SECTION 3

STATIONARY NON-POINT SOURCES

3.1 Introduction

Stationary non-point sources represent a large and diverse set of individual emission source categories. A non-point source category is either represented by small facilities too numerous to individually inventory, such as gas stations or print shops, or is a common activity, such as the use of paints or cleaning solvents. Emissions from the non-point source categories were estimated at the county level.

3.1.1 Source Categories

There are many non-point source categories which contribute emissions of one or more ozone precursors. These categories can be grouped into several category types. These include:

- **Solvent Use –** Many products used by homeowners and businesses contain VOC solvents to achieve the intended purpose of the product. Paints, cleaners, pesticides, personal care products, and inks are a few examples of products that contain VOC solvents.

- **Gasoline Usage –** The distribution and use of gasoline in vehicles and other gasoline-powered engines result in emissions of VOCs whenever the volatile gasoline vapors are allowed to escape.

- **Fuel Combustion –** The combustion of fuels in industrial, commercial, institutional, and residential furnaces, engines, boilers, wood stoves, and fireplaces create emissions of VOCs, NO_x, and CO.

- **Open Burning –** Open burning creates emissions of VOCs, NO_x, and CO. Open burning categories include trash burning, prescribed burning, burning of land clearing material, wildfires, and house and vehicle fires.

Individual facilities are typically grouped with other like sources into a source category. Source categories are grouped in such a way that emissions are estimated collectively using one methodology. For example, gasoline stations, auto refinishing shops, and print shops are treated as non-point sources. For the 2002 inventory, the distinction between point and non-point was defined by an annual emission threshold based on recent point source data (see Section 2 for point source criteria). Table 3-1 lists the source categories for which ozone precursors were estimated.

There were several source categories evaluated, but not included, in the non-point source inventory. These include:

- **Agricultural Burning –** No activity for the burning of either crop residue or sheet plastic was identified. The Delaware Department of Agriculture has indicated this activity is not practiced in Delaware. Crop residues are left to biodegrade in place or are tilled under at the time of planting the next crop.

Table 3-1. Non-point Source Categories Inventoried

VOC Emissions Only	Emissions of VOC, NO_x, and CO
Agricultural Pesticides	Catastrophic/Accidental Releases
AIM Coatings	Commercial Cooking
Asphalt Paving	Commercial Fuel Combustion
Auto Refinishing	Industrial Fuel Combustion
Bakeries	Land Clearing Debris Burning
Commercial & Consumer Products	Prescribed Burning
Dry Cleaning	Residential Fuel Combustion
Gasoline (Petroleum) Marketing	Residential Open Burning
Graphic Arts	Residential Wood Combustion
Industrial Adhesives	Structure Fires
Industrial Surface Coatings	Vehicle Fires
Landfills (Inactive)	Wildfires
Leaking Underground Storage Tanks	
Publicly-Owned Treatment Works	
Solvent Cleaning	
Traffic Markings	

- **Breweries, Wineries, and Distilleries** – Delaware is home to only a few very small wineries and several microbreweries. There are no distilleries in Delaware. Since emission estimates for this source category in past inventories have been negligible (less than one ton of VOCs per year), the category was eliminated from further consideration.

- **Crematories** – While there are at least a dozen human/pet crematories and several laboratory animal incinerators in Delaware, DNREC was unable to locate emission factors for ozone precursors. Emissions from fuels used at these facilities are included in the commercial fuel combustion category.

- **Dover Speedway** – An attempt was made to quantify emissions from racing vehicles participating in the two major race weekends that are held at the speedway each year. However, there were no emission factors associated with the unique engines, fuels, and operating conditions associated with racing vehicles. Applying uncontrolled (i.e., non-catalyst) light-duty truck emission factors yielded negligible emissions for the four races performed each year (none of which were held on a summer season weekday.)

- **Slash Burning** - No activity for the burning of slash from logging for future silvicultural operations was identified. This was confirmed by the Delaware Division of Forestry. However, recently logged lands are occasionally converted to agriculture. This activity, previously reported as slash burning, is now reported under the land clearing debris burning category.

- **Small Facilities –** The small facilities category was established for VOC emissions that were not accounted for in other categories. For 2002, there was insufficient information to develop credible employee-based emission factors, which was the method employed in past inventories. Since the point source reporting threshold for VOCs was reduced from ten tons per year (TPY) in past inventories to two TPY for 2002, DNREC believes very little data was lost by eliminating this category.

3.1.2 Emission Estimation Methodologies

The 1999 Periodic Emission Inventory (PEI) served as the starting point for non-point source category selection and methodology development. Several source categories, such as inactive landfills, commercial cooking, and portable fuel containers are new to Delaware's non-point source inventory. New methods were applied to some existing source categories, and emission factors were updated where available. New source categories, methods, and emission factors came primarily from current *Emission Inventory Improvement Program, Volume III* documents and documented projects performed by the California Air Resource Board (CARB). Other sources of information included the *Compilation of Air Pollutant Emission Factors, Volume I* (AP-42), the *Factor Information Retrieval System* (FIRE), and several projects performed by the Mid-Atlantic Regional Air Management Association (MARAMA).

Emissions from most non-point source categories were estimated by multiplying an indicator of collective activity by a corresponding emission factor. An indicator is any parameter associated with the activity level of a source, such as production, employment, fuel usage, or population that can be correlated with the emissions from that source. The corresponding emission factors are per unit of production, per employee, per unit of commodity consumed, or per capita, respectively. The basic equation that was applied to emission development for most non-point source categories is as follows:

$$\textit{Emissions (E)} = \textit{Activity Data (Q)} \times \textit{Emission Factor (EF)}$$

If a source category had a regulatory control placed on it from the Federal or State level, the equation expands to the following:

$$E = Q \times EF \times [1 - (CE)(RE)(RP)]$$

where: CE = control efficiency
RE = rule effectiveness
RP = rule penetration

The control efficiency (CE) represents the typical emissions reduction achieved as compared to the otherwise uncontrolled emissions. A control may be a piece of equipment, such as a condenser used to recover vaporized solvent, or it may be an operational control, such as the use of only low VOC content paints.

Rule effectiveness (RE) reflects the ability of the regulatory program to achieve all emissions reductions that could have been achieved by full compliance with the applicable regulations at all sources at all times. If a rule is not being followed by all of the regulated community, then emissions will be higher than would otherwise be if there was 100% compliance. As an example, while the burning of trash is illegal under any circumstances in Delaware, the practice of burning household trash in backyard burn barrels still takes place in many rural areas of the State.

Rule penetration (RP) represents the percent of sources within a source category that are subject to the rule that requires control. As an example, gas stations that dispense more than 10,000 gallons of gasoline in a month are required by Delaware regulations to place vapor recovery systems on their gas pumps. Those dispensing less than 10,000 gallons are not required to install controls. Therefore, RP is less than 100%. In the case of the burning of trash or leaves, no person or business is exempt, and thus RP is 100%.

The mass balance approach was used for several source categories as an alternative to the use of an emission factor. The mass balance approach is applicable to VOC source categories where all of the VOC content in the products used (i.e., paints and adhesives) evaporates and is emitted as a result of the normal use of the product. Raw material or product purchase records were used to quantify emissions. Emissions were equated to the VOC content of the material usage minus amounts leaving the site as or in waste.

A major portion of the work involved in creating the 2002 non-point source inventory was in collecting activity data for each source category. The activity data gathered was related to the type of emission factors available and, in many cases, obtained from local sources. Surveys, letters, e-mails, and phone calls to individual businesses to obtain representative data for a source category was a technique used for several source categories. The details of each method used are described in the individual source category accounts within this section of the report.

Non-reactive VOCs were excluded from emission estimates. Emission factors specified as non-methane organic carbon (NMOC) in *AP-42* were used when available. In some instances, the *AP-42* emission factor was in terms of total organic carbon (TOC) and the percentage of the methane component was indicated in a footnote. In these cases, the emission factor was reduced by the percentage of methane to remove the non-reactive methane component in the emission total. For example, for evaporative emissions from crude oil, the methane component was 15 percent. The emission factor was reduced by 15 percent to remove methane from the calculation.

Point source backout was performed for seven non-point source categories. In addition, there was one inactive landfill and one wastewater treatment plant that were part of the point source inventory. Emissions were backed out for four categories, while activity data (employment or fuel consumption) were backed out for the remaining three categories. The categories include:

- Catastrophic/Accidental Releases (emissions),
- Commercial/Institutional Fuel Combustion (fuel usage),
- Graphic Arts (emissions),
- Industrial Adhesives (emissions),
- Industrial Fuel Combustion (fuel usage),
- Industrial Surface Coatings (emissions), and
- Solvent Cleaning (employees).

Source activity may fluctuate significantly on a seasonal basis. As an example, residential wood combustion is primarily performed outside the summer season. Paint usage, on the other hand, is used more often in the warmer months of the year. Because non-point source emissions are generally a direct function of source activity, seasonal changes in activity levels were examined closely. Emissions were calculated on an annual basis. Summer season weekday (SSWD) daily emissions were developed through the use of a temporal allocation factor (TAF) applied to the annual emissions. Monthly and weekly profiles were used to develop the TAF. The monthly profile for each source category was developed through the use of monthly activity data, when available, or through EPA guidance (*Procedures, Volume I* and EIIP documents.) Most weekly profiles were developed through EPA guidance which defines activity taking place five, six, or seven days per week. Through EPA guidance, all TAFs include the work week. A few TAFs were developed based on the exact dates of episodic activity, such as firefighting training burns and wildfires.

3.1.3 2002 Emissions Summary

Table 3-2 provides a statewide summary of the 2002 annual (tons per year, TPY) and SSWD (tons per day, TPD) emissions for each non-point source category. Tables 3-3 through 3-5 provide the emissions data for each of the three counties in Delaware. The totals may not match the sum of the individual values due to independent rounding.

The non-point sector is dominated by a number of large VOC source categories, many associated with solvent use. Figure 3-1 presents the top 10 VOC sources representing nearly 90% of statewide VOC SSWD daily emissions for 2002 from non-point sources. Nearly all NO_x emissions from non-point sources are from fuel combustion. Only a small amount of NO_x is created during open burning. As with NO_x, carbon monoxide is formed from fuel combustion, but unlike NO_x, the lower temperatures and other characteristics associated with open burning accounts for a large amount of the reported CO emissions from non-point sources.

Figure 3-1. 2002 Statewide VOC SSWD Emissions by Non-point Source Category

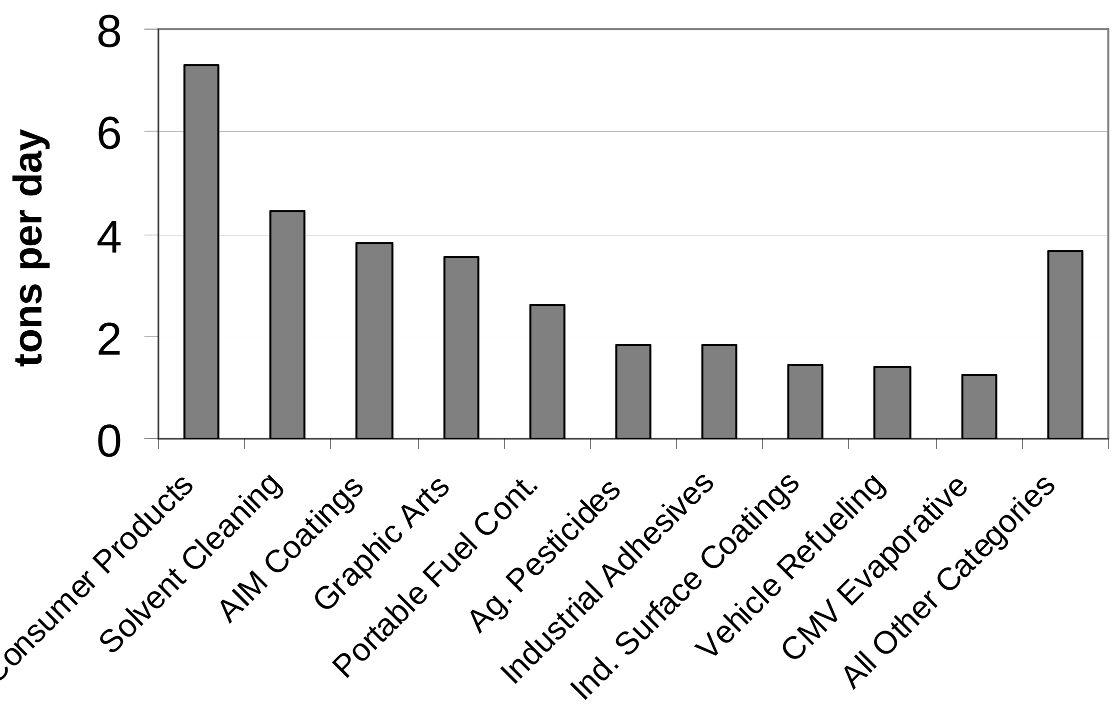

Table 3-2. Summary of 2002 Statewide Emissions from Non-point Sources

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
SOLVENT USE						
Agricultural Pesticides	339	1.83	---	---	---	---
AIM Coatings	1,006	3.81	---	---	---	---
Asphalt Paving	53	0.12	---	---	---	---
Auto Refinishing	141	0.63	---	---	---	---
Commercial & Consumer Products	2,531	7.30	---	---	---	---
Dry Cleaning	4	0.01	---	---	---	---
Graphic Arts	921	3.54	---	---	---	---
Industrial Adhesives	473	1.82	---	---	---	---
Industrial Surface Coating	375	1.44	---	---	---	---
Solvent Cleaning	1,174	4.43	---	---	---	---
Traffic Markings	99	0.75	---	---	---	---
Solvent Use Total	**7,116**	**25.68**	---	---	---	---
GASOLINE MARKETING						
Retail Gasoline Stations						
Tank Truck Unloading (Stage 1)	221	0.78	---	---	---	---
Refueling and PFC Filling (Stage 2)	507	1.39	---	---	---	---
Underground Tank Breathing	55	0.17	---	---	---	---
Tank Trucks in Transit	13	0.04	---	---	---	---
Other Gasoline Marketing Activities						
Aircraft Refueling	60	0.19	---	---	---	---
Marinas	55	0.18	---	---	---	---
Portable Fuel Containers	757	2.61	---	---	---	---
CMV Loading and Transport	448	1.23	---	---	---	---
Gasoline Marketing Total	**2,116**	**6.59**	---	---	---	---
FUEL COMBUSTION						
Commercial/Institutional	18	0.02	405	0.52	258	0.35
Industrial	28	0.06	715	1.59	430	0.96
Residential Fossil Fuel	52	0.04	1,140	0.91	341	0.26
Residential Wood	679	0.19	75	0.02	3,918	1.26
Fuel Combustion Total	**777**	**0.32**	**2,335**	**3.05**	**4,948**	**2.84**
OPEN BURNING						
Residential Open Burning	27	0.02	14	0.02	259	0.32
Land Clearing Debris Burning	51	0.14	22	0.06	739	2.03
Prescribed Burning	67	0	31	0	1,425	0
Structure Fires	25	0.05	3	0.01	134	0.27
Vehicle Fires	2	0.01	< 1	< 0.01	8	0.02
Wildfires	48	0.07	22	0.03	1,020	1.53
Open Burning Total	**220**	**0.29**	**92**	**0.12**	**3,585**	**4.17**
MISCELLANEOUS SOURCES						
Bakeries	1	<0.01	---	---	---	---
Catastrophic/Accidental Releases	1	< 0.01	< 1	0	---	---
Commercial Cooking	30	0.08	---	---	85	0.23
Landfills (Inactive)	42	0.11	---	---	---	---
Leaking UST Remediations	13	< 0.01	---	---	---	---
POTWs	1	< 0.01	---	---	---	---
Miscellaneous Sources Total	**88**	**0.20**	**< 1**	**0**	**85**	**0.23**
NON-POINT SECTOR TOTAL	**10,316**	**33.08**	**2,427**	**3.17**	**8,618**	**7.24**

