BMC provided miles of unpaved roads at the county-level to spatially allocate emission estimates.

### *Temporal*

The unpaved road VMT data were temporally allocated by month using the NAPAP<sup>79</sup> temporal allocation factors.

## Emissions Calculation

### *AP-42 Unpaved Roads Emission Factor Formula*

$$EF = \frac{\left[ k * \left( \frac{s}{12} \right)^a * \left( \frac{SPD}{30} \right)^b \right]}{\left( \frac{M}{0.5} \right)^c} - C$$

Where k, a, b, and c are empirical constants given in Table 1 and

EF = size specific emission factor (lb/VMT)

s = surface material silt content (%)

SPD = mean vehicle speed (mph)

M = surface material moisture content (%)

C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

Calculate Local Unpaved Roads Emission Factors

Example: Anne Arundel County - Local Rural Unpaved Roads – PM<sub>25</sub>

$$EF_{PM25} = \frac{\left[ k * \left( \frac{s}{12} \right)^a * \left( \frac{SPD}{30} \right)^b \right]}{\left( \frac{M}{0.5} \right)^c} - C$$

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<sup>79</sup> U.S. Environmental Protection Agency. "The 1985 NAPAP Emissions Inventory: Development of Temporal Allocation Factors," EPA-600/7-89-010d. Air & Energy Engineering Research Laboratory. Research Triangle Park, NC. April 1990.

$$EF_{PM_{25}} = \frac{\left[ 0.27 * \left( \frac{3.9}{12} \right)^1 * \left( \frac{30}{30} \right)^{0.5} \right]}{\left( \frac{0.5}{0.5} \right)^{0.2}} - 0.00036$$

$$EF_{PM_{25}} = 0.08739$$

***Adjust Emission Factor Formula for Precipitation***

$$EF_{CORR} = EF * \left[ \frac{(D - p)}{D} \right]$$

Where:

$EF_{CORR}$  = unpaved road dust emission factor corrected for precipitation effects

EF = uncorrected emission factor

D = number of days in the month

p = number of days in the month with at least 0.01 inches of precipitation

**Calculate Unpaved Roads Emission Factors Adjusted for Precipitation**

(Example Calculation: Anne Arundel County – July – PM<sub>25</sub>)

$$EF_{PM_{25}-CORR} = EF_{PM_{25}} * \left[ \frac{(D - p)}{D} \right]$$

$$EF_{PM_{25}-CORR} = 0.08739 * \left[ \frac{(31 - 8)}{31} \right]$$

$$EF_{PM_{25}-CORR} = 0.064838$$

Emission Equation:

$$EM_{PM_{25}} = \frac{EF_{PM_{25}-CORR} * VMT * VMTFRAC}{2000} * [1 - (CE * RE * RP)]$$

Where:

$EM_{PM_{25}}$  = PM<sub>25</sub> emissions in tons per year for unpaved roads in county i

$VMT_i$  = Annual VMT (million miles of Vehicle Miles Traveled for county i)

VMTFRAC = Temporal Allocation Factor

$EF_{PM_{25}-CORR_i}$  = Unpaved road emission factor adjusted for precipitation in county i

CE = Control efficiency of 0% applied to Urban and Rural roads

RE = Rule effectiveness of 100% applied to Urban and Rural roads

RP = Rule penetration of 100% applied to Urban and Rural roads

Sample Calculation Unpaved Roads (Anne Arundel County - July)

$$EM_{PM25} = \frac{EF_{PM25-CORR} * VMT * VMTFRAC}{2000} * [1 - (CE * RE * RP)]$$

$$EM_{PM25} = \frac{0.0648377 * 0.0001533 * 0.09586}{2000} * [1 - (0 * 100 * 100)]$$

$$EM_{PM25} = 4.764 \times 10^{-10} \text{ Tons}$$

### 3.1.8 FIRE SOURCES

Other area sources include forest fires, slash and prescribed burning, agricultural burning, structure fires, orchard heaters, leaking underground storage tanks and natural organic sources. Although often intermittent in nature, many of these sources can produce large quantities of air pollutant emissions.

Date: September 10, 2012

This note is intended to support the DRAFT 2011 day-specific emissions estimates that EPA has posted for Wild Land Fires (WLF= prescribed and wild fires) intended for the NEI EVENT data category. These data are posted as .csv files for every state. The state FIPS is used in the title of the file to identify the area in question. The methods used by EPA reflect use of the SMARTFIRE2 (SF2) framework. We have provided background on these methods as part of the training(s) we have offered over the past few months on the 2011 NEI submittal process. For further information on this training, please see our 2011 webpage under “Events Inventory” training at: <http://www.epa.gov/ttn/chief/eidocs/training.html#eis>.

For the 2011 cycle, EPA is offering three options for SLTs to submit WLF emissions into the EVENTS module.

Note: EPA’s methods will be reporting all Wild Fires to SCC 281001000; all Prescribed Fires to 2811015000; all Wild Land Fire Use to 2810001001. MDE calculated and reported emissions for Prescribed Fires.

**Option 1:** Review the DRAFT 2011 emission estimates and report back to EPA through a Support Request in the Emission Inventory System (EIS) indicating that your agency accepts the EVENT data from EPA.

### 3.1.8.1 Vehicle Fires

SCC: 28 10 001 000

#### Description

This emission guidance report covers air emissions from accidental vehicle fires. Vehicles included are any commercial or private mode of transportation that is authorized for use on public roads.

#### Pollutants

PM<sub>10</sub>, NO<sub>x</sub>, CO, VOC

#### Method and Data Sources

##### *Activity*

Local data was collected from state or local fire marshals and public safety departments. See the spatial apportioning section for available information sources.

##### *Emission Factors*

Emission factors are available for open burning of automobile components including upholstery, belts, hoses, and tires (AP-42, Section 2.5 Open Burning) (EPA, 1996)<sup>80</sup>. The amount of vehicle material burned (the fuel loading) in a vehicle fire must be estimated to use these factors. A conservative assumption is that an average vehicle has 500 pounds of components that can burn in a fire, based on a 3,700 pound average vehicle weight (CARB, 1995)<sup>81</sup>. Maryland used a more conservative assumption based on a 2,000 pound average vehicle weight. EPA and ERTAC committee through a joint study estimated PM<sub>2.5</sub>-PRI to be 100 lbs per ton of material burned in fire. Also, EIIP, Vehicle Fires – January 1999 and 2000.

| <b>Pollutant</b>       | <b>Lbs/ton burned</b> |
|------------------------|-----------------------|
| VOC                    | 32                    |
| NO <sub>x</sub>        | 4                     |
| CO                     | 125                   |
| PM <sub>10</sub> -PRI  | 100                   |
| PM <sub>2.5</sub> -PRI | 100                   |

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<sup>80</sup> EPA. 1996. *Compilation of Air Pollutant Emission Factors--Volume I: Stationary Point and Area Sources. Fifth Edition, AP-42*. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. (GPO 055-000-00251-7). Research Triangle Park, North Carolina

<sup>81</sup> CARB. 1995. *Emission Inventory Procedural Manual, Vol. III: Methods for Assessing Area Source Emissions*. California Environmental Protection Agency: Air Resources Board.

## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

## Adjustment for Controls

No controls are available for this source category.

## Spatial and Temporal Allocations

### *Spatial*

The activity data for vehicle fires was collected at a county-level. No other method to spatially profile the vehicle fire source category was used.

### *Temporal*

Data for temporal allocation is not available for this source.

## Emissions Calculation

$$E_{VF,i} = \frac{VB_j \times FLF_{VF} \times EF_{VF,i}}{2000}$$

Where:

$E_{VF,i}$  = Emissions of pollutant i in tons per year from vehicle fires

$VB_j$  = Vehicles burned in county j in 2011

$FLF_{VF}$  = Fuel loading factor (tons/vehicle burned) for vehicle fires (500 lbs/2000 lb auto) which is also equal to 0.25 tons/vehicle burned

$EF_{VF,i}$  = Emissions factor in pounds per ton burned for pollutant i

### 2011 Sample Calculation Vehicle Fires (Anne Arundel County)

$$E_{VF,i} = \frac{VB_j \times FLF_{VF} \times EF_{VOC}}{2000}$$

$$E_{VF,i} = \frac{(241 \times (0.25) \times 32)}{2000}$$

$$E_{VF,i} = 0.96 \text{ tons VOC per year emitted from vehicle fires in Anne Arundel County in 2011}$$



**3.1.8.2 Forest Fires**

SCC: 28 10 001 000 (Wildfires)

(MDE accepted EPA’s Wild Fire Emissions generated by their SmartFire Tool, but calculated emissions for forest fires in order to compare them with the tool.)

**3.1.8.3 Slash/Prescribed Burning**

SCC: 28 10 015 000 (prescribed burn)

SCC: 28 10 005 000 (slash burn)

**Description**

Slash burning is a technique used to control waste from logging operations burned under controlled conditions to reduce the potential fire hazard in forests and to remove brush that can serve as a host for destructive insects. Also, to cleared forest to create fields for farming, pastures for livestock, and many other reasons. 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.

**Pollutants**

PM<sub>10</sub> and PM<sub>2.5-PRI</sub>

**Method and**

**Data Sources**

*Activity*

Emissions from this source were calculated using data from the Maryland Forest Service for prescribed burning by county and type of material burned (see Appendices).

*Emission Factor*

|                        | VOC<br>(Lbs./ton) | CO<br>(Lbs./ton) | NO <sub>x</sub><br>(Lbs./ton) | PM10-<br>FIL<br>(Lbs./ton) | PM2.5-<br>FIL<br>(Lbs./ton) | SO <sub>2</sub><br>(Lbs./ton) |
|------------------------|-------------------|------------------|-------------------------------|----------------------------|-----------------------------|-------------------------------|
| Prescribed Marsh Grass | 13.6              | 289              | 6.2                           | 28.1                       | 24.1                        | 1.7                           |
| Pine Slash             | 19                | 140              | 4                             | 17                         | unavailable                 | unavailable                   |

|                              |                  |
|------------------------------|------------------|
| <b>Fuel loading factors:</b> | <b>tons/acre</b> |
| <b>Prescribed</b>            | <b>2</b>         |
| <b>Slash</b>                 | <b>30</b>        |

## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

## Adjustments for Controls

No controls are available for this source category.

## Spatial and Temporal Allocations

### *Spatial*

The activity data for prescribed burning was collected at a county-level. No other method to spatially profile the prescribed burning source category was used.

### *Temporal*

Because prescribed burning is done at different times of the year, ARMA used no seasonal adjustment factor. The activity level is seven days per week.

## Emissions Calculation

$$E_{PB,i} = \frac{AB_j \times EF_{PB,i} \times FLF_m}{2000}$$

Where:

- $E_{PB,i}$  = Emissions of pollutant i in tons per year from prescribed burning
- $FLF_m$  = Fuel loading factor for type of material burned j (for marsh grass the factor is 2 tons per acre and for pine slash it is 30 tons per acre burned)
- $AB_k$  = Acres burned in county k in 2011
- $EF_{PB,i}$  = Emission factor for pollutant i

### 2011 Sample Calculation Prescribed Burning (Frederick County)

$$E_{PB,i} = \frac{AB_j \times EF_{PB,i} \times FLF_m}{2000}$$

$$E_{PB,i} = \frac{(55.5 \times 13.6 \times 2)}{2000}$$

$$E_{PB,i} = 0.75 \text{ tons VOC / year}$$

Slash burning calculations are done in a similar manner.