Table 3-3. Summary of 2002 Non-point Emissions for Kent County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
SOLVENT USE						
Agricultural Pesticides	97	0.52	---	---	---	---
AIM Coatings	163	0.62	---	---	---	---
Asphalt Paving	11	0.02	---	---	---	---
Auto Refinishing	14	0.06	---	---	---	---
Commercial & Consumer Products	411	1.18	---	---	---	---
Dry Cleaning	4	0.01	---	---	---	---
Graphic Arts	94	0.36	---	---	---	---
Industrial Adhesives	102	0.39	---	---	---	---
Industrial Surface Coating	39	0.15	---	---	---	---
Solvent Cleaning	205	0.78	---	---	---	---
Traffic Markings	23	0.18	---	---	---	---
Solvent Use Total	**1,163**	**4.29**	---	---	---	---
GASOLINE MARKETING						
Retail Gasoline Stations						
Tank Truck Unloading (Stage 1)	43	0.15	---	---	---	---
Refueling and PFC Filling (Stage 2)	103	0.28	---	---	---	---
Underground Tank Breathing	11	0.03	---	---	---	---
Tank Trucks in Transit	3	0.01	---	---	---	---
Other Gasoline Marketing Activities						
Aircraft Refueling	11	0.03	---	---	---	---
Marinas	0	0	---	---	---	---
Portable Fuel Containers	123	0.42	---	---	---	---
CMV Loading and Transport	101	0.28	---	---	---	---
Gasoline Marketing Total	**393**	**1.20**	---	---	---	---
FUEL COMBUSTION						
Commercial/Institutional	2	< 0.01	60	0.08	34	0.05
Industrial	2	0.01	61	0.14	37	0.08
Residential Fossil Fuel	9	0.01	204	0.17	54	0.04
Residential Wood	142	0.04	15	< 0.01	797	0.36
Fuel Combustion Total	**156**	**0.05**	**341**	**0.39**	**922**	**0.53**
OPEN BURNING						
Residential Open Burning	7	< 0.01	3	< 0.01	65	0.07
Land Clearing Debris Burning	15	0.04	6	0.02	218	0.60
Prescribed Burning	12	0	6	0	259	0
Structure Fires	5	0.01	1	< 0.01	26	0.03
Vehicle Fires	1	< 0.01	< 1	< 0.01	2	0.01
Wildfires	5	0.07	2	0.03	99	1.49
Open Burning Total	**45**	**0.12**	**18**	**0.06**	**669**	**2.20**
MISCELLANEOUS SOURCES						
Bakeries	< 1	< 0.01	---	---	---	---
Catastrophic/Accidental Releases	< 1	< 0.01	---	---	---	---
Commercial Cooking	4	0.01	---	---	11	0.03
Landfills (Inactive)	23	0.06	---	---	---	---
Leaking UST Remediations	3	0	---	---	---	---
POTWs	1	< 0.01	---	---	---	---
Miscellaneous Sources Total	**31**	**0.08**	**---**	**---**	**11**	**0.03**
NON-POINT SECTOR TOTAL	**1,786**	**5.75**	**359**	**0.45**	**1,602**	**2.76**

Table 3-4. Summary of 2002 Non-point Emissions for New Castle County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
SOLVENT USE						
Agricultural Pesticides	47	0.25	---	---	---	---
AIM Coatings	638	2.41	---	---	---	---
Asphalt Paving	15	< 0.01	---	---	---	---
Auto Refinishing	100	0.45	---	---	---	---
Commercial & Consumer Products	1,606	4.63	---	---	---	---
Dry Cleaning	0	0	---	---	---	---
Graphic Arts	789	3.04	---	---	---	---
Industrial Adhesives	317	1.22	---	---	---	---
Industrial Surface Coating	278	1.07	---	---	---	---
Solvent Cleaning	738	2.77	---	---	---	---
Traffic Markings	40	0.30	---	---	---	---
Solvent Use Total	**4,567**	**16.14**	---	---	---	---
GASOLINE MARKETING						
Retail Gasoline Stations						
Tank Truck Unloading (Stage 1)	119	0.42	---	---	---	---
Refueling and PFC Filling (Stage 2)	273	0.76	---	---	---	---
Underground Tank Breathing	30	0.09	---	---	---	---
Tank Trucks in Transit	7	0.02	---	---	---	---
Other Gasoline Marketing Activities						
Aircraft Refueling	41	0.13	---	---	---	---
Marinas	26	0.09	---	---	---	---
Portable Fuel Containers	470	1.62	---	---	---	---
CMV Loading and Transport	177	0.49	---	---	---	---
Gasoline Marketing Total	**1,145**	**3.62**	---	---	---	---
FUEL COMBUSTION						
Commercial/Institutional	14	0.02	298	0.39	209	0.29
Industrial	18	0.04	465	1.03	280	0.62
Residential Fossil Fuel	34	0.03	679	0.51	235	0.17
Residential Wood	364	0.09	41	0.01	2,170	0.64
Fuel Combustion Total	**430**	**0.18**	**1,484**	**1.95**	**2,894**	**1.72**
OPEN BURNING						
Residential Open Burning	8	0.01	4	0.01	75	0.08
Land Clearing Debris Burning	0	0	0	0	0	0
Prescribed Burning	53	0	24	0	1,123	0
Structure Fires	8	0.02	1	< 0.01	44	0.11
Vehicle Fires	1	< 0.01	< 1	< 0.01	4	0.01
Wildfires	< 1	< 0.01	< 1	< 0.01	2	0.03
Open Burning Total	**70**	**0.03**	**29**	**0.01**	**1,247**	**0.23**
MISCELLANEOUS SOURCES						
Bakeries	1	< 0.01	---	---	---	---
Catastrophic/Accidental Releases	1	< 0.01	< 1	0	---	---
Commercial Cooking	19	0.05	---	---	53	0.15
Landfills (Inactive)	2	0.01	---	---	---	---
Leaking UST Remediations	2	0	---	---	---	---
POTWs	< 1	< 0.01	---	---	---	---
Miscellaneous Sources Total	**24**	**0.06**	**< 1**	**0**	**53**	**0.15**
NON-POINT SECTOR TOTAL	**6,236**	**20.02**	**1,513**	**1.95**	**4,194**	**2.10**

Table 3-5. Summary of 2002 Non-point Emissions for Sussex County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
SOLVENT USE						
Agricultural Pesticides	196	1.05	---	---	---	---
AIM Coatings	204	0.77	---	---	---	---
Asphalt Paving	27	0.10	---	---	---	---
Auto Refinishing	27	0.12	---	---	---	---
Commercial & Consumer Products	514	1.48	---	---	---	---
Dry Cleaning	0	0	---	---	---	---
Graphic Arts	38	0.15	---	---	---	---
Industrial Adhesives	54	0.21	---	---	---	---
Industrial Surface Coating	58	0.22	---	---	---	---
Solvent Cleaning	231	0.88	---	---	---	---
Traffic Markings	36	0.27	---	---	---	---
Solvent Use Total	**1,385**	**5.26**	---	---	---	---
GASOLINE MARKETING						
Retail Gasoline Stations						
Tank Truck Unloading (Stage 1)	60	0.21	---	---	---	---
Refueling and PFC Filling (Stage 2)	131	0.35	---	---	---	---
Underground Tank Breathing	14	0.04	---	---	---	---
Tank Trucks in Transit	3	0.01	---	---	---	---
Other Gasoline Marketing Activities						
Aircraft Refueling	8	0.02	---	---	---	---
Marinas	28	0.10	---	---	---	---
Portable Fuel Containers	164	0.57	---	---	---	---
CMV Loading and Transport	170	0.47	---	---	---	---
Gasoline Marketing Total	**578**	**1.77**	---	---	---	---
FUEL COMBUSTION						
Commercial/Institutional	1	< 0.01	46	0.06	14	0.02
Industrial	7	0.02	189	0.41	114	0.25
Residential Fossil Fuel	10	0.01	257	0.23	52	0.04
Residential Wood	173	0.06	18	0.01	952	0.27
Fuel Combustion Total	**191**	**0.08**	**510**	**0.71**	**1,132**	**0.58**
OPEN BURNING						
Residential Open Burning	12	0.01	7	0.01	120	0.16
Land Clearing Debris Burning	36	0.10	15	0.04	521	1.43
Prescribed Burning	2	0	1	0	43	0
Structure Fires	12	0.02	1	< 0.01	64	0.14
Vehicle Fires	< 1	< 0.01	< 1	< 0.01	2	< 0.01
Wildfires	43	< 0.01	20	< 0.01	919	< 0.01
Open Burning Total	**106**	**0.13**	**44**	**0.06**	**1,669**	**1.74**
MISCELLANEOUS SOURCES						
Bakeries	< 1	< 0.01	---	---	---	---
Catastrophic/Accidental Releases	---	---	---	---	---	---
Commercial Cooking	7	0.02	---	---	21	0.06
Landfills (Inactive)	16	0.04	---	---	---	---
Leaking UST Remediations	9	< 0.01	---	---	---	---
POTWs	< 1	< 0.01	---	---	---	---
Miscellaneous Sources Total	**33**	**0.07**	**---**	**---**	**21**	**0.06**
NON-POINT SECTOR TOTAL	**2,293**	**7.31**	**554**	**0.77**	**2,822**	**2.38**

3.2 Solvent Use

Emission estimation methodologies are described in this section for the following categories:

- Agricultural Pesticides,
- AIM Coatings,
- Asphalt Paving,
- Auto Refinishing,
- Commercial and Consumer Products,
- Dry Cleaning,
- Graphic Arts,
- Industrial Adhesives,
- Industrial Surface Coatings,
- Solvent Cleaning (Degreasing), and
- Traffic Markings.

3.2.1 Agricultural Pesticides

Pesticides are substances used to control nuisance weeds (herbicides), insects (insecticides), fungi (fungicides), and rodents (rodenticides). Formulations of pesticides are made through the combination of the pest-killing material referred to as the active ingredient and various solvents (which act as carriers for the pest-killing material) referred to as the inert ingredient. Both types of ingredients contain VOCs that can potentially be emitted to the air either during application or as a result of evaporation.

Pesticide applications can be broken down into two user categories: agricultural and non-agricultural, which includes municipal, commercial and consumer. Emissions for agricultural pesticides are reported under the following SCCs:

Table 3-6. SCCs for Agricultural Pesticides

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2461850001	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Herbicides, Corn
2461850005	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Herbicides, Soy Beans
2461850006	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Herbicides, Hay & Grains
2461850009	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Herbicides, Not Elsewhere Classified
2461850051	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Other Pesticides, Corn
2461850055	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Other Pesticides, Soy Beans
2461850056	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Other Pesticides, Hay & Grains
2461850099	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	Other Pesticides, Not Elsewhere Classified

VOC emissions from non-agricultural use of pesticides are inventoried under the Commercial and Consumer Products category.

Activity Data

The preferred EIIP method was used for estimating emissions from land applied agricultural pesticides (EIIP, 2001). This method considered the following factors: the vapor pressure of the active ingredient, the amount of pesticide applied to an area, the percentage of the active ingredient in the pesticide applied, the application method, and the type of formulation. This method assumed that volatilization is essentially complete within 30 days of application.

The EIIP document stated that the preferred method cannot be used for aerial applications. This is because a major factor in losses by aerial application is drift, and neither equations nor experimental data are currently available to predict these losses, or develop emission factors. However, it is not clear why the issue of drift would impact the calculation of VOC emissions. While some fraction of the applied pesticide may not reach its target area, the volatile portion will still result in VOC emissions. Therefore, emissions from aerial applications were estimated in the same way as land applied pesticides.

The total amount of each pesticide used was calculated by multiplying the crop acreage on which the pesticide is applied by the application rate. The Delaware Department of Agriculture (DDA) was contacted to obtain county level data on the types and formulation of pesticides used, the method of application, and crop acres to which each pesticide was applied. The pesticide application rate per acre was determined from pesticide labels used for developing the 1999 PEI (DNREC, 2002). These same application rates were used for this inventory with updates on crop acres in 2002.

Pesticide application to the following major crops was investigated: corn, wheat/barley, soybeans, hay/alfalfa, sweet corn and peas/lima beans. These crops represent most of the harvested crops in Delaware according to the USDA's Census of Agriculture.

Data are available for most major crops on county-level acres planted that can be used to estimate pesticide emissions. However, sweet corn and peas-lima beans do not have county-level breakdowns for 2002. County breakdowns for field corn and soybeans were used to allocate crop acreage by county for sweet corn and peas/lima beans, respectively.

Emission Factors

Information on the inert and active ingredients in pesticides was needed for this inventory effort. In addition to the total amount of pesticide applied, the following information was needed to calculate VOC emissions:

- The type of active ingredient(s) in the pesticide applied,
- The vapor pressure of the active ingredient(s),
- Active ingredient emission factors,
- The percentage of inert ingredients in the pesticide applied, and
- The percentage of VOC in the inert ingredients.

This information was taken from previous work performed for the 1999 inventory (DNREC, 2002), DDA, the *EIIP* document on pesticide application (EIIP, 2001), and other sources, as needed (e.g., product Material Safety Data Sheets).

Emissions from pesticide active ingredients and inert ingredients were estimated separately. For emissions from active ingredients, the total amount of pesticide was multiplied by the fraction of active ingredient in the pesticide and by the VOC emission factor. The active ingredient emission factor was determined based on the vapor pressure of the active ingredient. For emissions from inert ingredients, the total amount of pesticide was multiplied by the fraction of inert ingredients in the pesticide and the fraction of VOC in the inert ingredients.

Temporal Allocation

DNREC assembled a crop calendar to support emission inventory development for a number of agricultural source sectors, including this one. Emissions were allocated to the months during which pesticides are applied. Daily emissions were allocated to seven days per week. Although emissions are dependent on ambient temperature, there is no known information to develop a temperature-dependent profile. Therefore, temperature was not used to adjust the allocation of emissions to the ozone season.

Controls

There were no programs in place that would affect the emission estimates, as they were calculated directly from estimates of application rates and pesticide VOC content. Therefore, the control parameters (CE, RE, and RP) were set to zero.

Sample Calculations and Results

An example calculation of annual county level VOC emissions for agricultural pesticides follows. First, the emissions from the active ingredient of the pesticide applied were calculated:

$$E_1 = \frac{R}{2000\ lb/ton} \times A \times PA \times \frac{EF}{2000\ lb/ton}$$

where: E_1 = emissions from the active ingredient (ton/year),
R = pesticide application rate (lb/acre-yr),
A = crop area (acre),
PA = fraction of active ingredient in the pesticide (unitless), and
EF = emission factor (lb/ton).

Next, emissions from the inert ingredients of the pesticide applied were calculated:

$$E_2 = \frac{R}{2000\ lb/ton} \times A \times PI \times PVI$$

where: E_2 = emissions from inert ingredients (ton/yr),
R = pesticide application rate (lb/acre-yr),

A = crop area (acre),
PI = fraction inert ingredient in the pesticide (unitless), and
PVI = fraction VOC in the inert ingredient (unitless).

Total emissions are the sum of emissions from active and inert ingredients:

$$E = E_1 + E_2$$

where: E = total pesticide emissions (ton/yr),
E_1 = VOC emissions from the active ingredient (ton/yr), and
E_2 = VOC emissions from the inert ingredients (ton/yr).

Table 3-7. 2002 Statewide Annual and SSWD VOC Emissions for Agricultural Pesticides

SCC	Category Description	VOC	
		TPY	TPD
2461850001	Herbicides, Corn	184	0.99
2461850005	Herbicides, Soy Beans	103	0.55
2461850006	Herbicides, Hay & Grains	1	< 0.01
2461850009	Herbicides, Not Elsewhere Classified	36	0.20
2461850051	Other Pesticides, Corn	3	0.02
2461850055	Other Pesticides, Soy Beans	4	0.02
2461850056	Other Pesticides, Hay & Grains	5	0.03
2461850099	Other Pesticides, Not Elsewhere Classified	3	0.02
246185xxxx	**Total: Agricultural Pesticides**	**339**	**1.83**

References

DNREC, 2002. *1999 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NOx and CO*, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, 2002.

EIIP, 2001. *Pesticides – Agricultural and Nonagricultural, Volume III*, Chapter 9, Emission Inventory Improvement Program, Area Sources Committee, June 2001.

3.2.2 Architectural & Industrial Maintenance (AIM) Coatings

Architectural surface coating operations consist of applying a thin layer of coating such as paint, paint primer, varnish, or lacquer to architectural surfaces, and the use of solvents as thinners and for cleanup. Surface coatings include either a water-based or solvent-based liquid carrier that generally evaporates in the curing process. Architectural surface coatings are applied to protect the substrate and/or to increase the aesthetic value of a structure.

Industrial maintenance coatings include primers, sealers, undercoats, and intermediate and topcoats formulated for and applied to substrates in industrial, commercial, coastal, or institutional situations that are exposed to extreme environmental and physical conditions. These conditions include immersion in water, chemical solutions and corrosives, and exposures to high temperatures. Emissions for AIM coatings are reported under the following SCCs:

Table 3-8. SCCs for AIM Coatings

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2401002000	Solvent Utilization	Surface Coating	Architectural Coatings - Solvent-based	Total: All Solvent Types
2401003000	Solvent Utilization	Surface Coating	Architectural Coatings - Water-based	Total: All Solvent Types
2401102000[a]	Solvent Utilization	Surface Coating	Industrial Maintenance Coatings- Solvent-based	Total: All Solvent Types
2401103000[a]	Solvent Utilization	Surface Coating	Industrial Maintenance Coatings- Water-based	Total: All Solvent Types

[a] Proposed SCCs to separate out industrial maintenance coatings into solvent-based and water-based

The industrial maintenance coatings sub-category has a point and non-point source component. Point source surface coating emission estimates typically do not break out surface coating emissions associated with industrial maintenance (e.g., coating of facility components such as railings, equipment, etc.) and the coating of products. There was not enough detail present in the point source inventory to identify industrial maintenance coatings use that could be subtracted out of the non-point source inventory.

Activity Data

The preferred EIIP method is to perform a survey of manufacturers to gather sales data specific to the inventoried area (EIIP, 1995). This type of approach was beyond the scope of this inventory. For this inventory, the EIIP alternative approach was used. The alternative approach involves allocating national shipments of both solvent- and water-based coatings to the county based on population. Emission factors are then applied to the county-level consumption estimates.

Per capita usage factors for architectural coatings were calculated by dividing the total national usage of solvent-based paints and the total national usage of water-based paints by the U.S. population. Total shipments of solvent-based and water-based paints were obtained from the Census Bureau's *Current Industrial Reports* (BOC, 2002). The per capita usage factors were then used to estimate county level consumption in Delaware. The EIIP also mentions performing a survey of local recycling facilities to gather information on the amount and type of coatings that have been recycled (EIIP, 1995). With this information, the amount of recycled coatings can be subtracted from the county-level consumption estimate. A survey of this type was beyond the scope of this inventory.

Emissions from industrial maintenance coatings were calculated using a per capita VOC emission factor (see below). County level population estimates were obtained from the Delaware Population Consortium (DPC, 2003).

Emission Factors

VOC emission factors (lbs/gallon) for water- and solvent-based architectural coatings in the EIIP documents are based on EPA data from the early 1990's (EIIP, 1995). However, newer emission factors (in Table 3.9) from CARB's 1998 survey work were used to estimate VOC emissions (CARB, 1999). These newer data from CARB better reflect the changes in AIM coating formulations that have occurred since the mid-1990s as a result of both the Federal AIM coatings rule and state rules.

Table 3-9. VOC Emission Factors for AIM Coatings[a]

Product Category	Emission Factor [b]	Factor Units
Architectural Coatings - Solvent-based	3.10	lb VOC/gal
Architectural Coatings - Water-based	0.469	lb VOC/gal
Industrial Maintenance Coatings - Solvent-based	0.32	lb VOC/person
Industrial Maintenance Coatings- Water-based	0.16	lb VOC/person

[a] Source: CARB, 1999: *1998 Architectural Coatings Survey Results,* Final Report
[b] Compounds listed as non-reactive by the CARB have been excluded. Significant changes to earlier definitions are the removal of acetone from the list of reactive VOCs.

VOC emission factors from CARB's 1998 survey work are also used to estimate emissions from industrial maintenance coatings. As with architectural coatings, the emission factor from the EIIP document for industrial surface coatings (EIIP, 1997) is based on dated information and probably does not reflect coatings used in 2002.

Temporal Allocation

Architectural coating usage is assumed to take place 7 days per week. A higher amount of activity occurs during the ozone season than during the rest of the year. In the EIIP, the seasonal factor for ozone season activity is assumed to be 1.3 or 33% of annual activity (EIIP, 1995). As mentioned in the EIIP, DNREC reviewed the Bureau of Census (BOC) data on quarterly shipments of architectural coatings and derive the monthly profile based on those data.

For industrial maintenance coatings, activity is assumed to occur 5 days per week (i.e., during the work week). The EIIP document for industrial surface coatings does not provide information on the seasonal allocation of emissions (EIIP, 1997), although, as with architectural coatings, usage should be higher during the ozone season. A monthly profile was developed for industrial maintenance coatings from BOC quarterly coatings shipments.

Controls

In 1998, EPA promulgated a national standard for architectural coatings requiring that VOC content limits be achieved by September 1999. Use of the newer CARB data should capture the changes in formulation brought about by the Federal Rule and state rules, such as those in California and other states. Therefore, it would not be appropriate to account for additional emission reductions associated with these rules. Hence, CE, RE, and RP were all set to zero.

Sample Calculations and Results

An example calculation of annual VOC emissions for solvent-based architectural coating emissions in county y ($E_{s,y}$) follows. First, the per capita usage factor is calculated from national consumption data:

$$u_s = \frac{U_{s,us}}{Pop_{us}}$$

where: u_s = per capita usage of solvent-based coatings (gallons/person)
$U_{s,us}$ = total US consumption of solvent-based coatings (gallons)
Pop_{us} = total US population

The population of county y is multiplied by the per capita usage factor to obtain the county-level consumption:

$$u_{s,y} = u_s * Pop_y$$

where: $u_{s,y}$ = usage of solvent-based coatings in county y (gallons)
Pop_y = population in county y

The emission factor can then be applied to the county consumption to estimate emissions:

$$E_{s,y} = u_{s,y} * EF_s * 1/2000$$

where: EF_s = emission factor for solvent-based coatings (lb/gallon)
1/2000 = conversion from lb to ton

Table 3-10. 2002 Statewide Annual and SSWD VOC Emissions for AIM Coatings

SCC	Category Description	VOC	
		TPY	TPD
2401002000	Architectural Coatings - Solvent-based	491	1.80
2401003000	Architectural Coatings - Water-based	321	1.18
2401102000	Industrial Maintenance Coatings - Solvent-based	129	0.56
2401103000	Industrial Maintenance Coatings - Water-based	65	0.28
2401xxxxxx	**Total: AIM Coatings**	**1006**	**3.81**

References

BOC, 2002. *Current Industrial Reports, Paint and Allied Products*, MA325F(02)-1. U.S. Department of Commerce, Bureau of Census, Washington, DC. 2002.

CARB, 1999. *1998 Architectural Coatings Survey Results*, Final Report, California Air Resource Board, September 1999.

DPC, 2003. *2003 Draft Annual Population Estimates by County, Age, Gender, and Race 2000-2030*, downloaded from http://www.cadsr.udel.edu/demography/consortium.htm.

EIIP, 1995. *Architectural Surface Coatings, Volume III*, Chapter 3, Emission Inventory Improvement Program, Area Sources Committee, November 1995.

EIIP, 1997. *Industrial Surface Coatings, Volume III*, Chapter 8, Emission Inventory Improvement Program, Area Sources Committee, September 1997.

3.2.3 Asphalt Paving

Asphalt is used to pave, seal, and repair surfaces such as roads, parking lots, driveways, walkways, and airport runways; emissions from asphalt paving occur during the application and curing of asphalt concrete, which is a mixture of asphalt cement and an aggregate. Asphalt cement is the semi-solid residual material left from petroleum refining after the lighter and more volatile fractions have been distilled out.

Cutback asphalt is asphalt cement thinned with petroleum distillates (diluents). Asphalt cold mix is a mixture of cutback asphalt and aggregate. Emissions from the application of cold mix asphalt will be inventoried under cutback asphalt. Emulsified asphalt is a mixture of asphalt cement with water and emulsifiers.

Emissions from hot-mix asphalt were not calculated for this source category because the VOC emissions from paving with hot-mix asphalt are assumed to be minimal per EPA's EIIP asphalt paving chapter (EIIP, 2001). DNREC conducted its own evaluation of emissions from hot-mix asphalt. DNREC calculated the total hot mixed asphalt produced in the state of Delaware and multiplied that number by a CARB asphalt paving emission factor and found that the 2002 VOC emissions were less than one ton. Emissions for asphalt paving are reported under the following SCCs:

Table 3-11. SCCs for Asphalt Paving

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2461021000	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Cutback Asphalt	Total: All Solvent Types
2461022000	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Emulsified Asphalt	Total: All Solvent Types

No point source SCCs are associated with this area source sub-sector.

Activity Data

The preferred EIIP methodology for asphalt paving operations is to conduct a comprehensive survey of all state and local transportation agencies to obtain asphalt use data. Alternative methods allow abbreviated surveys of transportation agencies with assumptions from AP-42 for emission factors. For this inventory, DNREC used a combination of these methods.

DNREC obtained the county-level usage of cold mix and emulsified asphalts by the Delaware Department of Transportation (DelDOT) in 2002 and state-level production of cold mix asphalt by asphalt plants in 2002. The percentage of cutback asphalt contained in the cold mix was based on survey data from the 1999 inventory (DNREC, 2002).

By subtracting the DelDOT usage of cold mix from this state production total, the amount of cold mix (and thus the amount of cutback asphalt) used by non-DelDOT entities was estimated. This 2002 non-DelDOT consumption was allocated to counties using the 1999 survey data.

Emission Factors

For cutback asphalt, VOC emissions per ton of cold mix were calculated by multiplying the fraction of cutback asphalt in the cold mix, the percent solvent content of the cutback asphalt (provided by DelDOT in the 1999 survey), and the percent evaporation loss. The percent evaporation loss is dependent upon the type of solvent used. The 1999 survey revealed that kerosene was the solvent used in the manufacture of cutback asphalt. Per EPA's EIIP, the percent evaporation loss for this type of cutback asphalt is approximately 70% (EIIP, 2001).

For emulsified asphalt, the VOC content per gallon of asphalt was determined by DelDOT testing of various batches of emulsified asphalt used in 1999 (DNREC, 2002). The emission factor derived for the 1999 inventory was revised by adjusting it downward to account for the density of the VOC (i.e., light petroleum products), instead of the density of the emulsified asphalt product:

(0.5 ml VOC/200 ml asphalt) x (5.34lb VOC/gal VOC) = 0.0134 lb VOC/gal asphalt

The VOC content was used for asphalt application by counties and private contractors.

Temporal Allocation

As was done for the 1999 survey, DNREC requested 2002 data from DelDOT on monthly asphalt usage. These data were used to develop a monthly temporal profile. Daily allocation of emissions for asphalt paving operations differ from other source categories in that emissions occur over a period of time after the paving is done. Therefore, a seven day week was used to allocate daily emissions from this source category (EIIP, 2001).

Controls

Delaware Air Regulation 24 (DNREC, 1993), Section 34, prohibits the application of both cutback asphalt and VOC-containing emulsified asphalt during the peak ozone season. This provision was added in January of 1993 and listed a compliance date of May 31, 1995. Through feedback from the 1999 asphalt survey it was determined that cutback and emulsified asphalt were being widely applied during the peak ozone season. In any case, the control parameters (CE, RP, and RE) were set to zero (i.e., if compliance was achieved, the impacts of the rule are to move activity outside of the ozone season; this was handled through appropriate temporal allocation.)

Sample Calculations and Results

An example calculation of annual county level emissions for cutback and emulsified asphalt follows:

$$U_{x,02,cnty} = U_{x,02,st} \times \frac{U_{x,99,cnty}}{U_{x,99,st}}$$

where: $U_{x,02,cnty}$ = 2002 county usage of asphalt type x (tons)
$U_{x,02,st}$ = 2002 state usage of asphalt type x (tons)
$U_{x,99,cnty}$ = 1999 county usage of asphalt type x (ton)
$U_{x,99,st}$ = 1999 state usage of asphalt type x (ton)

$$E_{c,cnty} = U_{c,02,cnty} \times C/100 \times L/100$$

where: $E_{c,cnty}$ = county emissions from cutback asphalt (ton)
$U_{c,02,cnty}$ = 2002 county usage of cutback asphalt (ton)
C = weight percent of solvent in cutback asphalt (%)
L = evaporation percent for cutback solvent (%)

$$E_{e,cnty} = U_{e,02,cnty} \times V \times 1/2000$$

where: $E_{e,cnty}$ = county emissions from emulsified asphalt (ton)
$U_{e,02,cnty}$ = 2002 county usage of emulsified asphalt (gal)
V = asphalt VOC content (lb/gal)
1/2000 = lb to ton conversion

Table 3-12. 2002 Statewide Annual and SSWD VOC Emissions for Asphalt Paving

SCC	Category Description	VOC	
		TPY	TPD
2461021000	Cutback Asphalt	45	0.06
2461022000	Emulsified Asphalt	8	0.07
246102xxxx	**Total: Asphalt Paving**	**53**	**0.12**

References

DNREC, 2002. *1999 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NO_x and CO*, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, 2002.

DNREC, 1993. *Regulations Governing the Control of Air Pollution.* 40-09-81/02/01. Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Updated to January 1993.

EIIP, 2001. *Asphalt Paving, Volume III*, Chapter 17, Emission Inventory Improvement Program, Area Sources Committee, April 2001.

3.2.4 Auto Refinishing

Auto refinishing is the repairing of worn or damaged automobiles, light trucks, and other vehicles, and refers to any coating applications that occur subsequent to those at original equipment manufacturer (OEM) assembly plants (i.e., coating of new cars is not included in this category). The majority of these operations occur at small body shops that repair and refinish automobiles. This category covers solvent emissions from the refinishing of automobiles, including paint solvents, thinning solvents, and solvents used for surface preparation and cleanup. Emissions for auto refinishing are reported under the following SCCs:

Table 3-13. SCCs for Auto Refinishing

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2401005500	Solvent Utilization	Surface Coating	Auto Refinishing: SIC 7532	Surface Preparation Solvents
2401005600	Solvent Utilization	Surface Coating	Auto Refinishing: SIC 7532	Primers
2401005700	Solvent Utilization	Surface Coating	Auto Refinishing: SIC 7532	Top Coats
2401005800	Solvent Utilization	Surface Coating	Auto Refinishing: SIC 7532	Clean-up Solvents

Activity Data

Emissions for this category were calculated using a method developed by E.H. Pechan & Associates under subcontract to Environ for a 1999 Texas criteria pollutant inventory (Environ, 2001). This method uses facility-level employment and revenue data to assign individual facilities to one of six size classes (shown in Table 3-14 below). The method is based on survey work conducted by the State of Texas (Smith and Dunn, 1999). This information was used in the development of the EIIP chapter on auto refinishing (EIIP, 2000). The method is similar to the preferred method in the draft EIIP; however Pechan did not recommend using the EIIP methods for surface preparation and clean-up solvents. During the work conducted for Texas, Pechan found that the EIIP data for solvents produced emission estimates that were much higher than expected (Environ, 2001).