### 3.1.8.4 Agricultural Burning

SCC: 21 01 500 000

#### Description

This source category covers agricultural burning practices used to clear and/or prepare land for planting. Operations included under this category are stubble burning, burning of agricultural crop residues, and burning of standing field crops as part of harvesting (e.g., sugar cane).

#### Pollutants

PM<sub>10</sub> and PM<sub>2.5</sub>

#### Method and Data Sources

Emissions from this source were assigned to the open burning category because the county permits issued in 2008 did not require information distinguishing the amount of agricultural waste to be burned versus other materials.

### 3.1.8.5 Structure Fires

SCC: 28 10 030 000

#### Description

Building fires produce short-term emissions of organic compounds.

#### Pollutants

PM<sub>10</sub> and PM<sub>2.5</sub>

#### Method and Data Sources

MDE staff used emission factors, fuel loading factors and methodology documented in EIIP<sup>82</sup>, Structure Fires, dated July 1999.

#### *Activity*

The Maryland State Fire Marshal's office provided the number of structure fires by county.

#### *Emission Factors*

|                      | VOC        | NO <sub>x</sub> | CO         | PM10-PRI   |
|----------------------|------------|-----------------|------------|------------|
|                      | (lbs./ton) | (lbs./ton)      | (lbs./ton) | (lbs./ton) |
| Emissions            | 11.0       | 1.4             | 60.0       | 10.8       |
| Fuel loading factor: | 1.15       | Tons/fire       |            |            |

<sup>82</sup> Emission Inventory Improvement Program

## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

## Adjustments for Controls

No controls are available for this source category.

## Spatial and Temporal Allocations

### *Spatial*

The activity data for structure fires was collected at a county-level. No other method to spatially profile the prescribed burning source category was used.

### *Temporal*

Because structure fires occur at different times of the year, ARMA used no seasonal adjustment factor. The activity level is seven days per week.

## Emissions Calculation

$$E_{SF,i} = \frac{SF_k \times EF_{SF,i} \times FLF_{SF}}{2000}$$

where:

$E_{FF,i}$  = Emissions of pollutant i in tons per year from structure fires

$FLF_{SF}$  = Fuel loading factor (tons/acre burned) for structure fires

$SF_k$  = Structure fires in county k in 2011

$EF_{SF,i}$  = Emission factor for pollutant i in pounds per ton

ARMA used an activity level of 7 days a week with no seasonal variation as given in Table 5.8-1 in the EIIP document.

### 2011 Sample Calculation Structure Fires (Baltimore County)

Equation:

$$E_{SF,i} = \frac{SF_k \times EF_{SF,i} \times FLF_{SF}}{2000}$$

$$E_{SF,i} = \frac{310 \times 11 \times 1.15}{2000}$$

$$E_{SF,i} = 1.96 \text{ tons}_{VOC} / \text{year}$$

### **3.1.8.6 Orchard Heaters**

SCC: 28 01 520 000

#### **Description**

In areas of the country where frost threatens orchards, heaters may be used in cold portions of the growing season.

#### **Pollutants**

PM<sub>10</sub> and PM<sub>2.5</sub>

#### **Method and Data Sources**

Calls to several orchards in Washington and Frederick Counties (where most of the orchards in Maryland are located), revealed that no heaters were used. One orchard used fans to move air on still nights when there would be danger of frost to fruit tree blossoms. Therefore, orchard heaters are not included in Maryland's baseline inventory.

### 3.1.9 AMMONIA SOURCES

#### INTRODUCTION

Currently, there is a significant amount of uncertainty concerning the contribution of soil to ammonia emission levels. High quality emission factors for this category do not exist, and even the physics of ammonia-surface exchange is not well understood. Soils emit and uptake ammonia so it is difficult to evaluate the net contribution, emissions may be potentially significant in some regions if the uptake is not substantial. Indeed, the literature shows that a soil-plant canopy system can be a source of ammonia emissions under certain conditions and a sink under other conditions. Because of this uncertainty, the State of Maryland has decided not to include emissions from soils. MDE inventoried the following sources for ammonia emissions.

- Agricultural Livestock Production Operations
- Agricultural Fertilizer Application
- Mobile Sources
- Publicly Owned Treatment Works (POTWs)
- Human activity

#### Emission Calculations Methodology

Normally, the Department use the Carnegie Mellon University Ammonia Model (CMU-Ammonia Model version 3.6)<sup>83</sup> computer program to develop an ammonia emissions inventory. However, for the 2011 NEI emissions inventory cycle, MDE has accepted EPA's 2011 emissions inventory data.

The CMU-Ammonia Model program is an approved methodology by EPA for developing ammonia source categories emissions inventory. Basically, the CMU-Ammonia Model program multiplies emission factors per source category by its particular activity data

##### 3.1.9.1 Agricultural Livestock Production Operations

Livestock waste is one of the most important sources of ammonia when considering the sheer magnitude of the emissions. Existing ammonia inventories indicate that livestock wastes are responsible for 50-70% of national ammonia emissions. The United States Department of Agriculture publishes the Census of Agriculture (USDA, 2007), conducted every five years, which includes accurate inventories for livestock; however, the categories of animals reported at the county level differ from the categories of animals for which current emission factors exist. 2007 activity data were used from the USDA Census of Agriculture data to develop the 2011 ammonia emission inventory.

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<sup>83</sup> Copyright 2004, *CMU- NH3 Ammonia Model Inventory Version 3.6 computer program*. Departments of Civil and Environmental Engineering and Engineering and Public Policy Porter Hall Room 119, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213

### 3.1.9.2 Dairy Cattle (cows)

SCC: 2805001100 (Beef feedlots (drylots) Confinement)  
2805001200 (Beef Manure handling & storage)  
2805002000 (Beef Not Elsewhere Classified)  
2805003100 (Beef pasture Confinement)  
2805018000 (Not elsewhere classified Composite)  
2805019100 (Flush Confinement)  
2805019200 (Flush Manure handling & storage)  
2805019300 (Flush Land application of manure)  
2805021100 (Scrape Confinement)  
2805021200 (Scrape Manure handling & storage)  
2805021300 (Scrape Land application of manure)  
2805022100 (Deep pit Confinement)  
2805022200 (Deep pit Manure handling & storage)  
2805022300 (Deep pit Land application of manure)  
2805023100 (Drylot pasture Confinement)  
2805023200 (Drylot pasture Manure handling & storage)  
2805023300 (Drylot pasture Land application of manure)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and**

#### **Data Sources**

Conceptually, the method for estimating emissions from cattle is to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

#### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

#### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source**

#### **Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

### **Spatial and Temporal Allocations**

#### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

#### *Temporal*

The CMU-NH<sub>3</sub> ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

### **Emissions Calculation**

#### Equation:

#### 2011 TPY ammonia emissions for cows in an individual county

$$EM_{\text{COWS-2011 Total}} = 2011EM_{\text{BC}} + 2011 EM_{\text{MC}} + 2011EM_{\text{HF}} + 2011 EM_{\text{ST}}$$

Where:

$EM_{\text{COWS-2011 Total}}$  = Total NH<sub>3</sub> emissions from cows, all categories

$EM_{\text{BC}}$  = 2011 Uncontrolled emissions from beef cows

$EM_{\text{MC}}$  = 2011 Uncontrolled emissions from milk cows

$EM_{\text{HF}}$  = 2011 Uncontrolled emissions from heifers

$EM_{\text{ST}}$  = 2011 Uncontrolled emissions from steers

Where:

$$EM_{\text{BC}} = (AC_{\text{BC}} * EF_{\text{BC}})$$

$$EM_{\text{MC}} = (AC_{\text{MC}} * EF_{\text{MC}})$$

$$EM_{\text{HF}} = (AC_{\text{HF}} * EF_{\text{HF}})$$

$$EM_{\text{ST}} = (AC_{\text{ST}} * EF_{\text{ST}})$$

Where:

$AC_{\text{BC}}$  = Activity level (number) of beef cows

$AC_{\text{MC}}$  = Activity level (number) of milk cows

$AC_{\text{HF}}$  = Activity level (number) of heifers

$AC_{\text{ST}}$  = Activity level (number) of steers

$EF_{\text{BC}}$  = Emission factor for beef cows

$EF_{\text{MC}}$  = Emission factor for milk cows

$EF_{\text{HF}}$  = Emission factor for heifers

$EF_{\text{ST}}$  = Emission factor for steers



### 3.1.9.3 Hogs and Pigs

SCC: 28 05 025 000 (Swine Composite)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and Data Sources**

Conceptually, the method for estimating emissions from hogs and pigs are to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

##### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

##### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

#### **Spatial and Temporal Allocations**

##### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

##### *Temporal*

The CMU-NH<sub>3</sub> ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

## Emissions Calculation

### Equation:

2011 TPY ammonia emissions for swine in an individual county

$$EM_{\text{SWINE-2011 Total}} = 2011 EM_{\text{HOGS}} + 2011 EM_{\text{PIGS}}$$

Where:

$EM_{\text{SWINE-2011 Total}}$  = Total NH<sub>3</sub> emissions from swine, all categories

$EM_{\text{HOGS}}$  = 2011 Uncontrolled emissions from hogs

$EM_{\text{PIGS}}$  = 2011 Uncontrolled emissions from pigs

Where:

$$EM_{\text{HOGS}} = (AC_{\text{HOGS}} * EF_{\text{HOGS}})$$

$$EM_{\text{PIGS}} = (AC_{\text{PIGS}} * EF_{\text{PIGS}})$$

Where:

$AC_{\text{HOGS}}$  = Activity level (number) of hogs

$AC_{\text{PIGS}}$  = Activity level (number) of pigs

$EF_{\text{HOGS}}$  = Emission factor for hogs

$EF_{\text{PIGS}}$  = Emission factor for pigs

### 3.1.9.4 Chickens (Pullets, Layers, Broilers, and Misc Poultry)

SCC: 28 05 007 100 (Chickens Composite)  
28 05 007 300 (Chickens Composite)  
28 05 008 100 (Chickens Composite)  
28 05 008 200 (Chickens Composite)  
28 05 008 300 (Chickens Composite)  
28 05 009 100 (Chickens Composite)  
28 05 009 200 (Chickens Composite)  
28 05 009 300 (Chickens Composite)  
28 05 030 000 (Misc Poultry)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and Data Sources**

Conceptually, the method for estimating emissions from chickens composite is to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

#### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

#### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

#### **Spatial and Temporal Allocations**

#### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

### *Temporal*

The CMU-NH3 ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

### **Emissions Calculation**

#### Equation:

#### 2011 TPY ammonia emissions for chickens in an individual county

$$EM_{\text{CHICKENS-2011 Total}} = 2011 EM_{\text{PULLET}} + 2011 EM_{\text{LAYER}} + 2011 EM_{\text{BROILER}}$$

Where:

$$\begin{aligned} EM_{\text{CHICKENS-2011 Total}} &= \text{Total NH}_3 \text{ emissions from chickens, all categories} \\ EM_{\text{PULLET}} &= \text{2011 Uncontrolled emissions from pullets} \\ EM_{\text{LAYER}} &= \text{2011 Uncontrolled emissions from layers} \\ EM_{\text{BROILER}} &= \text{2011 Uncontrolled emissions from broilers} \end{aligned}$$

Where:

$$\begin{aligned} EM_{\text{PULLET}} &= (AC_{\text{PULLET}} * EF_{\text{PULLET}}) \\ EM_{\text{LAYER}} &= (AC_{\text{LAYER}} * EF_{\text{LAYER}}) \\ EM_{\text{BROILER}} &= (AC_{\text{BROILER}} * EF_{\text{BROILER}}) \\ &= \end{aligned}$$

Where:

$$\begin{aligned} AC_{\text{PULLET}} &= \text{Activity level (number) of pullet chickens} \\ AC_{\text{LAYER}} &= \text{Activity level (number) of layer chickens} \\ AC_{\text{BROILER}} &= \text{Activity level (number) of broiler chickens} \\ EF_{\text{PULLET}} &= \text{Emission factor for pullet chickens} \\ EF_{\text{LAYER}} &= \text{Emission factor for layer chickens} \\ EF_{\text{BROILER}} &= \text{Emission factor for broiler chickens} \end{aligned}$$

### 3.1.9.5 Sheep

SCC: 28 05 040 000 (Sheep Composite)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and Data Sources**

Conceptually, the method for estimating emissions from sheep composite is to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

#### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

#### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

#### **Spatial and Temporal Allocations**

#### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

#### *Temporal*

The CMU-NH<sub>3</sub> ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

**Emissions  
Calculation**

Equation:

2011 TPY ammonia emissions for sheep in an individual county

$$EM_{SHEEP} = AC_{SHEEP} * EF_{SHEEP}$$

Where:

$EM_{SHEEP}$  = Total NH3 emissions from sheep, all categories

$AC_{SHEEP}$  = Activity level (number) of sheep

$EF_{SHEEP}$  = Emission factor for sheep

### 3.1.9.6 Goats (Angora and Milk)

SCC: 28 05 045 001(Goats Composite)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and Data Sources**

Conceptually, the method for estimating emissions from goats are to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories.

#### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

#### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

#### **Spatial and Temporal Allocations**

#### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

#### *Temporal*

The CMU-NH<sub>3</sub> ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

## Emissions Calculation

### Equation:

#### 2011 TPY ammonia emissions for goats in an individual county

$$EM_{GOATS-2011\ Total} = 2011\ EM_{AG} + 2011\ EM_{MG}$$

Where:

$$\begin{aligned} EM_{GOATS-2011\ Total} &= \text{Total NH}_3 \text{ emissions from goats, all categories} \\ EM_{AG} &= \text{2011 Uncontrolled emissions from angora goats} \\ EM_{MG} &= \text{2011 Uncontrolled emissions from milk goats} \end{aligned}$$

Where:

$$\begin{aligned} EM_{AG} &= (AC_{AG} * EF_{AG}) \\ EM_{MG} &= (AC_{MG} * EF_{MG}) \\ &= \end{aligned}$$

Where:

$$\begin{aligned} AC_{AG} &= \text{Activity level (number) of angora goats} \\ AC_{MG} &= \text{Activity level (number) of milk goats} \\ EF_{AG} &= \text{Emission factor for angora goats} \\ EF_{MG} &= \text{Emission factor for milk goats} \end{aligned}$$



### 3.1.9.7 Horses

SCC: 28 05 035 000 (Horses)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and Data Sources**

Conceptually, the method for estimating emissions from horses are to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

#### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

#### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

#### **Spatial and Temporal Allocations**

#### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

#### *Temporal*

The CMU-NH<sub>3</sub> ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

**Emissions  
Calculation**

Equation:

2011 TPY ammonia emissions for horses in an individual county

$$EM_{\text{HORSE}} = AC_{\text{HORSE}} * EF_{\text{HORSE}}$$

Where:

$EM_{\text{HORSE}}$  = Total NH<sub>3</sub> emissions from horses, all categories

$AC_{\text{HORSE}}$  = Activity level (number) of horses

$EF_{\text{HORSE}}$  = Emission factor for horses

### 3.1.9.8 Ducks, Geese and Turkeys

SCC: 28 05 030 007 (Ducks)  
SCC: 28 05 010 100 (Turkeys)  
28 05 010 200  
28 05 010 300  
SCC: 28 05 030 008 (Geese)

#### **Description**

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

#### **Pollutants**

NH<sub>3</sub>

#### **Method and Data Sources**

Conceptually, the method for estimating emissions from ducks, geese and turkeys are to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

#### *Activity*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

#### *Emission Factors*

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustment for Controls**

The CMU ammonia model automatically applies controls, when applicable for a given year.

#### **Spatial and Temporal Allocations**

#### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

#### *Temporal*

The CMU-NH<sub>3</sub> ammonia model temporally allocates activity data to the different months of the year or annually (yearly).

**Emissions  
Calculation**

Equation:

2011 TPY ammonia emissions for ducks in an individual county

$$EM_{DUCKS} = AC_{DUCKS} * EF_{DUCKS}$$

Where:

$EM_{DUCKS}$  = Total NH<sub>3</sub> emissions from ducks, all categories

$AC_{DUCKS}$  = Activity level (number) of ducks

$EF_{DUCKS}$  = Emission factor for ducks

### 3.1.9.9 Agricultural Fertilizer Application

SCC: 28 01 700 001 (Anhydrous Ammonia)  
28 01 700 002 (Aqueous Ammonia)  
28 01 700 003 (Nitrogen Solutions)  
28 01 700 004 (Urea)  
28 01 700 005 (Ammonium Nitrate)  
28 01 700 006 (Ammonium Sulfate)  
28 01 700 007 (Ammonium Thiosulfate)  
28 01 700 010 (Mix-N-P-K MGN Fertilizers)  
28 01 700 011 (Calcium Ammonium Nitrate)  
28 01 700 012 (Potassium Nitrate)  
28 01 700 013 (Diammonium Phosphate)  
28 01 700 014 (Monoammonium Phosphate)  
28 01 700 015 (Liquid Ammonium Polyphosphate)  
28 01 700 099 (Miscellaneous Fertilizers)

#### Description:

Fertilizer in this category refers to any nitrogen-based compound, or mixture containing such a compound, that is applied to land to improve plant fitness. The consumption of fertilizer data includes total fertilizer sales or shipments for farm and non-farm usage. Fertilizer application is typically considered to be the second or third most important source on a national level.

Fertilizer emissions were calculated per fertilizer types per SCC listed above. These fertilizer types are the activity input files for the CMU Ammonia Model v.3.6.

Finally, ammonia emissions from fertilizer application have a strong temporal component that has previously been ignored; yearly averages have been used in existing inventories. Significantly more fertilizer is applied in the spring and fall than in the summer and winter, corresponding to crop cycles. To improve temporal allocation, USDA data on crop planting times and fertilizer application times and rates were used to generate a monthly distribution of fertilizer application.

#### Pollutants

NH<sub>3</sub>

#### Method and Data Sources

The method for estimating emissions from fertilizer sources is simple: collect data on the amount of fertilizer sold to farmers and non-farms in a specific county, and then multiply this by the percent of ammonia released per fertilizer application (that is **Table: Fertilizer Nitrogen Content**), and the resulting value provides the emissions. The fertilizer activity files provided with the CMU Ammonia Model v.3.6 were used and county-level ammonia emissions were then calculated by running the model. The model corrects for the difference in mass between nitrogen and ammonia.

**Activity**

Activity level data for fertilizer application was obtained from the Fertilizer Institute’s Commercial Fertilizers 2007 reports and the Association of American Plant and Food Control Officials (AAPFCO). These fertilizer reports show sales to farmers and non-farms per county level activities. AAPFCO dataset only contained state-level resolution; the USGS dataset was used to allocate the AAPFCO state-level data to county-level.

**Emission Factors**

Emission factors (percent of Nitrogen volatilized as Ammonia) were collected from 2004 CMU Ammonia Model v.3.6 run and is presented in the table below:

**Emission Factors and Source**

| Fertilizer Type                   | Emission Factor<br>% N volatilized as NH3 | Source of<br>Emission Factor |
|-----------------------------------|---|------------------------------|
| Ammonium Nitrate                  | 2.0                                       | CMU NH3 Model v.3.6          |
| Ammonium Sulfate                  | 10.0                                      | CMU NH3 Model v.3.6          |
| Ammonium Thiosulfate              | 2.5                                       | CMU NH3 Model v.3.6          |
| Anhydrous Ammonia                 | 4.0                                       | CMU NH3 Model v.3.6          |
| Aqueous Ammonia                   | 4.0                                       | CMU NH3 Model v.3.6          |
| Calcium Ammonium Nitrate          | 2.0                                       | CMU NH3 Model v.3.6          |
| Diammonium Phosphate              | 5.0                                       | CMU NH3 Model v.3.6          |
| Liquid Ammonium Polyphosphate     | 5.0                                       | CMU NH3 Model v.3.6          |
| Miscellaneous Fertilizers         | 6.0                                       | CMU NH3 Model v.3.6          |
| Monoammonium Phosphate            | 5.0                                       | CMU NH3 Model v.3.6          |
| Nitrogen Solutions                | 8.0                                       | CMU NH3 Model v.3.6          |
| Mix: N-P-K (multi-grade nutrient) | 2.0                                       | CMU NH3 Model v.3.6          |
| Potassium Nitrate                 | 2.0                                       | CMU NH3 Model v.3.6          |
| Urea                              | 15.0                                      | CMU NH3 Model v.3.6          |

**Table: Fertilizer Nitrogen Content**

| Fertilizer                    | Nitrogen Content (percent) |
|-------------------------------|----------------------------|
| Ammonium Nitrate              | 36                         |
| Ammonium Sulfate              | 22                         |
| Ammonium Thiosulfate          | 12                         |
| Anhydrous Ammonia             | 82                         |
| Aqueous Ammonia               | 21                         |
| Calcium Ammonium Nitrate      | 17                         |
| Diammonium Phosphate          | 18                         |
| Liquid Ammonium Polyphosphate | 10                         |
| Miscellaneous                 | 8                          |
| Mix                           | 12                         |
| Monoammonium Phosphate        | 11                         |
| Nitrogen Solutions            | 29                         |
| Potassium Nitrate             | 14                         |
| Urea                          | 46                         |

## Point Source Adjustments

No subtraction of emissions from point sources is necessary.

## Adjustment for Controls

The CMU ammonia model automatically applies controls, when applicable for a given year.

## Spatial and Temporal Allocations

### *Spatial*

The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

### *Temporal*

Finally, ammonia emissions from fertilizer application have a strong temporal component that has previously been ignored; yearly averages have been used in existing inventories. Significantly more fertilizer is applied in the spring and fall than in the summer and winter, corresponding to crop cycles. To improve temporal allocation, USDA data on crop planting times and fertilizer application times and rates were used to generate a monthly distribution of fertilizer application (USDA, 1997; USDA-ERS, 1991; USDA-ERS, 1996; USDA-ERS, 1996-1997; USDA-NASS, 1992-1997a; USDA-NASS, 1992-1997b; USDA-NASS, 1992-1997c; USDA-NASS, 1992-1997d; USDA-NASS, 1992-1997a; USDA-NASS, 1995; USDA-NASS, 1997). Results show that assuming a yearly average for this category results in a substantial error for most months of the year.