For this source sector, employment and revenue class data, geographic coordinates, facility name and phone number were purchased from Dun & Bradstreet (D&B, 2003). The D&B data were reviewed to remove duplicates and facilities that appeared to be in a different industrial classification (e.g., car washes, auto glass shops, etc.). After removal of duplicates and misclassified businesses, 169 auto refinishing facilities were identified in Delaware. Each facility was assigned to a size category by revenue class. If revenue was listed as unknown, facilities were assigned based on employment (based on relationships between the number of employees and annual facility revenues described by Smith and Dunn (1999).

Emission Factors

VOC emission factors for six facility size categories are shown in Table 3.14 (Environ, 2001). These emission factors are based on data developed by Smith and Dunn (1999) of the Texas Commission on Environmental Quality (TCEQ). Facility sizes were adjusted from Smith and Dunn estimates to match D&B employee size categories and revenue classes. Also, two size categories were added to account for potentially larger shops. These assignments were based on the D&B revenue size classifications of $1.0MM to $2.4MM and $2.5MM to $4.9MM, respectively. Emission levels for these size classes were derived by extrapolation of the weekly emission rates given by Smith and Dunn (Environ, 2001).

Telephone surveys were performed for the two largest facility size classes to verify the information in the D&B data. For these larger facilities, the main point of the survey was to verify that auto refinishing actually occurs at the facility (i.e., to exclude headquarter facilities) and to verify the number of employees. In cases where the number of employees obtained through the survey did not match the D&B data, the revised number of employees was used to assign the facility to a size class.

The information initially developed by TCEQ only covered emissions from coatings. Based on discussions with TCEQ staff and information presented in the draft EIIP document, Pechan developed emission estimates for surface preparation and clean-up solvents (Environ, 2001). The VOC emission estimates were based on assumed emission rates for surface preparation solvents of 2% of the total coatings emission rates. For clean-up solvents, the emission rates are assumed to be equivalent to 8% of the total coatings emissions. These same assumptions were applied to emission estimates for Delaware.

Table 3-14. VOC Emission Factors for Auto Refinishing

	Facility Size Classes ($/yr)					
	Very Small	**Small**	**Medium**	**Large**	**Very Large**	**Mega**
Annual Revenue ($)	**<200k**	**200k-400k**	**400k-600k**	**600k-1000k**	**1.0MM-2.4MM**	**2.5MM-4.9MM**
No. of employees ($100k/employee)	**1**	**2-3**	**4-6**	**7-9**	**10-24**	**>24**
Types of Coatings (SCC Assignment)	**VOC (lb/yr)**					
Precoat Primer (2401005600)	60	130	175	305	648	1,411
Primer (2401005600)	115	255	310	755	1,604	3,492
Sealer (2401005600)	65	145	290	315	669	1,457
Base Coat (2401005700)	125	290	485	735	1,532	3,399
Clear Coat (2401005700)	145	300	425	815	1,732	3,769
Other Products (2401005700)	100	240	340	605	1,286	2,798
Total	**610**	**1,360**	**2,025**	**3,530**	**7,501**	**16,323**

Notes: (1) Extrapolation based on a ratio of the mid-points of D&B employment categories (e.g., for the next largest category shops, the ratio was 17/8).
(2) Facility sizes were adjusted from the Smith & Dunn estimates to match up with D&B employee size categories and sales revenue classes.
(3) The small number of facilities with reported revenues greater than the Mega size class was assigned to the Mega size class.

Temporal Allocation

A monthly temporal allocation profile was developed based on quarterly shipments of special purpose coatings from the Bureau of Census (BOC, 2002). The weekly allocation profile is based on a five day work week (i.e., during the work week).

Controls

Since 1996, *Delaware Regulation 24 Section 11* posed VOC content limits on auto refinishing coatings. In 1998, EPA promulgated a national standard for auto refinishing requiring that VOC content limits be achieved by January 11, 1999. The VOC content limits in the National Rule were similar to those in *Regulation 24*. Although Texas did not have VOC content limits in effect at the time that the Texas emission inventory work was performed, the effects of other state and local control programs (including Delaware's) had probably already served to reduce the VOC content of auto refinishing coatings due to the small number of manufacturers involved (five companies produce 95% of the auto refinishing coatings in the U.S.; EIIP, 2000).

In 2001, *Delaware Regulation 24 Section 11* was revised to include operating requirements for auto refinishing (mobile equipment refinishing and repair). These requirements include the need for high transfer efficiency spray equipment and methods to reduce emissions from spray gun cleaning. Based on analysis of the Ozone Transport Commission (OTC) model rule, high transfer spray equipment can achieve emission reductions of 35% (Pechan, 2001). Also, the use of spray gun cleaners and/or other techniques can reduce emissions by 33%. However, Texas had a rule in effect at the time that the emission factors were developed that required similar application and operating practices. Hence, additional emission reductions associated with *Regulation 24* were not applied. Therefore, CE, RE, and RP were set to zero.

Sample Calculations and Results

An example calculation of annual VOC emissions for coating operation x at the county level (E_x) follows:

$$E_x = \sum_{i=1}^{n} (N_i)(EF_{xi}) \, {}^{1}\!/_{2000}$$

where:

where:	n	=	number of facility size classes
	N_i	=	number of facilities for size class *i* in county
	EF_x	=	VOC emission factor for operation x (lb/facility)
	1/2000	=	conversion from lb to ton

Table 13-15. 2002 Statewide Annual and SSWD VOC Emissions for Auto Refinishing

SCC	Category Description	VOC	
		TPY	TPD
2401005500	Auto Refinishing: Preparation Solvents	3	0.01
2401005600	Auto Refinishing: Primers	46	0.21
2401005700	Auto Refinishing: Top Coats	81	0.36
2401005800	Auto Refinishing: Clean-up Solvents	11	0.05
2401005xxx	**Total: Auto Refinishing**	**141**	**0.63**

References

BOC, 2002. *Current Industrial Reports, Paint and Allied Products*, MA325F(02)-1. U.S. Department of Commerce, Bureau of Census, Washington, DC. 2002.

D&B, 2003. *MarketPlace CD-ROM*, Dun & Bradstreet, Waltham, MA, 2003.

EIIP, 2000. *Auto Refinishing, External Review Draft, Volume III*, Chapter 13, Emission Inventory Improvement Program, Area Sources Committee, January 2000.

Environ, 2001. Environ International, E.H. Pechan and Associates, Inc., Pollution Solutions, and Starcrest Consulting, *1990-2010 Emission Inventory Trends and Projections for All Counties in Texas,* prepared for Texas Natural Resource Conservation Commission, August 2001.

Pechan, 2001. *Control Measure Development Support Analysis of Ozone Transport Commission Model Rules,* prepared for the Ozone Transport Commission, prepared by E.H. Pechan & Associates, Inc., March 31, 2001.

Smith & Dunn, 1999. Smith, K. and K. Dunn. 1999. *VOC Emissions from Autobody Shops.* Draft report prepared for the Texas Natural Resources Conservation Commission, 1999.

3.2.5 Commercial and Consumer Products

Commercial and consumer products are defined as products used around the home, office, institution, or similar settings. The VOCs in these products may act either as the carriers for the active product ingredients or as the active ingredients themselves. The EIIP preferred method was used to calculate emissions, which uses national-based per capita emission factors for this category. Emissions for commercial and consumer products are reported under the following SCCs:

Table 3-16. SCCs for Commercial and Consumer Products

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2460100000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Personal Care Products	Total: All Solvent Types
2460200000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Household Products	Total: All Solvent Types
2460400000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Automotive Aftermarket Products	Total: All Solvent Types
2460500000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Coatings and Related Products	Total: All Solvent Types
2460600000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Adhesives and Sealants	Total: All Solvent Types
2460800000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All FIFRA-Related Products	Total: All Solvent Types
2460900000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	Misc. Products (Not Otherwise Covered)	Total: All Solvent Types

Activity Data

The activity data used for this category is population. County level population for 2002 was obtained from the Delaware Population Consortium (DPC, 2003).

Emission Factors

Emissions were calculated using per capita VOC emission factors derived from CARB's 1997 Consumer Products Survey (Delao, 2003). The emission factors are provided in Table 3-17 and believed to be more representative of Delaware emissions than those available in the EIIP document for consumer and commercial products (EIIP, 1996). This is because the EIIP emission factors are based on national usage and population data for 1990. National and state VOC programs were implemented in the mid-1990's that have changed the formulation of many consumer products. Even though a consumer products regulation did not exist in Delaware as of 2002, manufacturers of most consumer products supply a national market and have reformulated their products to be compliant with the national and state rules. Therefore, CARB's survey data (CARB, 2003) is believed to be more representative of 2002 Delaware emissions.

Temporal Allocation

Emissions from this source category are not expected to vary substantially from season to season or from day-to-day. Uniform monthly temporal allocation was assumed. Daily allocation was seven days per week. The only exception to this was for pesticide application, which was based on a five day week (most commercial and municipal application is believed to occur only five or six days per week and should represent the bulk of pesticide application.)

Table 3-17. VOC Emission Factors for Commercial and Consumer Products[a]

Product Category	Emission Factor (lb VOC/person/yr)
Personal Care Products	1.05
Household Products	1.29
Automotive Aftermarket Products	0.78
Adhesives and Sealants	0.28
FIFRA-Regulated Products	0.76
Coatings and Related Products	1.38
Miscellaneous Products	0.73
Total for All Commercial and Consumer Products	**6.27**

[a] Source: Delao, 2003

Controls

In 1998, EPA promulgated a National Rule for consumer products requiring that VOC content limits be achieved by December 1999 *(63 FR 48819)*. EPA estimated a 20 percent reduction in VOC emissions from the national regulation. The National Rule did not cover all consumer and commercial products, and DNREC estimated RP to be 48.6% (DNREC, 2001). Since the emission factors selected are based on data from CARB's 1997 survey, DNREC does not believe any additional emission reductions should be attributed to the implementation of the National Rule in Delaware. This is because California already had a consumer products rule in place which likely achieved much of the emission reduction for the National Rule. Therefore, for the purposes of this inventory, CE, RE, and RP were set to zero.

Sample Calculations and Results

An example calculation of annual VOC emissions for product type x and county y (E_{xy}) follows:

$$E_{xy} = Pop_y \times EF_x \times \frac{1}{2000}$$

where:

Pop_y	=	population of county y
EF_x	=	emission factor for product type x (lb/capita-yr)
1/2000	=	conversion from lb to ton

Table 3-18. 2002 Statewide Annual and SSWD VOC Emissions for Commercial and Consumer Products

SCC	Product Group	VOC	
		TPY	TPD
2460100000	Personal Care Products	424	1.17
2460200000	Household Products	521	1.43
2460400000	Automotive Aftermarket Products	315	0.87
2460500000	Coatings and Related Products	557	1.53
2460600000	Adhesives and Sealants	113	0.31
2460800000	FIFRA-Regulated Products	307	1.18
2460900000	Miscellaneous Products	295	0.81
2460xxxxxx	**Total: Commercial and Consumer Products**	**2531**	**7.30**

References

CARB, 2003. *California Air Resources Board, 1997 Consumer Products Survey*, downloaded from http://www.arb.ca.gov/emisinv/speciate/speciate.htm.

Delao, 2003. A. Delao, California Air Resources Board, personal communication with H. Lindquist, E.H. Pechan & Associates, Inc., October 2003.

DNREC, 2001. *1999 Periodic Emissions Inventory*, Delaware Department of Natural Resources and Environmental Control, 1999.

DPC, 2003. *2003 Draft Annual Population Estimates by County, Age, Gender, and Race 2000-2030*. downloaded from http://www.cadsr.udel.edu/demography/consortium.htm.

EIIP, 1996. *Consumer and Commercial Solvent Use, Volume III*, Chapter 5, Emission Inventory Improvement Program, Area Sources Committee, August 1996.

3.2.6 Dry Cleaning

The dry cleaning industry is a service industry for the cleaning of garments, draperies, leather goods, and other fabric items. Dry cleaning operations do not use water that can swell textile fibers but typically use either synthetic halogenated or petroleum distillate organic solvents for cleaning purposes. Use of solvents rather than water prevents wrinkles and shrinkage of fabrics. The dry cleaning industry is the most significant emission source of perchloroethylene in the United States (EIIP, 1996). While perchloroethylene emissions were estimated for 2002, it is considered to be negligibly reactive in forming ozone. Therefore, only petroleum solvent dry cleaners are accounted for in the ozone precursor inventory. The applicable SCC for petroleum solvent dry cleaning is shown in Table 3-19.

Table 3-19. SCC for Petroleum Solvent Dry Cleaning

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2420010370	Solvent Utilization	Dry Cleaning	Commercial/Industrial Processes	Special Naphthas

Point source emissions are reported under the 401001xx SCCs. No point source emissions are included in 2002 inventory; hence no point source corrections were necessary.

Activity Data

All perchloroethylene dry cleaners in Delaware are inspected annually by AQMS staff. At the time of the inspection, the inspector obtains data on the most recent 12 months of solvent purchases. The database contained 79 facilities for 2002.

In order to gather information on petroleum solvent dry cleaning operations, a survey was performed of facilities that did not appear in the dry cleaner database but were identified in the Dun & Bradstreet Marketplace (D&B, 2003) listing as either a commercial operation (SIC 7216) or industrial launderer (SIC 7218). DNREC determined that there is a low probability that coin-operated facilities (SIC 7215) would have dry cleaning operations, and thus did not include these businesses in the survey.

Of the 26 surveys sent by DNREC, seven were returned as undeliverable, seven were identified as drop shops with no chemicals onsite, one facility reported using petroleum solvents, and eleven did not respond. Due to time limitations, a second mailing was not sent to facilities that did not respond to the first mailing. The facility reporting petroleum solvent use provided solvent purchases and waste data.

Emission Factors

Emissions for the one petroleum solvent facility were estimated directly from the survey data. CARB mineral spirits speciation was used to identify non-reactive compounds within the solvent. Spent filters were the only waste shipped offsite from this facility. An emission rate of 100% was assumed, since no data were available on the solvent content of the spent filters.

Temporal Allocation

Uniform monthly distribution was assumed for dry cleaning. Weekly operations were assumed to be five days per week.

Controls

Petroleum solvent dry cleaners using in excess of 32,500 gallons of solvent per year are subject to *Delaware Air Regulation 24*. The methods used to estimate emissions were based on mass balance. Therefore, the control parameters for all commercial dry cleaners (i.e., CE, RE, and RP) were all set to zero.

Results

Table 3-20. 2002 Statewide Annual and SSWD VOC Emissions for Dry Cleaners

SCC	Category Description	VOC	
		TPY	TPD
2420010370	Commercial/Industrial Processes - Special Naphthas	4	0.01

References

D&B, 2003. *MarketPlace CD-ROM,* Dun & Bradstreet, Waltham, MA, 2003.

EIIP, 1996. *Dry Cleaning,* Final Report, Volume III: Chapter 4, prepared by the Emissions Inventory Improvement Program, May 1996.

3.2.7 Graphic Arts

Printing operations are a source of VOC emissions due to the volatile organic content of inks and thinners used in the industry. It is estimated that, on average, half of the graphic arts establishments are in-house printing services in non-printing industries. The remaining establishments are located at businesses whose main function is printing or graphic arts. Large printing operations with VOC emissions of 10 TPY or more are included in the point source inventory. Emissions for graphic arts are reported under the following SCCs:

Table 3-21. SCCs for Graphic Arts

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2425010000	Solvent Utilization	Graphic Arts	Lithography	Total: All Solvent Types
2425020000	Solvent Utilization	Graphic Arts	Letterpress	Total: All Solvent Types
2425030000	Solvent Utilization	Graphic Arts	Rotogravure	Total: All Solvent Types
2425040000	Solvent Utilization	Graphic Arts	Flexography	Total: All Solvent Types

Point source emissions were reported under the 405xxxxx SCCs. Therefore, point source corrections were needed for this sector (see below).