## Emissions Calculation

Equation:

2011 TPY ammonia emissions for agricultural fertilizer sources in an individual county

$$EM_{\text{FERT-2011 Total}} = EM_{\text{AmmNit}} + EM_{\text{AmmSul}} + EM_{\text{AmmThio}} + EM_{\text{AnhyAmm}} + EM_{\text{AqueAmm}} + EM_{\text{CalAmmNit}} + EM_{\text{NitSol}} + EM_{\text{Urea}} + EM_{\text{DiAmmPhos}} + EM_{\text{MonoAmmPhos}} + EM_{\text{LiqAmmPhos}} + EM_{\text{PotNit}} + EM_{\text{Mix-N-P-K}} + EM_{\text{Misc}}$$

Where:

- $EM_{\text{Fertilizer-2011 Total}}$  = Total NH<sub>3</sub> emissions from agricultural fertilizer application, all categories
- $EM_{\text{AmmNit}}$  = Emissions from Ammonium Nitrate fertilizer
- $EM_{\text{AmmSul}}$  = Emissions from Ammonium Sulfate fertilizer
- $EM_{\text{AmmThio}}$  = Emissions from Ammonium Thiosulfate fertilizer
- $EM_{\text{AnhyAmm}}$  = Emissions from Ammonium Anhydrous Ammonia
- $EM_{\text{AqueAmm}}$  = Emissions from Ammonium Aqueous Ammonia
- $EM_{\text{CalAmmNit}}$  = Emissions from Calcium Ammonium Nitrate fertilizer
- $EM_{\text{NitSol}}$  = Emissions from Nitrogen Solutions fertilizer

- EM<sub>Urea</sub> = Emissions from Urea fertilizer
- EM<sub>DiAmmPhos</sub> = Emissions from Diammonium Phosphate fertilizer
- EM<sub>MonAmmPhos</sub> = Emissions from Monoammonium Phosphate fertilizer
- EM<sub>LiqAmmPhos</sub> = Emissions from Liquid Ammonium Polyphosphate fertilizer
- EM<sub>PotNit</sub> = Emissions from Potassium Nitrate fertilizer
- EM<sub>Mix-N-P-K</sub> = Emissions from Mix-N-P-K (multi-grade nutrient)
- EM<sub>Misc</sub> = Emissions from Miscellaneous fertilizer

Where:

- EM<sub>AmmNit</sub> = (AC<sub>AmmNit</sub> \* Per Cent Released<sub>AmmNit</sub>)
- EM<sub>AmmSul</sub> = (AC<sub>AmmSul</sub> \* Per Cent Released<sub>AmmSul</sub>)
- EM<sub>AmmThio</sub> = (AC<sub>AmmThio</sub> \* Per Cent Released<sub>AmmThio</sub>)
- EM<sub>CalAmmNit</sub> = (AC<sub>CalAmmNit</sub> \* Per Cent Released<sub>CalAmmNit</sub>)
- EM<sub>NitSol</sub> = (AC<sub>NitSol</sub> \* Per Cent Released<sub>NitSol</sub>)
- EM<sub>Urea</sub> = (AC<sub>Urea</sub> \* Per Cent Released<sub>Urea</sub>)
- EM<sub>DiAmmPhos</sub> = (AC<sub>DiAmmPhos</sub> \* Per Cent Released<sub>DiAmmPhos</sub>)
- EM<sub>MonAmmPhos</sub> = (AC<sub>MonAmmPhos</sub> \* Per Cent Released<sub>MonAmmPhos</sub>)
- EM<sub>LiqAmmPhos</sub> = (AC<sub>LiqAmmPhos</sub> \* Per Cent Released<sub>LiqAmmPhos</sub>)
- EM<sub>PotNit</sub> = (AC<sub>PotNit</sub> \* Per Cent Released<sub>PotNit</sub>)
- EM<sub>Misc</sub> = (AC<sub>Misc</sub> \* Per Cent Released<sub>Misc</sub>)
- EM<sub>Mix-N-P-K</sub> = (AC<sub>Mix</sub> \* Per Cent Released<sub>Mix-N-P-K</sub>)
- EM<sub>AnhyAmm</sub> = (AC<sub>AnhyAmm</sub> \* Per Cent Released<sub>AnhyAmm</sub>)
- EM<sub>AqueAmm</sub> = (AC<sub>AqueAmm</sub> \* Per Cent Released<sub>AqueAmm</sub>)

Where:

- AC<sub>AmmNit</sub> = Activity level (amount of Ammonium Nitrate fertilizer applied per county) (Appendix 8.\*\*)
- Per Cent Released<sub>AmmNit</sub> = Per Cent of NH<sub>3</sub> released during fertilizer application



### 3.1.9.10 Human Breath and Perspiration

SCC: 28 10 010 000 (Human Perspiration)

#### Description

Ammonia emissions from human breath and perspiration comprise a few percent of the national ammonia emission inventory.

#### Data Sources

##### *Activity Data Source*

The U.S. Census Bureau, 2007 was used to obtain activity level data for this category.

##### *Emission Factor Data Source*

Emission factors were obtained from 2007 CMU Ammonia Model v.3.6 run and is presented in the table below:

| <b>Emission Factors and Source</b> |  |  |
|------------------------------------|--|--|
| <b>Emission Category</b>           | <b>Emission Factor</b><br>Kg NH <sub>3</sub> /person*month | <b>Source of</b><br><b>Emission Factor</b> |
| Human Breathe & Perspiration       | 0.0367   | CMU NH <sub>3</sub> Model v.3.6            |

#### Method Sources

Conceptually, the method for estimating emissions from human breathe and perspiration is simple: count the number of people, and then multiply this by the average emissions per person and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

#### Equation:

2011 TPY ammonia emissions from human breathe and perspiration in an individual county

$$EM_{\text{HUMAN B\&P}} = AC_{\text{HUMAN}} * EF_{\text{HUMAN B\&P}}$$

Where:

$EM_{\text{HUMAN B\&P}}$  = Total NH<sub>3</sub> emissions from human breathe and perspiration

$AC_{\text{HUMAN}}$  = Activity level (number) of people per county

$EF_{\text{HUMAN B\&P}}$  = Emission factor for human breathe and perspiration

## **4.0 NONROAD SOURCES**

### **4.1 NONROAD VEHICLES/ENGINES**

This section contains the nonroad source emission inventory for volatile organic compounds (VOCs), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), sulfur oxides (SO<sub>x</sub>), particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), ammonia (NH<sub>3</sub>), and toxic air pollutants. Nonroad mobile sources include motorized vehicles and equipment that are normally not operated on public roadways to provide transportation. Nonroad mobile sources explained within are broken up into the following categories:

- Railroads
- Commercial aviation
- Air taxis
- General aviation
- Military aviation
- Commercial marine vessels

## 4.2 RAILROADS

SCC: 22 85 002 006 (Class I - Line Haul)

SCC: 22 85 002 007 (Class II and III)

SCC: 22 85 002 008 (Passenger)

SCC: 22 85 002 009 (Commuter)

SCC: 22 85 002 010 (Yard Engines)

### Description

Railroad locomotives used in the United States are primarily of two types: electric and diesel-electric. Electric locomotives are powered by electricity generated at stationary power plants. Emissions are produced only at the electrical generation plant, which is considered a point source and therefore not included here. Diesel-electric locomotives, on the other hand, use a diesel engine and an alternator or generator to produce the electricity required to power its traction motors. Emissions produced by these diesel engines are of interest in emission inventory development. Other sources of emissions from railroad operations include the small gasoline and diesel engines used on refrigerated and heated rail cars. These engines are thermostatically controlled, working independently of train motive power, and fall in the category of nonroad equipment, addressed elsewhere in this document.

Locomotives can perform two different types of operations: Line Haul and Yard. Line haul locomotives, which perform the line haul operations, generally travel between distant locations, such as from one city to another. Yard locomotives, which perform yard operations, are primarily responsible for moving railcars within a particular railway yard. The use of these engines can be further divided into subcategories such as, Class 1, Class 2, Class3, Passenger, and Commuter.

### Rail Classification – Subcategory Description:

**1. A Class I railroad** is a large freight railroad company, with annual operating revenue in excess of \$250 million dollars as defined by the Surface Transportation Board (STB) and Bureau of Labor Statistics (BLS).

**2. Class II railroads** are mid-sized freight-hauling railroads with revenues greater than \$20.5 million, but less than \$250 million for at least three consecutive years. Switching and terminal railroads are excluded from Class II status.

**3. A Class III railroads** annual operating revenue is less than \$20 million. Class III railroads are typically local short line railroads, serving a few towns or industries; many Class III railroads were once part of larger railroads.

Class II and Class III are also defined by different labor regulations creating the two classes.

**4. Passenger Railroad consists** of passenger trains or passenger-carrying vehicles. It may be a self powered railcars, or else a combination of one or more engines and one or more unpowered trailers. These trains travel station to station or to a depot where passengers board and get off, usually operate on a fixed schedule.

**5. Commuter rail**, also called **suburban rail**, transport passengers, but only between a city and outer suburbs or near by towns where people need to travel to on a daily basis, for reasons like working. Commuter trains also operate by schedules.

**Pollutants**

PM2.5-PRI, SO<sub>x</sub>, NO<sub>x</sub>, CO, VOC and HAPs

**Method and**

**Data Sources:**

The following thirteen railroad companies operate in Maryland and were asked to provide the amount of fuel used in 2011, and the distribution of the company's track mileage by Maryland County:

| <b>Railroad Company</b>                     | <b>Railroad Classification</b> |
|---|--------------------------------|
| 1. AMTRAK                                   | Passenger Railroad             |
| 2. Canton Railroad Company                  | Class III - Yard Railroad      |
| 3. CSX Transportation, Incorporated         | Class I – Yard Railroad        |
| 4. Bay Coast Railroad                       | Class II Railroad              |
| 5. Maryland & Delaware Railroad Company     | Class I – Yard Railroad        |
| 6. Maryland Midland Railway, Incorporated   | Class II – Yard Railroad       |
| 7. Norfolk and Southern Railway Company     | Class I – Yard Railroad        |
| 8. R. G. Steel Railroad Holdings LLC        | Class III Railroad             |
| 9. Western Maryland Scenic Railroad         | Class III Railroad             |
| 10. Winchester and Western Railroad Company | Class III Railroad             |
| 11. MARC                                    | Commuter Railroad              |
| 12. Walkersville Southern Railroad          | Passenger – Yard Railroad      |

For CSX and Norfolk railroad operating statistics contained in R-1 reports obtained from the Surface Transportation Board under the Office of Economics, Environmental Analysis and Administration were used to add in estimating the amount of fuel used within the state.

MDE received fuel usage and track mileage data from all the railroads. Fuel usage was proportioned to each county by the amount of track miles each company utilized in a county.