Activity Data

The preferred EIIP methodology for estimating emissions from graphic arts operations is to conduct a survey of printing facilities. This preferred method was beyond the scope of this project. The EIIP recommends two alternative methods. The first alternative method uses ink production data from the BOC (Census of Manufactures) as the primary activity variable. The second alternative method uses per capita emission factors (EIIP, 1996). The first alternative method was used to estimate emissions for all types of printing covered in this category.

National ink production data from the Census of Manufactures were allocated to the state based on 2001 County Business Patterns employment data for NAICS 323. The 2002 ink production data were not available for this study; therefore, DNREC used 1997 ink production data and grew these data to 2002 using a growth factor from EPA's forecasting model. The state level activity was allocated to the county level using ink sales to graphic arts facilities in each county obtained from Printing Industries of America, Inc. (PIA) (Kodey, 2003).

The EIIP recommends allocating the printing ink usage to each of the four printing processes based on market share data presented in the EIIP (EIIP, 1996). Pechan also reviewed data on ink sales to graphic arts facilities in each county obtained from PIA to check the validity of the market share data. PIA did not share the source of the data used to develop its estimates. The state level ink sales estimate provided by PIA agreed well with the estimate obtained by allocating national ink sales data to the state using employment data. DNREC used these data only to quality assure the market share methods used to allocate ink sales based on the EIIP. Finally, DNREC also reviewed 4-digit SIC employment data from the DE DOL to check the allocation of ink production to the county-level.

Point source corrections were then made using county-level uncontrolled point source emissions for each printing type. The point source correction resulted in a few negative area source estimates. These estimates were set to zero.

Emission Factors

VOC emissions were estimated based on the amount of ink used for each of the major printing processes identified above. In addition to the VOC emissions from ink, emissions from the use of fountain solutions and clean-up solvents are also tied to ink usage (i.e., lb VOC/lb ink used).

VOC emission factors for ink, fountain solutions, and clean-up solvents from letterpress, rotogravure, and flexographic printers were taken from the EIIP (EIIP, 1996; Table 7.5-2). VOC emission factors for lithographic printers were taken from a study that was done for Texas by Eastern Research Group (ERG) for 1999 emissions from this sector (ERG, 2001).

Temporal Allocation

Monthly allocation was uniform throughout the year and daily allocation was five days per week.

Controls

Graphic arts are regulated by *Delaware Air Regulation 24* (DNREC, 1993), Section 47, which applies to any offset lithographic printing facility including heatset web, non-heatset web (non-newspaper), non-heatset sheet-fed, and newspaper (non-heatset web) facilities. The rule covers operations with uncontrolled emissions greater than 15.0 lb/day. Therefore, control parameters were only applied to the lithographic printing SCC. Regulation 24, Section 47 control standards stipulate VOC content limits for the fountain and cleaning solutions. The limits for fountain solutions range from zero to 8.5% (by volume) depending on the type of printing process. The cleaning solution may not contain more than 30% VOC content. DNREC assumed that as a result of the regulation, all facilities, whether they meet the applicability threshold or not, are now using compliant fountain and cleaning solutions per the regulation.

In addition, any facility using a heatset printing press and meeting the applicability threshold must control 90% (by weight) of the uncontrolled VOC emissions from the press dryer exhaust vent. However, no facilities were identified in Delaware that have placed controls as a result of this requirement.

Since VOC content limits have been incorporated into the emission calculations, no further consideration of controls is applicable.

Sample Calculations and Results

An example calculation of annual county level VOC emissions (E) in ton/yr for lithographic printing follows:

$$E = (I \times EF_i) + (F \times EF_f) + (C \times EF_c)$$

where:	I	=	ink consumption (gal/yr)
	F	=	fountain solution consumption (gal/yr)
	C	=	cleaning solvent consumption (gal/yr)
	EF_i	=	VOC emission factor for ink (lb/gal ink)
	EF_f	=	VOC emission factor for fountain solution (lb/gal solution)
	EF_c	=	VOC emission factor for cleaning solvent (lb/gal solvent)
	1/2000	=	conversion factor, lb to ton

An example calculation of annual county level VOC emissions (E) in ton/yr for the three other printing types follows:

$$E = (I_x) \times (EF_i + EF_f + EF_c)_x * \frac{1}{2000}$$

where:	I_x	=	ink sales for printing segment x (lb/yr)
	EF_i	=	VOC emission factor for ink (lb/lb ink)
	EF_f	=	VOC emission factor for fountain solution (lb/lb ink)
	EF_c	=	VOC emission factor for cleaning solvent (lb/lb ink)
	1/2000	=	conversion factor, lb to ton

Table 3-22. 2002 Statewide Annual and SSWD VOC Emissions for Graphic Arts

SCC	Category Description	VOC	
		TPY	TPD
2425010000	Lithography	374	1.44
2425020000	Letterpress	69	0.26
2425030000	Rotogravure	446	1.71
2425040000	Flexography	33	0.13
24250xxxxx	**Total: Graphic Arts**	**921**	**3.54**

References

DNREC, 1993. *Regulations Governing the Control of Air Pollution,* 40-09-81/02/01, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Updated to January 1993.

EIIP, 1996. *Graphic Arts, Volume III*, Chapter 7, Emission Inventory Improvement Program, Area Sources Committee, November 1996.

EPA, 1994. *Alternative Control Techniques Document: Offset Lithographic Printing*, EPA 453/R-94-054, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, June 1994.

ERG, 2001. *1999 Emissions Inventory for Texas Graphic Arts Area Sources*, prepared for the Texas Natural Resource Conservation Commission, prepared by Eastern Research Group, October 2001.

Kodey, 2003. Steve Kodey, Printing Industries of America. Personal communication with Holly Lindquist, E.H. Pechan & Associates, Inc. November, 2003.

3.2.8 Industrial Adhesives

Industrial adhesives are a source of VOC emissions due to the volatile the solvents used in the adhesives. Industrial adhesive products come in a wide range of applications, including glues, cements, silicates, resins and sealants. Emissions for industrial adhesives are reported under the following SCCs:

Table 3-23. SCC for Industrial Adhesives

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2440020000	Solvent Utilization	Miscellaneous Industrial	Adhesive (Industrial) Application	Total: All Solvent Types

Point source emissions were reported under the following SCCs: 4020700, 40200701, 40200706, 40200707, 40200710, 40200711, and 4020012. Therefore, point source corrections were needed for this sector. Usages of adhesives in non-industrial applications are covered under the commercial and consumer products source category.

There is no EIIP methodology for estimating emissions from industrial adhesive operations. However, in 2005, EPA developed a methodology based on a solvent mass balance approach (EPA, 2005). Since DNREC had not previously estimated emissions for this source category, DNREC relied on EPA's estimation for the 2002 inventory. The following is a summary of that method as it applied to Delaware.

Activity Data

The material balance approach begins with solvent sales reports developed by the Freedonia Group (Freedonia, 2003a and 2003b). A national solvent sales number of 0.20 million tons for industrial adhesives for 2002 was used for this category. Solvents from the industrial adhesive category were allocated to NAICS codes using financial data from the Commerce Department's Bureau of Economic Analysis "Benchmark Input/Output Accounts" tables for each industry (BEA, 1992). At the time the study was conducted, 1992 data were the latest available. The following NAICS codes were used to develop this category: 3212, 32221, 32222, 322291, 32311, 326, 336211, 4441, and 8111.

The solvent for each NAICS code was allocated down to the county level based on employment data. Industrial adhesive solvents used by point sources were backed out for each county.

Emission Factors

For a solvent mass balance approach, all solvent is expected to evaporate in the use of the adhesive. Therefore, emissions for this category are equal to the amount of solvent allocated to each county minus the point source component.

Temporal Allocation

Industrial adhesive usage was considered uniform throughout the year. Daily allocation was five days per week.

Controls

There were no controls for this source category.

Results

Table 3-24. 2002 Statewide Annual and SSWD VOC Emissions for Industrial Adhesives

SCC	Category Description	VOC	
		TPY	TPD
2440020000	Industrial Adhesives	473	1.82

References

EPA, 2005. *"Solvent Mass Balance Approach for Estimating VOC Emissions From Eleven Nonpoint Solvent Source Categories"*, Donna Lee Jones, Steve Fudge, and Bill Battye EC/R, Inc., Chapel Hill, North Caroline

Freedonia, 2003a. The Freedonia Group, *"Solvents to 2003: Study 1115."* Cleveland, Ohio. 2003.

Freedonia, 2003b. The Freedonia Group, *"Solvents: Green & Conventional to 2007: Study 1663."* Chapter 2: Solvent Demand (million pounds) 1997 – 2012; Chapter 5: Paints and Coatings Market for Solvents (million pounds) 1992-2012. Cleveland, Ohio. April 2003.

BEA, 1992. U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C. 1992. http://www.bea.gov/bea/

3.2.9 Industrial Surface Coatings

Surface coating operations involve applying a thin layer of coating (e.g., paint, lacquer, enamel, varnish, etc.) to an object for decorative or protective purposes. The surface coating products include either a water-based or solvent-based liquid carrier that generally evaporates in the drying or curing process. For area source purposes, the industrial surface coating sector includes OEM coating applications (EIIP, 1997). Emissions for industrial surface coatings are reported under the SCCs in Table 3-25.

Activity Data

Emission estimates were based on employment data (see discussion under emission factors below). Employment data by facility for 2002 for the applicable NAICS codes were obtained from the Delaware DOL.

For the industrial surface coatings category, there is an important point source component. Two methods were employed to account for point source emissions from industrial surface coating usage. The first method involved backing out the number of employees at facilities within the point source inventory. Six-digit point source SCCs for related industrial surface coating operations are provided in Table 3-26.

The second method accounted for known facilities not in the 2002 point source inventory. Some smaller facilities did not meet the criteria for inclusion in the 2002 universe of facilities to be inventoried. DNREC had previous years' emissions data for nine facilities within the applicable NAICS codes for this category. For these facilities, the previous years' emissions were grown to 2002 and included in the total area source emissions for industrial surface coatings in lieu of including their employees in the area source calculation. There were four additional facilities with emission estimates based on data supplied by the AQMS Permitting Branch. Emissions from these four facilities were also included in the category and the number of employees from these facilities was removed from the county employment totals for the applicable NAICS code. This modified point source backout method avoided significant over-estimating emissions for most of the facilities considered.

Table 3-25. SCCs for Industrial Surface Coatings

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2401015000	Solvent Utilization	Surface Coating	Factory Finished Wood: SIC 242	Total: All Solvent Types
2401020000	Solvent Utilization	Surface Coating	Wood Furniture: SIC 25	Total: All Solvent Types
2401025000	Solvent Utilization	Surface Coating	Metal Furniture: SIC 25	Total: All Solvent Types
2401030000	Solvent Utilization	Surface Coating	Paper: SIC 26	Total: All Solvent Types
2401040000	Solvent Utilization	Surface Coating	Metal Cans: SIC 341	Total: All Solvent Types
2401045000	Solvent Utilization	Surface Coating	Metal Coils: SIC 3498	Total: All Solvent Types
2401055000	Solvent Utilization	Surface Coating	Machinery and Equipment: SIC 35	Total: All Solvent Types
2401060000	Solvent Utilization	Surface Coating	Large Appliances: SIC 363	Total: All Solvent Types
2401065000	Solvent Utilization	Surface Coating	Electronic and Other Electrical: SIC 36	Total: All Solvent Types
2401070000	Solvent Utilization	Surface Coating	Motor Vehicles: SIC 371	Total: All Solvent Types
2401075000	Solvent Utilization	Surface Coating	Aircraft: SIC 372	Total: All Solvent Types
2401080000	Solvent Utilization	Surface Coating	Marine: SIC 373	Total: All Solvent Types
2401085000	Solvent Utilization	Surface Coating	Railroad: SIC 374	Total: All Solvent Types
2401090000	Solvent Utilization	Surface Coating	Miscellaneous Manufacturing	Total: All Solvent Types

Emission Factors

National employment-based VOC emission factors developed by Pechan (under subcontract to Environ) for a 1999 Texas inventory was used to calculate emissions for this inventory (Environ, 2001). Much of this work was based on previous work performed by TCEQ. These SCC-specific emission factors, shown in Table 3-27, are based on VOC content data from the National Paint and Coatings Association (NPCA), national shipments of coatings from the U.S. Department of Commerce (DOC), and BOC employment data. The VOC content data from the NPCA are based on 1991 formulation data.

In the underlying emission factor work conducted by TCEQ, Pechan noted the need for additional research to verify that BOC coatings shipments under a small number of small categories(e.g., 3255107YWV, “Special purpose coatings, not specified by kind”) were covered (BOC, 2002). For the purposes of the TCEQ inventory, Pechan concluded that most of these shipments had been incorporated under either the miscellaneous industrial surface coatings categories or the industrial maintenance category. For TCEQ, Pechan recommended excluding the SCC for Special Purpose Coatings (2401200000). For this inventory, DNREC revisited this issue and verified that all industrial surface coatings shipments had been accounted for.

Table 3-26. Point Source SCCs for Industrial Surface Coatings

SCC	Descriptor 1	Descriptor 3	Descriptor 6
402001xx – 402007xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Surface Coating Application – General
402008xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Coating Oven – General
402009xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Thinning Solvents – General
402011xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating/Printing
402012xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Dyeing
402013xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Paper Coating
402014xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Large Appliances
402015xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Magnet Wire Surface Coating
402016xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Automobiles and Light Trucks
402017xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Metal Can Coating
402018xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Metal Coil Coating
402019xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Wood Furniture Surface Coating
402020xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Metal Furniture Operations
402021xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Flatwood Products
402022xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Plastic Parts
402023xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Large Ships
402024xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Large Aircraft
402025xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Miscellaneous Metal Parts
402040xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Printing
402041xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Knife Coating
402042xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Roller Coating
402043xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Dip Coating
402044xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Transfer Coating
402045xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Extrusion Coating
402046xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Melt Roll Coating
402047xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Coating, Coagulation Coating
402060xx	Petroleum and Solvent Evaporation	Surface Coating Operations	Fabric Dyeing

Table 3-27. VOC Emission Factors for Industrial Surface Coatings

SCC	VOC EF (lb/employee/yr)[a]	Avg. VOC Content (lb/gal)[a]	Typical DE Reg. 24 Limit (lb/gal)
2401015000 (Factory finished wood)	30.33	0.68	n/a
2401020000 (Wood furniture)	1349	4.93	n/a
2401025000 (Metal furniture and fixtures)	577.2	2.00	3.0
2401030000 (Paper, foil, and film)	152.1	3.81	2.9 (paper)
2401040000 (Metal containers)	5017	3.40	2.8-5.5 (cans)
2401045000 (Sheet, strip, and coil)	3101	3.60	2.6 (coil)
2401055000 (Machinery and equipment)	55.83	3.76	n/a
2401060000 (Large appliances)	323.1	2.72	2.8
2401065000 (Electronic and other electrical)	49.88	4.70	n/a
2401070000 (Motor vehicles)	737.6	2.76	2.8 (topcoat)
2401075000 (Aircraft)	183.2	4.66	3.5 (topcoat)
2401080000 (Marine)	289.6	2.95	n/a
2401085000 (Railroad)	1190	3.33	n/a
2401090000 (Miscellaneous manufacturing)	18.39	3.94	3.5 (misc. metal parts)

[a] As estimated by TCEQ using 1991 data from NPCA (Environ, 2001).

Temporal Allocation

The temporal allocation profiles assigned assumes daily emissions occur five days per week and uniformly by month throughout the year.

Controls

Surface coating processes having emissions of 15 lb VOC/day or more since May 31, 1995, are regulated by the *Delaware Air Regulation 24 (1993;* Sections 10 and 12-23). About half of the industrial surface coatings categories above are covered under *Regulation 24*. Table 3-27 shows typical VOC content limits from *Regulation 24* along with the average VOC content used during the development of the emission factors used in estimating emissions. Based on these data, the values in Table 3-28 for CE were derived.