***Activity***

A survey of railroad petroleum consumption and track mileage was conducted.

***Emission Factor***

Emission factors were obtained from the EPA's *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, 1992.

**TABLE 4.4.1-a      Emission Factor for Locomotives**  
**Line Haul                      Yard**

|             |                |             |                |
|-------------|----------------|-------------|----------------|
| <b>VOC</b>  | 0.0179 lbs/gal | <b>VOC</b>  | 0.0325lbs/gal  |
| <b>NOx</b>  | 0.3285 lbs/gal | <b>NOx</b>  | 0.5181 lbs/gal |
| <b>CO</b>   | 0.0587 lbs/gal | <b>CO</b>   | 0.0587 lbs/gal |
| <b>SO2</b>  | 0.0001 lbs/gal | <b>SO2</b>  | 0.0001 lbs/gal |
| <b>PM10</b> | 0.0097 lbs/gal | <b>PM10</b> | 0.0117 lbs/gal |
| <b>PM25</b> | 0.0094 lbs/gal | <b>PM25</b> | 0.0113 lbs/gal |

SO<sub>2</sub> emissions were calculated based on a sulfur content percent weight.

EPA estimates that yard locomotives operate 365 days per year (assuming that when a yard engine is taken in for repairs it is replaced during this period) and consumes an average of 228 gallons per day.

#### **Point Source Adjustments**

No subtraction of emissions from point sources is necessary.

#### **Adjustments for Controls**

Controls through Tier regulations were included in the EPA estimated emission factors.

#### **Spatial and Temporal Allocations**

##### *Spatial*

Emission estimates are based on fuel consumption. Company supplied state total fuel usage was allocated to the county level by the proportion of track miles used in a particular county.

##### *Temporal*

Data for temporal allocation is not available for this source.

#### **Emissions Calculation**

When specific county information was not provided, the following equations were used to compute the amount of fuel consumed by each railroad in each Maryland County.

$$G_{CTY} = \frac{M_{CTY}}{M_{ST}} * G_{ST}$$

$$M_{ST}$$

Where:

$M_{CTY}$  = mileage of company tracks in the county

$M_{ST}$  = mileage of company tracks in the state

$G_{ST}$  = amount of total fuel used in gallons by the company in the state

$G_{CTY}$  = amount of total fuel used in gallons by the company in the county

The following equation was used to calculate the emissions for line haul locomotives from each railroad company operating in a county.

$$E_{LH-i-CTYj} = \frac{\text{Fuel}_{CTY} \times EF_{LH}}{2000}$$

Where:

$E_{LH-i-CTYj}$  = Emissions from line haul railroad locomotives for pollutant i in County j

$\text{Fuel}_{CTYj}$  = Total amount of fuel consumed by every railroad operating in the calculated county

$\text{Fuel}_{CTYj}$  = ( $G_{cty1} + G_{cty2} + \dots + G_{cty12}$ )

$EF_{LH}$  = line haul locomotive emission factor for a given pollutant

The following equation was used to calculate the yearly emissions for yard locomotives from each railroad company operating in a county.

$$E_{YL-i-CTYj} = \frac{N_{YL-i-CTYj} \times 228 \times EF_{YL} \times 365}{2000}$$

Where:

$E_{YL-i-CTYj}$  = Emissions from yard locomotives for pollutant i in County j

$N_{YL-i-CTYj}$  = number of yard locomotives operated by each railroad company in county j

$N_{YL-i-CTYj}$  = ( $N_{cty1} + N_{cty2} + \dots + N_{cty12}$ )

$EF_{YL}$  = Yard locomotive emission factor for a given pollutant

### Example Calculations:

Montgomery County Emissions (not reflected in emissions table)

### ***Line Haul Emission Estimate***

AMTRAK, CSX, and MARC operated line haul locomotives in the county. AMTRAK also operated one yard (switcher) locomotive in the county.

Amount of fuel used in gallons by AMTRAK's line haul locomotives in Montgomery County:

$$G_{\text{cty1}} = 25,463.8 \text{ gallons used in Montgomery Co. per year by AMTRAK} \\ \text{(Information provided by AMTRAK)}$$

Amount of fuel used in gallons used by CSX Transportation line haul locomotives in Montgomery County:

$$G_{\text{cty4}} = \frac{36.37 \text{ track miles in Montgomery Co. for CSX}}{514.97 \text{ track miles in the state for CSX}} \times 10,512,431.53 \text{ gallons used in state per year}$$

$$G_{\text{cty4}} = 742,445.45 \text{ gallons used in Montgomery Co. per year by CSX}$$

Amount of fuel in gallons used by MARC line haul locomotives in Montgomery County:

$$G_{\text{cty12}} = \frac{28 \text{ track miles in Montgomery Co. for MARC}}{156 \text{ track miles in the state for MARC}} \times 1,782,750 \text{ gallons used in state per year}$$

$$G_{\text{cty12}} = 319980.77 \text{ gallons used in Montgomery Co. per year by MARC}$$

VOC Emissions from line haul locomotives in Montgomery County:

$$EM_{\text{VOC}} = \frac{(25,463.8 \text{ gal / yr} + 742,445.45 \text{ gal / yr} + 319980.77 \text{ gal / yr}) * 0.0213 \text{ lbs. VOC / gal}}{(2000 \text{ lbs. per ton})}$$

$$EM_{\text{VOC}} = 11.53 \text{ tons VOC / year}$$

NOx Emissions from line haul locomotives in Montgomery County:

$$EM_{\text{NOX}} = \frac{(25,463.8 \text{ gal / yr} + 742,445.45 \text{ gal / yr} + 319980.77 \text{ gal / yr}) * 0.4931 \text{ lbs. NOX / gal}}{(2000 \text{ lbs. per ton})}$$

$$EM_{\text{NOX}} = 268.20 \text{ tons NOX / year}$$

CO Emissions from line haul locomotives in Montgomery County:

$$EM_{\text{CO}} = \frac{(25,463.8 \text{ gal / yr} + 742,445.45 \text{ gal / yr} + 319980.77 \text{ gal / yr}) * 0.0626 \text{ lbs. CO / gal}}{(2000 \text{ lbs. per ton})}$$

$$EM_{\text{CO}} = 34.05 \text{ tons CO / year}$$

### ***Yard Locomotives Emission Estimate***

CSX operated 2 yard locomotives in Montgomery County:

VOC Emissions from yard locomotives in Montgomery County:

$$EM_{\text{VOC}} = \frac{(2 \text{ engine} * 228 \text{ gallons per engine per day} * 0.0509 \text{ lbs. VOC / gallon}) * 365}{(2000 \text{ lbs. per ton})}$$

$$EM_{\text{VOC}} = 4.23 \text{ tons VOC / year}$$

NOx Emissions from yard locomotives in Montgomery County:

$$EM_{\text{NOX}} = \frac{(2 \text{ engine} * 228 \text{ gallons per engine per day} * 0.5044 \text{ lbs. NOX / gallon}) * 365}{(2000 \text{ lbs. per ton})}$$

$$EM_{\text{NOX}} = 41.98 \text{ tons NOX / year}$$

CO Emissions from yard locomotives in Montgomery County:

$$EM_{\text{CO}} = \frac{(2 \text{ engine} * 228 \text{ gallons per engine per day} * 0.0894 \text{ lbs. CO / gallon}) * 365}{(2000 \text{ lbs. per ton})}$$

$$EM_{\text{CO}} = 7.45 \text{ tons CO / year}$$

### **Total Emissions**

Emissions from maintenance equipment used in the switching yards were calculated using the EPA's Non-Road Model and then added for the appropriate county.

Total VOC Emissions for Montgomery County:

$Emis_{\text{VOC}} = 11.53 \text{ tons / year from line haul} + 4.23 \text{ tons / year from yard} + 0.4745 \text{ tons VOC / year from EPA Non-Road Model.}$

$Emis_{\text{VOC}} = \mathbf{16.23} \text{ tons VOC / year}$

Total NOx Emissions for Montgomery County:

$Emis_{\text{NOX}} = 268.20 \text{ tons / year from line haul} + 41.98 \text{ tons / year from yard} + 0.1825 \text{ tons NOx / year from EPA Non-Road Model.}$

$Emis_{\text{NOX}} = \mathbf{310.36} \text{ tons NOx / year}$

Total CO Emissions for Montgomery County:

$Emis_{\text{CO}} = 34.05 \text{ tons / year from line haul} + 7.45 \text{ tons / year from yard} + 18.9.1 \text{ tons CO / year from EPA Non-Road Model.}$

$Emis_{\text{CO}} = \mathbf{60.47} \text{ tons CO / year}$



### 4.3 AIRCRAFT

SCC: 22 75 020 000 (Commercial Aircraft)

SCC: 22 75 050 000 (General Aviation)

SCC: 22 75 060 000 (Air Taxi)

SCC: 22 75 001 000 (Military Aviation)

#### **Description:**

This category includes three sub-categories identified as: commercial aircraft, general aviation, and military aircraft. Commercial aircraft are used in regularly scheduled flights transporting passengers, freight, or both. General aviation, which includes air taxis and commuter aviation, is used for recreational flying, business travel, personal transportation, and various other activities. Military aviation is the operation and activities of military aircraft at airports in Maryland. Air Taxi operation can be separated into its own subcategory.

#### **Pollutants**

PRI-PM<sub>10</sub>, PRI-PM<sub>2.5</sub>, SO<sub>x</sub>, NO<sub>x</sub>, CO, VOC

#### **Method and**

#### **Data Sources**

ARMA used a variety of sources for data and emission calculation methods as follows:

##### *Data sources*

- 1) Federal Aviation Administration (FAA) website contains airport activity statistics for some Maryland airports and air fields by subcategory description, plane, and engine types.
- 2) Landing and takeoff cycle information was obtained from the Maryland Aviation Administration for BWI, Martin State, Military Bases, several large, and several small airport and air fields.
- 3) The MDE's Emission Inventory section also performed a statewide survey to obtain LTO, engine type, location, and usage data from over 200 individual airports and air fields.

##### *Methods sources*

- 1) For general aviation ARMA used emission factors supplied in Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, EPA's Office of Mobile Sources, 1992. This source provided emission factors for specific commercial engine types, and alternative fleet average factors for general aviation, air taxis, and commuter aircraft.
- 2) For military aircraft ARMA used a composite factor from section 5.2.5, Table 5-7 of Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1988. This method required ARMA to collect LTO data rather than specific aircraft data. For the 2011 inventory ARMA requested operation data for military aircraft from Maryland Army, Navy, and Air Force base environmental support offices.

- 3) For commercial aviation ARMA used FAA's EDMS<sup>84</sup> emissions model and databases. EDMS is designed to assess the air quality impacts of airport emission sources, particularly aviation sources, which consist of aircraft, auxiliary power units, and ground support equipment. EDMS features the latest aircraft engine emission factors from the International Civil Aviation Organization (ICAO) Engine Exhaust Emissions Data Bank, vehicle emission factors from EPA MOBILE 6.2, and EPA-validated dispersion algorithms. Aircraft activity includes landside and airside operations. EDMS defines four distinct modes of aircraft operation based upon EPA and FAA guidance: approach, taxi/idle, takeoff, and climb out. Together, these four modes constitute one Landing and Takeoff (LTO) cycle. EDMS calculates aircraft emissions based on these four modes.
- 4) For all aircraft types, ARMA used a default mixing height value of 3,000 feet above ground level. The mixing height is the layer of air where airplane emissions affect ground level emission concentrations. Above the mixing level, pollutants are transported away according to sections 5.2.2 of the 1992 Procedures. Because of the mixing height, ARMA assigned all aircraft emissions from a particular airport to the county where that airport was located. We assumed no seasonal variation and a seven day per week activity level.

**Point Source  
Adjustments**

No subtraction of emissions from point sources is necessary.

**Adjustment for  
Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Data for spatial allocation is not available for this source.

*Temporal*

In EDMS actual weather (annual average values or hourly values) are in used for both modeling.

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<sup>84</sup> Emissions & Dispersion Modeling System (EDMS) Version 5.1 for Windows from CSSI, Inc.

### 4.3.1 Commercial Aircraft

SCC: 22 75 020 000

#### Steps in Creating and Airport Emission Inventory in EDMS:

- 1) Open the EDMS model and create a new study for the airport in question. Choose the airport identification code. Enter the parameters (name, measuring and reporting units, and analysis year you want modeled).
- 2) Provide EDMS with information to compute the emissions inventory. Begin by matching engines with aircraft and assigning them to the study. Select the aircraft to be used in the study (data that is collected from the airport) by picking the aircraft name from the menus. EDMS automatically associates specific aircraft with certain engine types (Choose from list).
- 3) For each aircraft fill in the yearly LTO cycles provided by surveying the airport.
- 4) Each time you fill in LTOs the model will automatically default the taxi time and queue time specific to the specified airport or use the EDMS provide default values.
- 5) Continue to add each aircraft/engine type, LTO cycle until all are LTOs are entered for that study.
- 6) EDMS has tables built into the model that associate aircraft type with the number of engines, auxiliary power units and ground support equipment. The model also assigns default values for Takeoff Time (typically 0.3 minutes), Climb-out Time (typically 5 minutes), and Approach Time (typically 6 minutes).
- 7) If emissions from parking lots, roadways, stationary sources, and training fires are also required, complete the dialog boxes associated with each of these subcategories.
- 8) Run the EDMS emission inventory program and view the results.

#### **Emissions Calculation**

The data for aircraft engines listed below in Table 4.5.1-a, are defaults used to calculate emissions within the EDMS Model. Each mode of operation, such as, annual LTO operations, average taxi time, approach, climb-out, takeoff, and annual queue times are used in the estimation of emissions, but LTO operations was taken from FAA and airport records.

**TABLE 4.5.1-a EDMS Aircraft & Engine Estimated Averages and Defaults Data**

| Aircraft Name    | Aircraft Type | Engine Assigned | Approach Time (min) | Climb-out Time (min) | Takeoff Time (min) | Annual LTO | Taxi Time (min) | Queue Time (min) |
|------------------|---------------|-----------------|---------------------|----------------------|--------------------|------------|-----------------|------------------|
| Falcon 100       | GA            | TFE731-3        | 1.60                | 0.50                 | 0.40               | 1825       | 10.50           | 3.00             |
| P-337P Skymaster | GA            | TSIO-360C       | 4.50                | 2.50                 | 0.50               | 9490       | 10.50           | 3.00             |
| 550 Citation     | GA            | JT15D-4 (B,C,D) | 1.60                | 0.50                 | 0.40               | 2190       | 10.50           | 3.00             |
| A320             | Comm          | CFM56-5B4       | 4.00                | 2.20                 | 0.70               | 2555       | 10.50           | 3.00             |
| AH-1             | Military      | T53-L-11D       | 6.80                | 6.80                 | 0.00               | 1825       | 10.50           | 3.00             |
| ATR42            | Comm          | PW120           | 4.50                | 2.50                 | 0.50               | 2190       | 10.50           | 3.00             |
| B727-100         | Comm          | JT8D-7A         | 4.00                | 2.20                 | 0.70               | 8030       | 10.50           | 3.00             |
| B737-200         | Comm          | JT8D-15A        | 4.00                | 2.20                 | 0.70               | 21900      | 10.50           | 3.00             |
| B737-300         | Comm          | CFM56-3B        | 4.00                | 2.20                 | 0.70               | 13140      | 10.50           | 3.00             |
| B737-400         | Comm          | CFM56-3B        | 4.00                | 2.20                 | 0.70               | 3650       | 10.50           | 3.00             |

|                   |          |              |      |      |      |       |       |      |
|-------------------|----------|--------------|------|------|------|-------|-------|------|
| B737-500          | Comm     | CFM56-3B     | 4.00 | 2.20 | 0.70 | 8030  | 10.50 | 3.00 |
| B737-700          | Comm     | CFM56-3C-1   | 4.00 | 2.20 | 0.70 | 730   | 10.50 | 3.00 |
| B747-100          | Comm     | JT9D-7A      | 4.00 | 2.20 | 0.70 | 183   | 10.50 | 3.00 |
| B757-200          | Comm     | PW2037       | 4.00 | 2.20 | 0.70 | 7665  | 10.50 | 3.00 |
| B767-200          | Comm     | CF6-80A (A1) | 4.00 | 2.20 | 0.70 | 1095  | 10.50 | 3.00 |
| BAE ATP           | Comm     | PT6A-45      | 4.00 | 2.20 | 0.70 | 2555  | 10.50 | 3.00 |
| BH-1900           | Comm     | PT6A-65B     | 1.60 | 0.50 | 0.40 | 3285  | 10.50 | 3.00 |
| C-12A/B/C         | Military | PT6A-41      | 3.50 | 0.80 | 0.40 | 730   | 10.50 | 3.00 |
| C-130 Hercules    | Military | T56-A-16     | 5.10 | 1.20 | 0.40 | 365   | 10.50 | 3.00 |
| C-9A              | Military | JT8D-9       | 5.10 | 1.20 | 0.40 | 365   | 10.50 | 3.00 |
| Canadair Reg-100  | Comm     | CF34-3A1     | 4.00 | 2.20 | 0.70 | 730   | 10.50 | 3.00 |
| Cessna 150        | GA       | O-200        | 6.00 | 5.00 | 0.30 | 5110  | 10.50 | 3.00 |
| Convair liner     | Comm     | RDA10        | 4.50 | 2.50 | 0.50 | 365   | 10.50 | 3.00 |
| DC10-10           | Comm     | CF6-50C      | 4.00 | 2.20 | 0.70 | 730   | 10.50 | 3.00 |
| DC9-10            | Comm     | JT8D-7A      | 4.00 | 2.20 | 0.70 | 4380  | 10.50 | 3.00 |
| DHC-8             | Comm     | PW120        | 4.50 | 2.50 | 0.50 | 3650  | 10.50 | 3.00 |
| DHC-8-400         | Comm     | PW123        | 4.50 | 2.50 | 0.50 | 18250 | 10.50 | 3.00 |
| F-16              | Military | F100-PW-100  | 3.50 | 0.80 | 0.40 | 183   | 10.50 | 3.00 |
| F-27 Series       | Military | RDa7         | 4.50 | 2.50 | 0.50 | 365   | 10.50 | 3.00 |
| Fokker 100        | GA       | TAY650       | 4.00 | 2.20 | 0.70 | 365   | 10.50 | 3.00 |
| H-46 Sea Knight   | Military | T58-GE-8F    | 6.80 | 6.80 | 0.00 | 183   | 10.50 | 3.00 |
| Kingair B200      | GA       | PT6A-41      | 1.60 | 0.50 | 0.40 | 5840  | 10.50 | 3.00 |
| Learjet 25B       | GA       | CJ610-6      | 1.60 | 0.50 | 0.40 | 1460  | 10.50 | 3.00 |
| MD-11             | Comm     | CF6-80C2D1F  | 4.00 | 2.20 | 0.70 | 730   | 10.50 | 3.00 |
| MD-80             | Comm     | JT8D-209     | 4.00 | 2.20 | 0.70 | 4563  | 10.50 | 3.00 |
| MD-80-88          | Comm     | JT8D-217     | 4.00 | 2.20 | 0.70 | 1825  | 10.50 | 3.00 |
| MD-90-10          | Comm     | V2525-D5     | 4.00 | 2.20 | 0.70 | 365   | 10.50 | 3.00 |
| Porter PC6/B2     | Military | PT6A-27      | 4.50 | 2.50 | 0.50 | 730   | 10.50 | 3.00 |
| SF-340-A          | Comm     | CT7-5        | 4.50 | 2.50 | 0.50 | 730   | 10.50 | 3.00 |
| Swearingen Merlin | Comm     | TPE331-3     | 4.50 | 2.50 | 0.50 | 2920  | 10.50 | 3.00 |
| Swearingen Merlin | Comm     | TPE331-3     | 4.50 | 2.50 | 0.50 | 365   | 10.50 | 3.00 |

Once all of the data is entered into the model, the model produces an emission inventory. Annual emission totals inventory are listed in the table below:

The model will also produce an inventory specific to each aircraft type, which allows the data to be separated into types (commercial, general aviation, and military) of operation. For BWI the separation results in the following:

**TABLE 4.5.1-b BWI Category Emissions Summary Using EDMS**

| <b>NAME</b>         | <b>CO<br/>Tons/year</b> | <b>VOC<br/>Tons/year</b> | <b>NOX<br/>Tons/year</b> | <b>SOX<br/>Tons/year</b> | <b>PM10<br/>Tons/year</b> | <b>PM2.5<br/>Tons/year</b> |
|---------------------|-------------------------|--------------------------|--------------------------|--------------------------|---------------------------|----------------------------|
| Commercial Aircraft | 2553.98                 | 322.80                   | 1859.37                  | 220.17                   | 20.72                     | 20.72                      |
| General Aviation    | 237.06                  | 29.96                    | 172.58                   | 20.44                    | 1.92                      | 1.92                       |
| Air Taxi            | 148.16                  | 18.73                    | 107.86                   | 12.77                    | 1.20                      | 1.20                       |
| Military Aviation   | 29.63                   | 3.75                     | 21.57                    | 2.55                     | 0.24                      | 0.24                       |
| <b>Total</b>        | <b>2968.83</b>          | <b>375.24</b>            | <b>2161.39</b>           | <b>255.94</b>            | <b>24.08</b>              | <b>24.08</b>               |

The model was run for all aircraft at BWI, Martin State, Hagerstown Regional, Ocean City Municipal, Frederick County, and Andrews Air Force Base. Aircraft emissions for Aberdeen Phillips Air Field, and Weide Army Air Field were submitted to ARMA by the military.

### 4.3.2 General Aviation

SCC: 22 75 050 000

#### Emission Calculation

Estimates of emissions were calculated after information on the LTO operations of aircraft and operation types were obtained from Maryland's airports. This method used the alternative fleet-average procedure of Section 5.2.4.2 of Procedures, 1992. The composite emission factors used are listed in the table below.