The majority of sources in the industrial coatings category should be fairly large VOC sources. Those that are covered by *Regulation 24* are likely emitting more than the 15 lb VOC/day exemption. However, due to this exemption, an RP of 90% was recommended for emission inventory purposes. Since facilities can choose between using VOC compliant coatings or another control option (e.g., add-on controls), an RE of 80% was assumed.

Table 3-28. Control Efficiencies Based on Delaware Regulation 24 Requirements

Source Category	CE (%)
2401030000 (Paper, foil, and film)	24
2401045000 (Sheet, strip, and coil)	28
2401075000 (Aircraft)	25
2401090000 (Miscellaneous manufacturing)	11

Sample Calculations and Results

An example calculation of annual VOC emissions for coating operation x in county y (E_{xy}) follows:

$$E_{xy} = \left(\left(Emp_{xy} - Emp_{ps} \right) * EF_x * \left(1 - \left\{ \frac{CE}{100} \right\} \left\{ \frac{RE}{100} \right\} \left\{ \frac{RP}{100} \right\} \right) \times \left(\frac{1}{2000} \right) \right) + P_{xy}$$

where:

Emp_{xy}	=	employment for NAICS associated with coating type x in county y
Emp_{ps}	=	point source employees associated with coating type x in county y
EF_x	=	emission factor for coating operation x (lb/employee)
CE	=	control efficiency (%)
RE	=	rule effectiveness (%)
RP	=	rule penetration (%)
1/2000	=	conversion from lb to ton
P_{xy}	=	Method 2 point source emissions for coating type x county y

Table 3-29. 2002 Statewide Annual and SSWD VOC Emissions for Industrial Surface Coatings

SCC	Category Description	VOC	
		TPY	**TPD**
2401015000	Factory Finished Wood	9	0.03
2401020000	Wood Furniture	76	0.29
2401025000	Metal Furniture	54	0.21
2401030000	Paper	26	0.10
2401040000	Metal Cans[(1)]	0	0
2401045000	Metal Coils	6	0.02
2401055000	Machinery and Equipment	22	0.09
2401060000	Large Appliances	< 1	< 0.01
2401065000	Electronic and Other Electrical	3	0.01
2401070000	Motor Vehicles[a]	0	0
2401075000	Aircraft	1	< 0.01
2401080000	Marine[b]	0	0
2401085000	Railroad	5	0.02
2401090000	Miscellaneous Manufacturing	172	0.66
24010xxxxx	**Total: Industrial Surface Coating**	**375**	**1.44**

[a] No facilities were identified in the Delaware DOL database.
[b] Zeroed out with DaimlerChrysler and General Motors assembly plants reporting under point sources.

References

BOC, 2002. *Current Industrial Reports, Paint and Allied Products*, MA325F(02)-1. U.S. Department of Commerce, Bureau of Census, Washington, DC. 2002.

EIIP, 1997. *Industrial Surface Coatings, Volume III,* Chapter 8, Emission Inventory Improvement Program, Area Sources Committee, EPA, 1997.

Environ, 2001. Environ International, E.H. Pechan and Associates, Inc., Pollution Solutions, and Starcrest Consulting. "1990-2010 Emission Inventory Trends and Projections for All

Counties in Texas." Prepared for Texas Natural Resource Conservation Commission, August 2001.

3.2.10 Solvent Cleaning

Solvent cleaning is the process of using organic solvents to remove grease, fats, oils, wax or soil from various metal, glass, or plastic items. Non-aqueous solvents such as petroleum distillates, chlorinated hydrocarbons, ketones, and alcohols have been used historically; however, the use of aqueous cleaning systems for some applications has recently gained acceptance.

The types of equipment used in this method are categorized as cold cleaners, open top vapor degreasers, or conveyorized degreasers. Paint stripping operations (e.g., with methylene chloride) are sometimes included in the solvent cleaning sector, but are not included here and are assumed to be covered in the point source inventory (no area source methods for paint stripping are available). Most conveyorized degreasing sources will have emissions of 10 TPY or more; therefore, all such facilities are assumed to be accounted for in the point source inventory. Emissions for solvent cleaning are reported under the SCCs in Table 3-30.

Table 3-30. SCCs for Solvent Cleaning

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2415100000	Solvent Utilization	Degreasing	All Manufacturing (except SIC 36): Vapor and In-Line Cleaning	Total: All Solvent Types
2415130000	Solvent Utilization	Degreasing	Electronic and Other Elec. (SIC 36): Vapor and In-Line Cleaning	Total: All Solvent Types
2415300000	Solvent Utilization	Degreasing	All Manufacturing: Cold Cleaning	Total: All Solvent Types
2415360000	Solvent Utilization	Degreasing	Transportation Equipment Repair Services: Cold Cleaning	Total: All Solvent Types

DNREC assigned point source facilities (based on SIC) to each solvent cleaning category. The number of employees at each point source facility was subtracted from the county-level employment for the appropriate SIC in order to estimate the non-point source component of the inventory.

Activity Data

Emissions from degreasing operations were estimated using the employee-based emission factors in the EIIP document (EIIP, 1997). Although this method has problems, it does not result in the assignment of solvent cleaning emissions to areas with no manufacturing (as would be done with a per capita based approach). The EIIP emission factors are based on SIC employment. Since there is not a one-to-one correspondence between SIC and NAICS, DNREC concluded that employment classified by SIC should be used with these emission factors. 2002 employment data from DE DOL and the BOC are classified by NAICS. Therefore, 1997 employment data available from County Business Patterns (BOC, 1997) were obtained and grown to 2002 using EGAS growth factors. 1997 is the last year that data was published by SIC.

Emission Factors

Employee-based VOC emission factors were taken from the EIIP document for degreasing operations (EIIP, 1997). For cold cleaning, the emissions are expected to be mainly from the use of petroleum distillate-based solvents (i.e., mineral spirits). For vapor and in-line cleaning equipment, there is greater variability in the solvent types used.

Temporal Allocation

Degreasing operations occur six days per week uniformly throughout the year as recommended in *Procedures, Volume I* (EPA, 1991).

Controls

Delaware Air Regulation 24, Section 33 applies to all solvent cleaning operations where the solvent capacity is greater than one liter. The most significant requirement is for cold cleaners to begin using low vapor pressure solvents no later than November 11, 2002. An overall control efficiency of 66% was estimated for the OTC model rule (Pechan, 2000). This included both cold cleaning and vapor/in-line cleaning processes.

The 66% CE was used for cold cleaning SCCs. This value may be somewhat low for cold cleaning SCCs based on a switch to low vapor pressure solvents; however no better information was located. The 66% CE may be too high for the vapor degreasing SCCs since most sources were probably already controlled to the level of EPA's 1977 Control Techniques Guideline (CTG). However, EPA estimated a 63% emission reduction for the Halogenated Solvents NESHAP (Pechan, 2000). Trichloroethylene is a halogenated solvent commonly used for degreasing. The 63% CE was applied to the vapor degreasing SCCs.

The RE selected for cold cleaning is 20% and the RE for vapor degreasing is 80%. Relative to cold solvent cleaning, a contact with Safety Kleen stated that most of their clients had not yet made the switch to aqueous solvents. A 100% rule penetration factor was assumed for all SCCs.

Sample Calculations and Results

An example calculation of annual VOC emissions for operation x in county y (E_{xy}) follows:

$$E_{xy} = Emp_x * EF_y * \left(1 - \left\{\frac{CE}{100}\right\}\left\{\frac{RE}{100}\right\}\left\{\frac{RP}{100}\right\}\right) \times \left(\frac{1}{2000}\right)$$

where:

where:	Emp_x	=	employment for county x
	EF_y	=	emission factor for operation y (lb/employee)
	CE	=	control efficiency (%)
	RE	=	rule effectiveness (%)
	RP	=	rule penetration (%)
	1/2000	=	conversion from lb to ton

Table 3-31. 2002 Statewide Annual and SSWD VOC Emissions for Solvent Cleaning

SCC	Category Description	VOC	
		TPY	TPD
2415100000	All Manufacturing (except SIC 36): Vapor and In-Line Cleaning	40	0.13
2415130000	Electronic and Other Elec. (SIC 36): Vapor and In-Line Cleaning	4	0.01
2415300000	All Manufacturing: Cold Cleaning	84	0.27
2415360000	Transportation Equipment Repair Services: Cold Cleaning	1046	4.02
2415xxxxxx	**Total: Solvent Cleaning**	**1174**	**4.43**

References

BOC, 1997. U.S. Bureau of Census, *County Business Patterns*, available from http://www.census.gov/epcd/dbp/view/cbpview.html, Washington, DC, 1997.

EIIP, 1997. *Solvent Cleaning, Volume III*, Chapter 6, Emission Inventory Improvement Program, Area Sources Committee, September 1997.

EPA, 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I: General Guidance for Stationary Sources*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, May 1991.

Pechan, 2000. *Control Measure Development Support - Analysis of Draft Model Rules*, Draft Report, prepared for the Ozone Transport Commission, November 30, 2000.

3.2.11 Traffic Markings

Traffic marking operations consist of marking highway center lines, edge stripes, and directional markings and painting on other paved surfaces, such as markings in parking lots. Materials used for traffic markings include solvent-based paints, water-based paints, thermoplastics, preformed tapes, field-reacted materials, and permanent markers. Solvent-based formulations of alkyd resins or chlorinated rubber resins are the most commonly-used traffic paints. Aerosol marking paints and preformed tapes applied with adhesive primer are inventoried under the commercial and consumer products category. Emissions for this category are strictly non-aerosol water- and solvent-based traffic paints. Emissions for traffic markings are reported under the following SCC:

Table 3-32. SCC for Traffic Markings

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2401008000	Solvent Utilization	Surface Coating	Traffic Markings	Total: All Solvent Types

Activity Data

The third alternate method provided in the EIIP document for traffic markings was used (EIIP, 1997). Emissions were estimated using per gallon emission factors multiplied by traffic paint usage values. DelDOT provided usage data for traffic paints applied by that agency at the county-level.

To estimate usage by local agencies and private companies, the total statewide usage of traffic markings was estimated. To do this, usage values were calculated by apportioning national usage to the county-level in two steps: allocation to the state level was accomplished by proportioning the national amount of traffic paint by the dollars spent on roads and highways in Delaware. This information is available in FHWA reports. This approach of using dollars spent will reflect differences between states in the number of lane miles, the types of roads in each state, and the level of maintenance. The FHWA report does not provide dollars spent on roads and highways in individual counties, so apportioning from the state to the county level required another surrogate. Paved lane miles for minor collectors and local roads were used to calculate county-level traffic paint usage by local agencies and private companies. Paved lane miles are available from DelDOT.

National usage data came from the U.S. Census Bureau, *Report MA28F-Paint and Allied Products* (BOC, 2002). The DelDOT usage above was subtracted from the total usage to estimate non-DelDOT usage.

Emission Factors

DelDOT provided an emission factor of 0.516 lb VOC/gallon of paint. Emission factors for non-DelDOT water-based and solvent-based paints were obtained from a 1998 survey conducted by CARB (CARB, 1999). This survey also provided the estimate that 69% of traffic paints are water-based and 31% are solvent-based. Based on these emission factors and the estimated amount of each type of paint used in each county, an average emission factor was calculated for each county.

Temporal Allocation

DelDOT provided the amount of paint used in each month. Use of paint by local agencies and private companies was assumed to have the same monthly profile as state usage. Weekly allocation is five days per week (EPA, 1991).

Controls

In 1998, EPA promulgated a national standard for architectural coatings, including traffic markings, requiring that VOC content limits be achieved by September 1999. The emission factor used for water-based paints is lower than the federal limit. However, solvent-based paints compliant with the national standard would have 41.4% lower VOC content than those represented by the emission factor. Therefore, a CE of 41.4% was assumed. A separate VOC limit was set for zone markings (markings in parking lots, driveways, sidewalks, and airport runways). Because the average VOC content prior to regulation was less than the limit for zone markings, DNREC assumed no emission reduction for zone markings.

Approximately 10% of traffic paint is applied to private roads and parking lots. Using the fraction of paints that are solvent-based for each county and the estimate that 90% of traffic paint falls under the limit for traffic markings, an RP value was calculated for each county. An RE estimate of 100 percent was applied.

Sample Calculations and Results

An example calculation of annual VOC emissions for traffic marking paints in county y ($E_{s,y}$) follows. First, the state paint usage was calculated:

$$u_{DE} = u_{US}\left(\frac{D_{DE}}{D_{US}}\right)$$

where: u_{DE} = state usage of traffic marking paint
$u_{,US}$ = total US consumption of traffic paints (gallons)
D_{US} = total US expenditures on roads and highways ($)
D_{DE} = total Delaware expenditures on roads and highways ($)

Paint usage was allocated to the county level by first subtracting the amount of paint used by DelDOT from the state estimate (u_{DE}) calculated above.

$$u_l = u_{DE} - u_{DOT}$$

where: u_l = the amount of paint applied by local agencies or private companies
u_{DOT} = the amount of paint applied by DelDOT

The resulting non-DelDOT portion of the total state paint usage was allocated using the number of lane miles for minor collectors and local roads:

$$u_{l.c} = u_l\left(\frac{M_c}{M_{DE}}\right)$$

where: u_{lc} = county level usage of non-DelDOT paint
M_c = minor collector and local road lane miles in county
M_{DE} = minor collector and local road lane miles in state

The total county paint usage was calculated by adding the county consumption by DelDOT back to the non-DelDOT portion:

$$u_c = u_{l,c} + u_{DOT,c}$$

The county average emission factor (EF_c) was calculated using the formula:

$$EF_c = f_{DOT} \times EF_{DOT} + f_w \times EF_w + f_s \times EF_s$$

where:
- f_{DOT} = fraction of county traffic paints used by DelDOT
- EF_{DOT} = emission factor for water-based paints used by DelDOT
- f_w = fraction of county traffic water-based paints, local or private
- EF_w = emission factor for water-based paints from CARB survey
- f_s = fraction of county traffic solvent-based paints, local or private
- EF_w = emission factor for solvent-based paints from CARB survey

The emission factor was then applied to the county consumption:

$$E_c = u_c * EF_c * \left(1 - \left\{\frac{CE}{100}\right\}\left\{\frac{RE}{100}\right\}\left\{\frac{RP}{100}\right\}\right) \times \left(\frac{1}{2000}\right)$$

where:
- E_c = county level emissions (tons)
- CE = control efficiency (%)
- RE = rule effectiveness (%)
- RP = rule penetration (%)
- 1/2000 = conversion from lb to ton.

Table 3-33. 2002 Statewide Annual and SSWD VOC Emissions for Traffic Markings

SCC	Category Description	VOC	
		TPY	TPD
2401008000	Surface Coating - Traffic Markings	99	0.75

References

BOC, 2002. *Current Industrial Reports, Paint and Allied Products*, MA325F(02)-1, U.S. Department of Commerce, Bureau of Census, Washington, DC, 2002.

CARB, 1999. *1998 Architectural Coatings Survey Results*, Final Report, California Air Resources Board, September, 1999.

EIIP, 1997. *Traffic Markings, Volume III*, Chapter 13, Emission Inventory Improvement Program, Area Sources Committee, May 1997.

EPA. 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone*, *Vol. I.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/4-91-016. Research Triangle Park, North Carolina, 1991.

3.3 Gasoline Marketing

VOC emissions from retail gasoline stations and other commercial accounts (airports, marinas) result from fuel storage container losses (e.g., tank breathing and working losses) or during fuel transfer (tank vapor displacement and fuel spillage). Stage 1 and Stage 2 emissions (occurring during the transfer of fuel from tank trucks to storage tanks, and subsequent transfer to the vehicle gasoline tank, respectively) are included, as well as emissions from delivery trucks in transit, and gasoline station storage tank breathing. Emissions from portable fuel containers (PFCs) are included in Delaware's inventory for the first time. Finally, commercial marine vessel (CMV) evaporative emissions associated with loading and transport of petroleum products (mostly crude oil and gasoline) are also included in this sector (details on the development of those emission estimates can be found in the CMV category description within the non-road mobile sources section).