**TABLE 4.5.2-a EPA Emission Factors for Aircraft**

| Aviation Category | CO<br>(lbs./LTO) | VOC<br>(lbs./LTO) | NOx<br>(lbs./LTO) | SO2<br>(lbs./LTO) | PM10-<br>PRI<br>(lbs./LTO) | PM2.5-<br>PRI<br>(lbs./LTO) |
|-------------------|------------------|-------------------|-------------------|-------------------|----------------------------|-----------------------------|
| General Aviation  | 12.014           | 0.382             | 0.065             | 0.100             | 0.020                      | 0.020                       |
| Air Taxis         | 28.130           | 1.223             | 0.158             | 0.015             | 0.020                      | 0.020                       |
| Military          | 48.800           | 27.10             | 9.160             | 1.430             | 15.23                      | 15.23                       |

\* Requires Hydrocarbon to VOC conversion factor of 0.9708 for General Aviation and 0.9914 for Air Taxis.

$$1) \text{Emiss}_{\text{VOC}} = \text{LTO (GA)} * \text{EF (GA)}_{\text{VOC}}$$

Where:

LTO (GA) = LTOs for General Aviation

EF (GA)<sub>xx</sub> = Emission Factors for General Aviation

$$2) \text{Emiss}_{\text{VOC}} = \text{LTO (AT)} * \text{EF (AT)}_{\text{VOC}}$$

Where:

LTO (AT) = LTOs for Air Taxis

EF (AT)<sub>xx</sub> = Emission factors for Air Taxis

#### *Sample Calculation – General Aviation:*

This calculation is for Easton Airport/Newman Field in Talbot County. The airport had 11,513.5 General Aviation LTOs over a twelve month period. Performing step 1 Equations (above) the calculations were:

$$\begin{aligned} \text{Emiss}_{\text{VOC}} &= [\text{LTO (GA)} * \text{EF (GA)}_{\text{HC}}] * \text{CF (VOC/HC)} \\ \text{Emiss}_{\text{VOC}} &= [(11,513.5 \text{ LTOs / Year} * 0.394 \text{ (lbs. HC / LTO)}) * 0.9708 \text{ (lbs. VOC / lbs. HC)}] \\ \text{Emiss}_{\text{VOC}} &= 4,403.86 \text{ lbs. VOC / Year} \\ \text{Emiss}_{\text{VOC}} &= 2.2 \text{ Tons VOC / Year} \\ \text{Emiss}_{\text{CO}} &= [11,513.5 \text{ LTOs / Year} * 12.014 \text{ (lbs. CO / LTO)}] \\ \text{Emiss}_{\text{CO}} &= 138,323.19 \text{ lbs. of CO / Year} \\ \text{Emiss}_{\text{CO}} &= 69.16 \text{ Tons CO / Year} \\ \text{Emiss}_{\text{NOx}} &= [11,513.5 \text{ LTOs / Year} * 0.065 \text{ (lbs. NOx / LTO)}] \\ \text{Emiss}_{\text{NOx}} &= 748.38 \text{ lbs. of NOx / Year} \\ \text{Emiss}_{\text{NOx}} &= 0.374 \text{ Tons NOx / Year} \end{aligned}$$

$$\begin{aligned} \text{Emiss}_{\text{SO}_2} &= [11,513.5 \text{ LTOs / Year} * 0.100 \text{ (lbs. SO}_2 \text{ / LTO)}] \\ \text{Emiss}_{\text{SO}_2} &= 1,151.35 \text{ lbs. of SO}_2 \text{ / Year} \\ \text{Emiss}_{\text{SO}_2} &= 0.576 \text{ Tons SO}_2 \text{ / Year} \end{aligned}$$

$$\begin{aligned} \text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} &= [11,513.5 \text{ LTOs / Year} * 0.020 \text{ (lbs. PM}_{10} \text{ / LTO)}] \\ \text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} &= 230.27 \text{ lbs. of PM}_{\text{PM}_{2.5\text{-PRI}}} \text{ / Year} \\ \text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} &= 0.115 \text{ Tons PM}_{\text{PM}_{2.5\text{-PRI}}} \text{ / Year} \end{aligned}$$

***Sample Calculation – Air Taxi:***

This calculation is for Easton Airport/Newman Field in Talbot County. The airport had 1,247.5 Air Taxi Aviation LTOs over a twelve month period. Performing step 1 Equations (above) the calculations were:

$$\begin{aligned} \text{Emiss}_{\text{VOC}} &= [\text{L (AT)} * \text{EF (AT)}_{\text{HC}}] * \text{CF (VOC/HC)} \\ \text{Emiss}_{\text{VOC}} &= [(1,247.5 \text{ LTOs / Year} * 1.234 \text{ (lbs. HC / LTO)}) * 0.9914 \text{ (lbs. VOC / lbs. HC)}] \\ \text{Emiss}_{\text{VOC}} &= 1,526.18 \text{ lbs. VOC / Year} \\ \text{Emiss}_{\text{VOC}} &= 0.763 \text{ Tons VOC / Year} \end{aligned}$$

$$\begin{aligned} \text{Emiss}_{\text{CO}} &= [1,247.5 \text{ LTOs / Year} * 28.130 \text{ (lbs. CO / LTO)}] \\ \text{Emiss}_{\text{CO}} &= 35,092.18 \text{ lbs. of CO / Year} \\ \text{Emiss}_{\text{CO}} &= 17.55 \text{ Tons CO / Year} \end{aligned}$$

$$\begin{aligned} \text{Emiss}_{\text{NOx}} &= [1,247.5 \text{ LTOs / Year} * 0.158 \text{ (lbs. NOx / LTO)}] \\ \text{Emiss}_{\text{NOx}} &= 197.11 \text{ lbs. of NOx / Year} \\ \text{Emiss}_{\text{NOx}} &= 0.099 \text{ Tons NOx / Year} \end{aligned}$$

$$\begin{aligned} \text{Emiss}_{\text{SO}_2} &= [1,247.5 \text{ LTOs / Year} * 0.015 \text{ (lbs. SO}_2 \text{ / LTO)}] \\ \text{Emiss}_{\text{SO}_2} &= 18.71 \text{ lbs. of SO}_2 \text{ / Year} \\ \text{Emiss}_{\text{SO}_2} &= 0.009 \text{ Tons SO}_2 \text{ / Year} \end{aligned}$$

$$\begin{aligned} \text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} &= [1,247.5 \text{ LTOs / Year} * 0.020 \text{ (lbs. PM / LTO)}] \\ \text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} &= 24.95 \text{ lbs. of PM}_{\text{PM}_{2.5\text{-PRI}}} \text{ / Year} \\ \text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} &= 0.012 \text{ Tons PM}_{\text{PM}_{2.5\text{-PRI}}} \text{ / Year} \end{aligned}$$

### 4.3.3 Military Aircraft

SCC: 22 75 001 000

There are five military airports in Maryland. They are Andrews Air Force Base, Fort Meade/Tipton, Aberdeen, Patuxent River Naval Air Station, and Martin State Airport. ARMA received LTO and onsite emission information from some military airports and emission totals from others due to national security concerns. Most of the county airports also receive a small number of military operations.

#### Method and Data Sources

Since ARMA asked for and received LTO information by aircraft operation type, ARMA used composite emission factors from Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1988 and the EDMS model (version 5.1).

**TABLE 4.5.3-a EPA Emission Factors for Military Aircraft**

|                   | CO<br>(lbs./LTO) | VOC<br>(lbs./LTO) | NO <sub>x</sub><br>(lbs./LTO) | SO <sub>2</sub><br>(lbs./LTO) | PM<br>(lbs./LTO) |
|-------------------|------------------|-------------------|-------------------------------|-------------------------------|------------------|
| Military Aircraft | 48.80            | 27.10             | 9.160                         | 1.43                          | 15.230           |

$$1) \text{Emiss}_{\text{VOC}} = L(\text{MA}) * \text{EF}(\text{MA})_{\text{VOC}}$$

Where:

$L(\text{MA})$  = LTOs for Military Aircraft

$\text{EF}(\text{MA})_{\text{xx}}$  = Emission factors for Military Aircraft

#### Emissions Calculation

This calculation is for Patuxent River Naval Air Station in St. Mary's county. The airport had 82,331 LTOs in 2011. Using step 1 from Equations (above) the calculations were:

$$\text{Emiss}_{\text{VOC}} = [L(\text{AT}) * \text{EF}(\text{MA})_{\text{HC}}]$$

$$\text{Emiss}_{\text{VOC}} = [(82,331 \text{ LTOs} / \text{Year} * 27.10 \text{ (lbs. VOC / LTO)})]$$

$$\text{Emiss}_{\text{VOC}} = 2,231,170.1 \text{ lbs. VOC / Year}$$

$$\text{Emiss}_{\text{VOC}} = 1,115.59 \text{ Tons VOC / Year}$$

$$\text{Emiss}_{\text{CO}} = [82,331 \text{ LTOs} / \text{Year} * 48.80 \text{ (lbs. CO / LTO)}]$$

$$\text{Emiss}_{\text{CO}} = 4,017,752.8 \text{ lbs. of CO / Year}$$

$$\text{Emiss}_{\text{CO}} = 2,008.88 \text{ Tons CO / Year}$$

$$\text{Emiss}_{\text{NO}_x} = [82,331 \text{ LTOs} / \text{Year} * 9.160 \text{ (lbs. NO}_x \text{ / LTO)}]$$

$$\text{Emiss}_{\text{NO}_x} = 754,151.96 \text{ lbs. of NO}_x \text{ / Year}$$

$$\text{Emiss}_{\text{NO}_x} = 377.08 \text{ Tons NO}_x / \text{Year}$$

$$\text{Emiss}_{\text{SO}_2} = [82,331 \text{ LTOs} / \text{Year} * 1.43 \text{ (lbs. SO}_2 / \text{LTO)}]$$

$$\text{Emiss}_{\text{SO}_2} = 117,733.33 \text{ lbs. of SO}_2 / \text{Year}$$

$$\text{Emiss}_{\text{SO}_2} = 58.87 \text{ Tons SO}_2 / \text{Year}$$

$$\text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} = [82,331 \text{ LTOs} / \text{Year} * 15.23 \text{ (lbs. PM} / \text{LTO)}]$$

$$\text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} = 1,253,901.13 \text{ lbs. of PM}_{\text{PM}_{2.5\text{-PRI}}} / \text{Year}$$

$$\text{Emiss}_{\text{PM}_{2.5\text{-PRI}}} = 626.95 \text{ Tons PM}_{\text{PM}_{2.5\text{-PRI}}} / \text{Year}$$



## 4.4 MARINE VESSELS

**SCC: 2280002100 (Diesel Oil – Port)**  
**2280002200 (Diesel Oil – Underway)**  
**2280003100 (Residual Oil – Port)**  
**2280003200 (Residual Oil – Underway)**

### **Description**

Commercial vessels include all boats and ships used either directly or indirectly for commerce or military activity. These include vessels ranging in size from 20-foot charter boats to the largest tankers and military vessels, which can exceed 1,000 feet in length.

### **Pollutants**

PM2.5-FIL, PM10-FIL, SO<sub>2</sub>, NO<sub>x</sub>, CO, HC, CO<sub>2</sub>, VOC, NH<sub>3</sub>, and 22 HAPS

### **Method and**

#### **Data Sources**

MDE used marine vessels data prepared by the Baltimore Maritime Exchange (BME). BME vessel data was analyzed to major categories associated with ship and port operations and their relationship to air quality issues in the Baltimore non-attainment area.

To calculate emissions from commercial marine vessels, MDE adapted the marine emission inventory guidance method outlined in Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data (EPA-450-R-00-002), February 2000. The methodology is based on a three-step calculation. The first step apportions the time spent by a vessel in a port area to different operating modes. The second calculates fuel consumption in each operating mode. The third step calculates emissions using fuel consumption specific emission factors, which is how marine engine emission factors have been historically specified. All of these calculations are made by vessel type and class, with the type specifying whether the vessel is a tanker, passenger liner, etc, and the class specifying either the weight or horsepower range.

This new methodology considers new information collected on marine vessels. The other factors used in the emission estimate computation are examined, with particular focus on the emission factors, for all pollutants of concern. One reason for a detailed reconsideration of the emission factors is that a number of large marine diesels have been tested for emissions and their test results have become available in the last few years. In addition, both the EPA and CARB have recently sponsored studies to calculate marine vessel emissions in the South Coast Air Basin and in some areas of Region IX, so that there is a body of new research available to update emission factors. Hence, the use of a larger and newer database on marine vessel emission is expected to substantially improve the quality of the derived emission factors

### ***Activity***

The computation of emissions can be performed by ship type for a given port and requires the following inputs:

- The number of calls to the port by vessel class and deadweight tonnage.
- The time spent, by ship type, in each of four operating modes defines as: normal cruise, slow cruise, maneuvering, and hostelling.

**Emission Factors**

Emission rates were calculated per pollutant (except SO<sub>2</sub>) per vessel type per mode of operation within the guidance document using the following formula:

$$E_{(i)} = a * (\text{Fractional Load})^{-x} + b$$

Where:

$E_{(i)}$  = Emission rate of pollutant i in grams per kilowatt-hour

a = Coefficient

x = Exponent

b = Intercept

Emission rates were calculated per pollutant (SO<sub>2</sub> only) per vessel type per mode of operation within the guidance document using the following formula:

$$E_{(SO_2)} = a * (\text{Fuel Sulfur Flow in g/kW-hr}) + b$$

The marine engine emission factor and fuel consumption algorithms are presented in the table below:

**TABLE 4.6.1-a Marine Engine Emission Factor and Fuel Consumption**

| <b>Pollutant</b> | <b>Exponent (x)</b> | <b>Intercept (b)</b> | <b>Coefficient (a)</b> |
|------------------|---------------------|----------------------|------------------------|
| PM               | 1.5                 | 0.2551               | 0.0059                 |
| NOx              | 1.5                 | 10.4496              | 0.1255                 |
| SO <sub>2</sub>  | 1                   | 0                    | 2.3735                 |
| CO               | 1                   | 0                    | 0.8378                 |
| HC               | 1.5                 | 0                    | 0.0667                 |
| CO <sub>2</sub>  | 1                   | 648.6                | 44.1                   |

The marine engine emission rates in grams per kilowatt-hour are presented in the table below:

| <b>Vessel Type</b>                   | <b>Cruise</b>                   | <b>Slow Cruise</b>              | <b>Maneuvering</b>              | <b>Hoteling</b>                 |
|--------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
|                                      | <b>PM10-FIL<br/>(gr/kw-hr)</b>  | <b>PM10-FIL<br/>(gr/kw-hr)</b>  | <b>PM 10-FIL<br/>(gr/kw-hr)</b> | <b>PM10-FIL<br/>(gr/kw-hr)</b>  |
| Bulk Carriers & Tankers              | 0.75                            | 0.2784                          | 0.75                            | 0.75                            |
| General Cargo                        | 0.75                            | 0.2836                          | 0.75                            | 0.75                            |
| Passenger                            | 1.14                            | 0.3211                          | 1.14                            | 1.14                            |
| Container/ RORO/ Reefer/Auto Carrier | 0.75                            | 0.291                           | 0.75                            | 0.75                            |
| All non-oceangoing                   | 1.14                            | 0.2784                          | 1.14                            | 1.14                            |
|                                      | <b>PM2.5-FIL<br/>(gr/kw-hr)</b> | <b>PM2.5-FIL<br/>(gr/kw-hr)</b> | <b>PM2.5-FIL<br/>(gr/kw-hr)</b> | <b>PM2.5-FIL<br/>(gr/kw-hr)</b> |
| Bulk Carriers & Tankers              | 0.28                            | 0.2784                          | 0.28                            | 0.28                            |

| <b>Vessel Type</b>                   | <b>Cruise</b>     | <b>Slow Cruise</b> | <b>Maneuvering</b> | <b>Hoteling</b>   |
|--------------------------------------|-------------------|--------------------|--------------------|-------------------|
| General Cargo                        | 0.28              | 0.2836             | 0.28               | 0.28              |
| Passenger                            | 1.1               | 0.3211             | 1.1                | 1.1               |
| Container/ RORO/ Reefer/Auto Carrier | 0.28              | 0.291              | 0.28               | 0.28              |
| All non-oceangoing                   | 1.1               | 0.2784             | 1.1                | 1.1               |
|                                      | <b>SO2</b>        | <b>SO2</b>         | <b>SO2</b>         | <b>SO2</b>        |
|                                      | <b>(gr/kw-hr)</b> | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b> |
| Bulk Carriers & Tankers              | 6.16              | 28.6027            | 6.16               | 11.1              |
| General Cargo                        | 6.16              | 29.2012            | 6.16               | 11.1              |
| Passenger                            | 11.1              | 32.7919            | 11.1               | 57.9273           |
| Container/ RORO/ Reefer/Auto Carrier | 6.16              | 29.9991            | 6.16               | 11.1              |
| All non-oceangoing                   | 11.1              | 28.6027            | 11.1               | 11.1              |
|                                      | <b>CO</b>         | <b>CO</b>          | <b>CO</b>          | <b>CO</b>         |
|                                      | <b>(gr/kw-hr)</b> | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b> |
| Bulk Carriers & Tankers              | 1.1               | 2.0945             | 1.1                | 1.1               |
| General Cargo                        | 1.1               | 2.3937             | 1.1                | 1.1               |
| Passenger                            | 1.1               | 4.189              | 1.1                | 1.1               |
| Container/ RORO/ Reefer/Auto Carrier | 1.1               | 2.7927             | 1.1                | 1.1               |
| All non-oceangoing                   | 1.1               | 2.0945             | 1.1                | 1.1               |
|                                      | <b>HC</b>         | <b>HC</b>          | <b>HC</b>          | <b>HC</b>         |
|                                      | <b>(gr/kw-hr)</b> | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b> |
| Bulk Carriers & Tankers              | 0.4               | 0.2637             | 0.4                | 0.4               |
| General Cargo                        | 0.4               | 0.3221             | 0.4                | 0.4               |
| Passenger                            | 0.4               | 0.7457             | 0.4                | 0.4               |
| Container/ RORO/ Reefer/Auto Carrier | 0.4               | 0.4059             | 0.4                | 0.4               |
| All non-oceangoing                   | 0.4               | 0.2637             | 0.4                | 0.4               |
|                                      | <b>CO2</b>        | <b>CO2</b>         | <b>CO2</b>         | <b>CO2</b>        |
|                                      | <b>(gr/kw-hr)</b> | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b>  | <b>(gr/kw-hr)</b> |
| Bulk Carriers & Tankers              | 620.62            | 758.85             | 620.62             | 620.62            |
| General Cargo                        | 620.62            | 774.6              | 620.62             | 620.62            |
| Passenger                            | 620.62            | 869.1              | 620.62             | 620.62            |
| Container/ RORO/ Reefer/Auto Carrier | 620.62            | 795.6              | 620.62             | 620.62            |
| All non-oceangoing                   | 620.62            | 758.85             | 620.62             | 620.62            |

### **Point Source Adjustments**

No point source emissions were subtracted from the area source inventory.

### **Adjustment for Controls**

No controls are available for this source category.

**Spatial and  
Temporal  
Allocations**

*Spatial*

Divided cruise emissions out to counties along travel route.

*Temporal*

Data for temporal allocation is not available for this source.

**Emissions  
Calculation**

The equation used to estimate emissions from commercial marine vessels is:

$$\text{Emissions}_{i,gh} = \text{Trips}_i \times \text{Power}_{i,h} \times \text{LF}_{i,g} \times \text{Time}_{i,g} \times \text{EF}_i$$

- a.  $\text{Trips}_i$  = Number of trips or vessel calls by vessel (i) and engine type (h)
- b.  $\text{Power}_i$  = rated power of propulsion engine by vessel (i) and engine type (h)
- c.  $\text{LF}_{i,g}$  = Load factor (fraction of rated power) in mode g (cruise, slow cruise or maneuvering)
- d.  $\text{Time}_{i,g}$  = average time for each mode by vessel (i) and mode (g) (hours)

This information can be obtained from local Port Authorities. If information is not available for certain ports, EPA developed a port matching method that can be used to match an unknown port to a port with detailed characteristics (EPA, 2002).

- e.  $\text{EF}_{i,h}$  = Emission factor in mode (i) and by engine type (h)

Emission Factors - Commercial Marine Emission Inventory Development  
(EPA420-R-02-019, July 2002)

$$\text{TIME}_{\text{VCC, DWT, MODE}} = \frac{\text{CALLS}_{\text{VCC, DWT}} \times \text{LENGTH}_{\text{VCC, DWT}} \times \% \text{TIME}_{\text{VCC, DWT, MODE}}}{100}$$

$$\text{EMISSIONS}_{\text{VCC, DWT, MODE}} = \frac{(\text{EF})(\text{LF}_{\text{MODE}}) \times (\text{HP})(\text{DWT}) \times \text{LF}_{\text{MODE}} \times \text{TIME}_{\text{VCC, DWT, MODE}}}{\text{MODE}}$$

Where:

VCC is the vessel class (bulk carrier, tanker, container, general cargo, passenger, reefer, RORO, tug, vehicle carrier, or miscellaneous)

DWT is the deadweight tons

EF is the emissions factor

LF is the mode specific load factor

For the calculation, the TIME equation requires port areas input estimation data from port calls, vessel types and typical times in different operating modes. Three different speeds were considered: cruising, reduced speed zone (RSZ), and maneuvering. For port calculations, diesel and residual fueled ships can use the same calculation methodology.

While the guidance method outlined in Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data (EPA-450-R-00-002), February 2000, provides the EF and HP relationships.

Data on the type of vessels, number of calls per vessel type, deadweight tons per vessel type, and time in each mode per vessel type using Baltimore port facilities came from the Baltimore Maritime Exchange (BME).

In addition, the BME provided data that translated into approximately 85 percent of the vessels arriving from the south (up the Chesapeake Bay) and 15 percent of the vessels arriving from the north (down from the Chesapeake and Delaware Canal). The data allowed MDE to allocate slow cruising emissions to the appropriate counties to the north and south of the Port of Baltimore. Emissions associated with "normal cruising" were assumed by MDE not to have occurred while in the Maryland air shed.

All of the maneuvering and hoteling emissions were assigned to the City of Baltimore.