Emissions for gasoline marketing are reported under the following SCCs:

Table 3-34. SCCs for Gasoline Marketing

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
Retail Gasoline				
2501060051	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 1: Submerged Filling
2501060053	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 1: Balanced Submerged Filling
2501060100	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 2: Total
2501060201	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Underground Tank: Breathing and Emptying
2501060204	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 2: PFC Filling Displacement Loss/Controlled
2501060205	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 2: PFC Filling Spillage
2505030120	Storage and Transport	Petroleum and Petroleum Product Transport	Trucks in Transit	Gasoline
Other Commercial Accounts				
2501080050	Storage and Transport	Petroleum and Petroleum Product Storage	Airports: Aviation Gasoline	Stage 1: Total
2501080102	Storage and Transport	Petroleum and Petroleum Product Storage	Airports: Aviation Gasoline	Stage 2: Displacement Loss
2501080201	Storage and Transport	Petroleum and Petroleum Product Storage	Airports: Aviation Gasoline	Underground Tank: Breathing and Emptying
2501010050	Storage and Transport	Petroleum and Petroleum Product Storage	Marinas: Gasoline	Stage 1: Total
2501010102	Storage and Transport	Petroleum and Petroleum Product Storage	Marinas: Gasoline	Stage 2: Displacement Loss
2501010103	Storage and Transport	Petroleum and Petroleum Product Storage	Marinas: Gasoline	Stage 2: Spillage
2501010201	Storage and Transport	Petroleum and Petroleum Product Storage	Marinas: Gasoline	Underground Tank: Emptying and Breathing
Portable Fuel Containers				
2501011011	Storage and Transport	Petroleum and Petroleum Product Storage	Portable Containers: Residential	Permeation
2501011012	Storage and Transport	Petroleum and Petroleum Product Storage	Portable Containers: Residential	Diurnal
2501011016	Storage and Transport	Petroleum and Petroleum Product Storage	Portable Containers: Residential	Transport
2501012011	Storage and Transport	Petroleum and Petroleum Product Storage	Portable Containers: Commercial	Permeation

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2501012012	Storage and Transport	Petroleum and Petroleum Product Storage	Portable Containers: Commercial	Diurnal
2501012016	Storage and Transport	Petroleum and Petroleum Product Storage	Portable Containers: Commercial	Transport
Commercial Marine Vessel Loading and Transit				
2505020030	Storage and Transport	Petroleum and Petroleum Product Transport	Marine Vessel	Crude Oil
2505020060	Storage and Transport	Petroleum and Petroleum Product Transport	Marine Vessel	Residual Oil
2505020090	Storage and Transport	Petroleum and Petroleum Product Transport	Marine Vessel	Distillate Oil
2505020120	Storage and Transport	Petroleum and Petroleum Product Transport	Marine Vessel	Gasoline
2505020150	Storage and Transport	Petroleum and Petroleum Product Transport	Marine Vessel	Jet Naphtha

Gasoline marketing emissions were reported by the Dover Air Force Base (DAFB) and Dassault Falcon Jet (DNREC, 2002). Point source corrections were performed based on the fuel usage reported by these facilities. Also, emissions from bulk terminals were included in the point source inventory, so no emissions for these sources were included in the area source inventory.

New SCCs that do not currently exist in the EPA master list of SCCs for Stage 2 filling of PFCs at service stations are included in this inventory. Other commercial accounts include refueling at airports and marinas, and new SCCs were also developed to report these emissions. Finally, new SCCs were developed for losses from PFCs. EPA had not added any of these new SCCs to its master list by the time this report was finalized.

Activity Data

Retail Gasoline Service Stations

Emissions from retail gasoline stations are based on the amount of gasoline throughput. The total amount of gasoline purchased in the State of Delaware was obtained from the Federal Highway Administration publication, *Highway Statistics 2002* (FHWA, 2003). Monthly sales of gasoline are also available from this publication. FHWA provides estimates of gasoline sales for highway vehicles and non-highway vehicles. For non-highway vehicles, estimates are provided in the following categories: agricultural, marine, aviation, industrial and commercial, construction, governmental, and miscellaneous.

To allocate state-level activity to the facility-level, AQMS obtained facility-level information from DNREC's Tanks Branch. These data included facility coordinates and tank volumes. The Tanks Branch also supplied estimates of the facility-level monthly throughput, so that the state-level throughput from the FHWA could be allocated to the facility level. State-level activity for highway vehicles and the construction, industrial and commercial, agricultural, governmental, and miscellaneous non-highway gasoline categories were allocated to retail gasoline service stations. Activity at airports and marinas were allocated as described under "other commercial accounts" below.

Other Commercial Accounts

Fuel usage for airports and marinas were taken from the aviation and marine state-level sales estimates from FHWA. In addition to the FHWA and EIA data, DNREC requested information on fuel throughput at Delaware airports during the survey work conducted under the non-road mobile sector inventory development. However, no throughput data were obtained from these efforts. The state-level totals were allocated to the airports based on commercial landing/takeoffs (LTOs) for non-jet engines.

For marinas, state-level marine gasoline sales were allocated to the marinas identified in the database from the Tanks Branch.

Portable Fuel Containers

Spillage during PFC transport, and permeation and diurnal losses from PFCs are included in this subcategory. Emissions for vapor displacement and spillage during the use of a PFC to fill a non-road equipment tank is estimated in the NONROAD model and included in the off-road sources sector. In addition, emissions from the filling of PFCs at retail gasoline stations were estimated by accounting for PFC throughput, as identified through the NONROAD model, and estimating emissions based on non-road equipment Stage 2 displacement and spillage emission factors.

Methods for estimating emissions from PFCs were based on CARB studies (CARB, 1999). Activity and emissions from PFCs are delineated between residential and commercial use. To use the CARB data to estimate the number of PFCs in Delaware, the number of occupied dwellings was used for residential PFC emissions, and the number of businesses in various SIC groups was used for commercial PFC emissions. The permeation, transport, and diurnal losses are based on the number of PFCs.

The number of commercial units using PFCs includes only those NAICS codes for industry sectors expected to use PFCs. These codes are provided in the gasoline marketing spreadsheet.

Emission Factors

Retail Gasoline

Emission factors for Stage 1, tank breathing and emptying, and tank trucks in transit were obtained from the EIIP document for gasoline marketing (EIIP, 2001). Emission factors from the EIIP are shown in Table 3-35 below. State regulations require that dispensing facilities with less than 10,000 gallons of throughput per month use submerged filling and that facilities with greater than 10,000 gallons of throughput use balanced submerged filling. Because throughput was estimated for individual stations, the Stage 1 emission factor was selected for each facility.

Gasoline distributed in an inventory area may be transported once (from bulk terminals directly to retail outlets) or twice (distribution to gasoline bulk plants, then subsequent distribution to retail outlets). To account for gasoline that has been transported twice, the activity data for tank trucks in transit should be multiplied by a gasoline transportation adjustment factor. However, in Delaware gasoline is typically shipped directly from the refinery to the retail stations without being transferred to a bulk plant, so no adjustment was made.

Table 3-35. VOC Emission Factors for Gasoline Marketing Activities

Emission Source	Emission Factor ($lb/10^3$ gal throughput)
Retail Gasoline Stations	
Gas tank trucks in transit	
Vapor-filled	0.055
Gasoline-filled	0.005
Filling underground tank (Stage 1)	
Submerged filling	7.3
Balanced submerged filling	7.3[a]
Underground tank breathing and emptying	1.0
On-road vehicle refueling (Stage 2)	*From MOBILE6 Model*
PFC filling at the pump	
Displacement loss	2.514
Spillage	1.654
Other Commercial Accounts	
Aviation gasoline unloading/tank filling - tank fill	9.0
Aviation gasoline storage tank - working losses	3.6
Aviation gasoline storage tank - breathing losses	1.7
Aviation gasoline – aircraft filling – displacement loss	11.9
Marina gasoline unloading/tank filling - tank fill	11.5
Marina gasoline storage tank - working and breathing losses	1.0
Marina – boat fueling – displacement loss	2.492
Marina – boat fueling - spillage	0.2426
Portable Fuel Containers	
PFC permeation losses – residential and commercial	0.543 (lb/PFC-yr)
PFC diurnal losses - residential	4.69 (lb/PFC-yr)
PFC diurnal losses - commercial	5.30 (lb/PFC-yr)
PFC transport spillage – residential	0.257 (lb/PFC-yr)
PFC transport spillage - commercial	3.32 (lb/PFC-yr)

[a] Vapor balance control was accounted for with the control parameters described in the Control section below.

For retail gasoline stations, monthly VOC emission factors for Stage 2 vehicle refueling and spillage were calculated with MOBILE6 using local temperature and Reid vapor pressure (RVP) data. Since non-road engine refueling emissions are generated by the NONROAD model in the nonroad source sector, the amount of gasoline at service stations that is dispensed directly from the pump to non-road equipment is removed from the overall Stage 2 throughput provided by the FHWA. Emissions from the refueling of non-road equipment from a PFC are also estimated by the NONROAD model. However, emissions from the filling of a PFC at the pump are included in this category, since these emissions are not estimated elsewhere. The PFC filling emission factors were derived from the NONROAD model data using fuel consumption and refueling emissions from non-road categories and based on Stage 2 vapor recovery.

Other Commercial Accounts

For aviation gasoline refueling, VOC emission factors were obtained from a report on alkylated lead emissions (TRC, 1993). No sources of information were identified to estimate emissions from spillage during storage tank or aircraft filling.

For storage tank filling at marinas, the uncontrolled (splash) filling emission factor from the EIIP was used (EIIP, 2001) based on findings of DNREC's Tanks Management Branch. Also, the EIIP emission factor for underground tank breathing and working losses was used. For boat fueling, Stage 2 emission factors were derived from the NONROAD model data using fuel consumption and refueling emissions for the appropriate non-road categories.

Portable Fuel Containers

Emission factors for permeation, diurnal and spillage during transport were derived from CARB survey data (CARB, 1999).

Temporal Allocation

For retail gasoline stations and other commercial accounts, monthly throughput data were used to develop temporal allocation factors. For on-road Stage 2, monthly emission factors generated by the MOBILE6.2 model for each county were used in conjunction with the monthly throughput data to develop temporal allocation factors for each county. The weekly activity for fuel delivery to outlets (Stage 1) occurs six days per week. Vehicle refueling (Stage 2), PFC filling, and tank breathing occur seven days per week, as recommended in the EIIP document (EIIP, 2001).

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, emissions were allocated based on an average temporal profile based on light commercial, industrial, and commercial lawn and garden categories in the NONROAD model. The monthly and weekly allocations from the NONROAD model are provided in Tables 4-13 and 4-14, respectively.

Controls

Delaware Air Regulation 24 requires that gasoline service stations use submerged or balanced submerged (>10,000 gals. throughput) fill methods for the filling of storage tanks. The submerged fill control method is included in the base Stage 1 emission factors. For sources using balanced submerged fill, CE was set to 95.89, RP was set to 100, and RE was set to 90 based on information provided by DNREC (Fees, 2004).

Delaware's Stage 2 vehicle refueling control program sets minimal standards for compliance inspections at gasoline dispensing facilities. Delaware *Air Regulation Number 24, Section 36* states that the effectiveness of the system (compliance) shall be tested annually but a DNREC representative shall be present at least once every three years. According to DNREC, the annual inspections of Stage 2 controls began in 2002, so many facilities would not have been tested until late in 2002. Therefore, the inspection frequency is recognized to be minimal and the rule effectiveness value is 65.3% (DNREC, 2002). The penetration rate for the use of a vapor recovery system is dependent upon the throughput threshold implemented by the non-attainment area. The national average penetration rate for facilities with a monthly throughput greater than 10,000 gallons per month is 97.2%. The vapor recovery control device efficiency is defined by Delaware *Air Regulation Number 24, Section 36.c.* as 95% (DNREC, 2002). The product of the control efficiency (95 percent), rule penetration (97.2 percent), and rule effectiveness (65.3

percent) yields an in-use efficiency value of 60 percent for Stage 2. This value was input into the MOBILE6.2 model to develop VOC emission factors.

For tank breathing/emptying, a control efficiency of 90% is assumed for pressure/vacuum (PV) relief valves on all Stage 2 controlled tanks. However, this CE was adjusted to 74% to account for on-board refueling vapor recovery (ORVR)/vacuum assist incompatibility. This adjustment was made based on CARB data and the penetration rate in DE of vacuum assist systems and ORVR. Since this control only applies to tanks with monthly throughput over 10,000 gallons, an RP was calculated for each county based on the amount of total throughput from tanks with monthly throughput over 10,000 gallons. RE was assumed to be 100%. For all other SCCs, no controls were assumed.

Sample Calculations and Results

An example calculation of annual VOC emissions (E_x) for a typical gasoline marketing SCC for county *x* follows:

$$E_x = T_x * EF$$

where:

T_x	=	annual gasoline throughput for county x
EF_y	=	emission factor for activity y
1/2000	=	conversion from lb to ton

Table 3-36. 2002 Statewide Annual and SSWD VOC Emissions for Gasoline Marketing

SCC	Category Description	VOC	
		TPY	TPD
	Retail Gasoline Stations		
2501060050	Underground Tank Filling (Stage 1)	221	0.78
2501060100	On-road Vehicle Refueling (Stage 2)	484	1.32
2501060201	Underground Tank Breathing	55	0.17
25010602xx	Portable Fuel Container Filling	23	0.07
2505030120	Tank Trucks in Transit	13	0.04
	Other Gasoline Marketing Activities		
2501010xxx	Marinas	55	0.18
2501011xxx	Residential PFC Losses	696	2.37
2501012xxx	Commercial PFC Losses	61	0.23
2501080xxx	Aviation	60	0.19
2505020xxx	CMV Loading and Transport of Petroleum Products	448	1.23
250xxxxxxx	**Total: Gasoline Marketing**	**2116**	**6.59**

References

CARB, 1999. *Mail-Out MSC 99-25, Notice of Public Meeting To Consider the Approval of California's Portable Gasoline-Container Emissions Inventory,* California Air Resources Board, September 23, 1999.

DNREC, 2002. *1999 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NOx and CO,* Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, 2002.

EIIP, 2001. *Gasoline Marketing, Volume III*, Chapter 11, Emission Inventory Improvement Program, Area Sources Committee, January 2001.

Fees, 2004. D. Fees, DNREC, personal communication with S. Roe, E.H. Pechan & Associates, Inc., October 2004.

FHWA, 2003. *Highway Statistics 2002*. U.S. Department of Transportation. Federal Highway Administration, Washington, D.C., Annual Publication, 2003.

TRC, 1993. *Estimation of Alkylated Lead Emissions, Final Report,* prepared by TRC Environmental Corporation, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC. 1993.

3.4 Fuel Combustion

Emission estimation methodologies are described in this section for the following categories:

- Commercial/Institutional Fuel Combustion,
- Industrial Fuel Combustion,
- Residential Fossil Fuel Combustion, and
- Residential Wood Combustion.

3.4.1 Commercial/Institutional Fuel Combustion

The commercial/institutional fuel combustion category includes small boilers, furnaces, heaters, and other heating units too small to be considered point sources. The fuel types included in this source category are distillate oil, residual oil, natural gas, liquefied petroleum gas (LPG), and coal. LPG includes propane, propylene, butane, and butylenes. Uses of natural gas and LPG in this sector include space heating, water heating, and cooking (EIIP, 1999c). Uses of distillate oil and kerosene include space and water heating (EIIP, 1999b). The commercial/institutional sector includes wholesale and retail businesses; health institutions; social and educational institutions; and federal, state, and local governments (i.e., prisons, office buildings) and are defined by SIC codes 50-99.

To avoid double counting, point source and certain off-road source commercial/institutional fuel consumption was subtracted from state-wide fuel consumption to arrive at area source fuel consumption. Area source emissions from commercial/institutional fuel combustion are reported under the following area source SCCs:

Table 3-37. SCCs for Commercial/Institutional Fuel Combustion

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2103002000	Stationary Source Fuel Combustion	Commercial/Institutional	Bituminous/Sub-bituminous Coal	Total: All Boiler Types
2103004000	Stationary Source Fuel Combustion	Commercial/Institutional	Distillate Oil	Total: Boilers and IC Engines
2103005000	Stationary Source Fuel Combustion	Commercial/Institutional	Residual Oil	Total: All Boiler Types
2103006000	Stationary Source Fuel Combustion	Commercial/Institutional	Natural Gas	Total: Boilers and IC Engines
2103007000	Stationary Source Fuel Combustion	Commercial/Institutional	Liquefied Petroleum Gas	Total: All Combustor Types

Activity Data

The preferred EIIP methodology for estimating emissions from fuel combustion sources is to gather fuel sales data from surveys of local distributors. Because of limited time and resources, the preferred method was not used. An alternative methodology found in the EIIP Residential & Commercial/Institutional Fuel Combustion Area Source Method Abstracts (EIIP, 1999a; EIIP, 1999b; and EIIP, 1999c) was used. This method relies on fuel consumption data compiled from the U.S. Department of Energy's (DOE) Energy Information Administration (EIA).

The EIA *State Energy Data 2002* (EIA, 2006a) provided Delaware fuel consumption in data tables through EIA's website for all fuel types of interest to this category. No commercial sector coal consumption was identified by EIA for Delaware. Therefore, no emissions from the use of coal were assigned to the commercial/institutional sector. Kerosene consumption was combined with distillate oil since emission factors for commercial use of kerosene were not identified.

Point source fuel use was determined from throughput data supplied by facilities. The EIA survey methods generate fuel consumption data for Delaware regardless of whether fuel was purchased from an in-state or out-of-state supplier (these activity data are described further below). Therefore, total point source fuel consumption is needed to make the area source correction. For commercial use of residual oil, the point source consumption data exceeded the amount obtained from EIA. Therefore, no emissions from the use of residual oil were assigned to the commercial/ institutional sector.

According to EIA *State Energy Data 2002 Consumption: Technical Notes* documentation (EIA, 2006a), *"Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use."* Therefore, certain non-road equipment fuel usage was removed from the EIA data for the commercial sector.

Fuel usage by equipment type was generated by the NONROAD model as part of estimating emissions for the non-road sector. These data were used to back out non-road equipment fuel usage from the EIA sector data. While the NONROAD model has one equipment category each for industrial and commercial, the model also includes categories for agricultural, logging, commercial lawn and garden, and construction equipment. The EIA industrial category includes manufacturing facilities, agriculture, forestry, and construction. Table 3-38 provides a crosswalk between the two data sources.

Table 3-38. NONROAD to EIA Sector Crosswalk

NONROAD Equipment Categories	EIA Fuel Consumption Sectors
Construction	Industrial
Industrial	Industrial
Commercial Lawn & Garden	Commercial
Agricultural	Industrial
Commercial	Commercial
Logging	Industrial

When grouping the NONROAD LPG fuel usage per the crosswalk in Table 3-38 it became apparent the definitions between the two data sources (EIA and NONROAD) were not similar. All forklifts in the NONROAD model are classified in the industrial sector. However, there are many warehouses and other operations within the commercial sector (as defined by EIA) that use forklifts. Forklifts are mostly powered by LPG. To account for forklift usage in the commercial sector, all NONROAD LPG usage for the commercial and industrial categories were summed and then split evenly between the industrial and commercial sectors for purposes of backing out non-road equipment LPG usage from the EIA data.

Since some non-road equipment (construction, logging, and commercial lawn and garden) are transported to job sites, some diesel refueling of these equipment takes place at retail service stations. These amounts would be reported under the EIA transportation sector and should not be part of the non-road fuel usage back out. Therefore, DNREC reduced the non-road equipment diesel fuel usage by 25 percent. The remaining 75 percent was assumed to be fuel obtained from tanks associated with a facility, farm, or place of business (i.e., a construction equipment yard.)

The EIIP method recommends using SIC employment (SIC 50-99) and heating degree-day (HDD) data to spatially allocate state activity data to the county-level. Year 2002 total HDDs for the counties in Delaware are: 5,667 for Kent County, 5,901 for New Castle County, and 5,560 for Sussex County. Since the 2002 data does not indicate a substantial difference in HDDs among the three counties, DNREC did not use HDD data for spatial allocation of activity data. Data from the BOC on the number of households in each county using each type of heating fuel suggests that not all areas of Delaware are served by all types of fuel. Therefore, activity was allocated to counties using this residential data (BOC, 2002).

Emission Factors

Emission factors for the commercial/institutional fuel combustion category were obtained from several sources. Emission factors are provided in Tables 3-38.

Table 3-39. Emission Factors for Commercial/Institutional Fuel Combustion

	Emission Factors[a]			
Fuel Type	VOC	NO_x	CO	Units
Distillate Oil	0.34	20	5	Lb/1000 gal.
Natural Gas	5.5	100	84	Lb/million cu. ft
LPG	0.5	14	1.9	Lb/1000 gal.

[a] Source of all factors from *EPA, 1998*.

Temporal Allocation

To estimate seasonal emissions for commercial/institutional distillate oil and LPG combustion, the EIIP Area Source Method Abstracts (EIIP, 1999b for distillate oil and EIIP, 1999c for LPG) recommend breaking out fuel use into water heating and space heating components. Consumption for water heating purposes may be assumed to be constant through the year, but fuel used for space heating must be apportioned according to heating needs. To estimate water heating usage for distillate oil and LPG, DNREC contacted a representative fuel oil distributor to obtain annual deliveries and lowest monthly deliveries. DNREC used the lowest monthly sales data to estimate the percentage of fuel oil consumption for water heating. The following equation was used to calculate the percent fuel oil consumption used for water heating:

$$\frac{12 \times \text{Lowest Monthly Fuel Use}}{\text{Annual Fuel Use}} \times 100$$

This percentage was applied to the commercial/institutional distillate oil and LPG throughputs to calculate the water heating portion of usage. DNREC temporally allocated consumption from water heating evenly throughout the year. This portion was subtracted from the annual total throughput, and the remaining throughput, assumed to represent space heating, was allocated by month using the proportion of monthly-to-annual heating degree-days.

For commercial/institutional use of natural gas, 2002 monthly consumption was obtained from EIA (EIA, 2006b).

The weekly profile for the commercial/institutional sector was based on activity occurring six days per week as defined in EPA's *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone* (EPA, 1991). The monthly throughputs and the weekly allocation were used to calculate the SSWD allocation factor for each fuel type.

Controls

Delaware *Regulation No. 12* requires the control of NO_x emissions from fuel burning equipment. It requires that NO_x sources larger than 100 MMBtu/hr must meet emission limits or install reasonably available control technology (RACT). Since most commercial boilers are smaller than 100 MMBtu/hr, no controls were applied.

Sample Calculations and Results

An example calculation of annual VOC emissions for commercial/institutional fossil fuel combustion for fuel type x at the county-level follows:

$$E_x = \left(FC_{s,x} - PFC_{s,x} - NFC_{s,x}\right) \times \left(\frac{E_{county}}{E_{state}}\right) \times EF_x$$

where:

E_x	=	county-level VOC emissions for fuel type x
$FC_{s,x}$	=	state annual fuel consumption (EIA data) for fuel type x
$PFC_{s,x}$	=	state annual point source fuel consumption for fuel type x
$NFC_{s,x}$	=	state annual non-road equipment fuel consumption for fuel type x
E_{county}	=	county-level number of households using fuel type x
E_{state}	=	state-level number of households using fuel type x
EF_x	=	VOC emission factor for fuel type x

Table 3-40. 2002 Statewide Annual and SSWD VOC, NO_X, and CO Emissions for Commercial/Institutional Fuel Combustion

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2103002000	Coal	0	0	0	0	0	0
2103004000	Distillate Oil	2	109	27	< 0.01	0.09	0.02
2103005000	Residual Oil	0	0	0	0	0	0
2103006000	Natural Gas	15	271	227	0.02	0.38	0.32
2103007000	Liquefied Petroleum Gas	1	25	3	< 0.01	0.05	0.01
210300xxxx	**Total : All Fuels**	**18**	**405**	**258**	**0.02**	**0.52**	**0.35**

References

BOC, 2002. U. S. Department of Commerce, Bureau of Census, *2000 Census of Population and Housing, Summary Tape File 3A,* Washington, DC, Issued September and October 2002.

EIA, 2006a. U.S. Department of Energy, Energy Information Administration, *State Energy Data 2002,* Issued June 2006.

EIA, 2006b. U.S. Department of Energy, Energy Information Administration, *Natural Gas Navigator,* accessed August 2006, available at http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_ dcu_SDE_m.htm

EIIP, 1999a. Emission Inventory Improvement Program, Area Sources Committee, *Residential & Commercial/Institutional Coal Combustion, Area Source Method Abstracts*, Chapter 5, April 1999.

EIIP, 1999b. Emission Inventory Improvement Program, Area Sources Committee, *Residential & Commercial/Institutional Fuel Oil and Kerosene Combustion, Area Source Method Abstracts*, Chapter 5, April 1999.

EIIP, 1999c. Emission Inventory Improvement Program, Area Sources Committee, *Residential & Commercial/Institutional Natural Gas and LPG Combustion, Area Source Method Abstracts*, Chapter 5, April 1999.

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3.4.2 Industrial Fuel Combustion

The industrial fuel combustion category includes small boilers, furnaces, heaters, and other heating units too small to be considered point sources. The fuel types included in this source category are distillate oil, residual oil, natural gas, liquefied petroleum gas (LPG), and coal. LPG includes propane, propylene, butane, and butylenes. The EIA industrial fuel consumption sector includes manufacturing facilities (NAICS sectors 31-33), agriculture and forestry (NAICS sector 11), mining and mineral processing (NAICS sector 21), and construction (NAICS sector 23).

To avoid double counting, point source and certain off-road source industrial fuel consumption was subtracted from state-wide fuel consumption to arrive at area source fuel consumption. DNREC determined that residual oil consumption at the Premcor Refinery involved its purchase from outside sources, which would be included in the EIA data. All other fuels consumed at Premcor, including distillate oil, refinery gas, and process gas, were generated on-site.

Emissions from industrial fuel combustion are reported under the following area source SCCs:

Table 3-41. SCCs for Industrial Fuel Combustion

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2102002000	Stationary Source Fuel Combustion	Industrial	Bituminous/Sub-bituminous Coal	Total: All Boiler Types
2102004000	Stationary Source Fuel Combustion	Industrial	Distillate Oil	Total: Boilers and IC Engines
2102005000	Stationary Source Fuel Combustion	Industrial	Residual Oil	Total: All Boiler Types
2102006000	Stationary Source Fuel Combustion	Industrial	Natural Gas	Total: Boilers and IC Engines
2102007000	Stationary Source Fuel Combustion	Industrial	Liquefied Petroleum Gas (LPG)	Total: All Boiler Types

For the natural gas SCC, information is not available to distinguish the amount of fuel combusted by boilers or internal combustion engines. DNREC assumed the bulk of natural gas is consumed by boilers and assigned emission factors based on combustion in boilers.

Activity Data

EPA's EIIP does not provide a methodology for estimating emissions from non-point source industrial fossil fuel combustion sources. For this inventory, emissions were estimated using methods similar to the commercial/institutional fuel combustion category found in EIIP Area Source Fuel Combustion Method Abstracts (EIIP, 1999a; EIIP, 1999b; and EIIP, 1999c). This method relies on fuel consumption data compiled from EIA.

The EIA *State Energy Data 2002* (EIA, 2006a) provided Delaware industrial fuel consumption in data tables through EIA's website for all fuel types of interest to this category. Kerosene consumption was combined with distillate oil since emission factors for industrial use of kerosene were not identified.

Point source fuel use was determined from throughput data supplied by facilities. The EIA survey methods generate fuel consumption data for Delaware regardless of whether fuel was purchased from an in-state or out-of-state supplier (these activity data are described further below). Therefore, total point source fuel consumption is needed to make the area source correction. For industrial use of residual oil, the point source consumption data exceeded the amount obtained from EIA. Therefore, no emissions from the use of residual oil were assigned to the industrial sector.

As previously discussed in the commercial/institutional fuel consumption category, certain non-road equipment fuel usage was removed from the EIA data for the industrial and commercial sectors. For industrial use of LPG, the point source and non-road equipment consumption data exceeded the amount obtained from EIA. Therefore, no emissions from the use of LPG were assigned to the industrial sector.

The EIIP method recommends using NAICS employment for the manufacturing sector and HDD data to spatially allocate state activity data to the county-level. Year 2002 total HDDs for the counties in Delaware are: 5,667 for Kent County, 5,901 for New Castle County, and 5,560 for Sussex County. Since the 2002 data does not indicate a substantial difference in HDDs among the three counties, DNREC used only the employment data in allocating state fuel combustion to counties. The 2002 employment data were obtained from the DE Department of Labor.

Emission Factors

Emission factors for the industrial fuel combustion category were obtained from several sources. Emission factors are provided in Tables 3-42.

Table 3-42. Emission Factors for Industrial Fuel Combustion

Fuel Type	Emission Factors			Units	Data Source
	VOC	NO_x	CO		
Bituminous/Sub-bituminous Coal	1.3	9.7	11	Lb/ton	EPA, 1998[a]
Distillate Oil	0.2	10	5	Lb/1000 gal.	EPA, 2000
Natural Gas	5.5	140	84	Lb/million cu. ft	EPA, 1998

[a] Source of NO_x factor for coal from *EPA, 2000*.

Temporal Allocation

Annual emissions for the industrial fuel combustion source categories were temporally allocated using methods similar to the commercial/institutional fuel combustion source category temporal allocation methodologies found in the EIIP (EIIP, 1999a; EIIP, 1999b; and EIIP, 1999c).

The monthly allocation of industrial coal combustion emissions was made based on monthly usage data for one industrial coal user reporting as a point source. Monthly industrial natural gas combustion emissions were allocated based on EIA monthly industrial natural gas consumption (EIA, 2006b). Monthly emissions of industrial distillate oil were estimated using the same monthly profile as industrial natural gas.

The weekly allocation profile for the industrial sector was based on activity occurring six days per week as defined in EPA's *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone* (EPA, 1991). The monthly throughputs and the weekly allocation were used to calculate the SSWD allocation factor for each fuel type.

Controls

Delaware *Regulation No. 12* requires the control of NO_x emissions from fuel burning equipment. It requires that NO_x sources larger than 100 MMBtu/hr must meet emission limits or install reasonably available control technology (RACT), which includes either:

1. Low NO_x burner technology with low excess air and including over fire air if technologically feasible; or
2. Flue gas recirculation with low excess air.

For all fuel types, emission factors for industrial boilers equipped with low NO_x burners were used to estimate emissions, thus no controls were applied.

Sample Calculations and Results

An example calculation of annual VOC emissions for industrial fossil fuel combustion for fuel type x at the county-level follows:

$$E_x = \left(FC_{s,x} - PFC_{s,x} - NFC_{s,x}\right) \times \left(\frac{E_{county}}{E_{state}}\right) \times EF_x$$

where:

where:	E_x	=	county-level VOC emissions for fuel type x
	$FC_{s,x}$	=	state annual fuel consumption (EIA data) for fuel type x
	$PFC_{s,x}$	=	state annual point source fuel consumption for fuel type x
	$NFC_{s,x}$	=	state annual non-road equipment fuel consumption for fuel type x
	E_{county}	=	county-level number of employees for NAICS codes 31-33 (adjusted for point source employment)
	E_{state}	=	state-level number of employees for NAICS codes 31-33 (adjusted for point source employment)
	EF_x	=	VOC emission factor for fuel type x

Table 3-43. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Industrial Fuel Combustion

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2102002000	Coal	1	6	7	< 0.01	0.03	0.03
2102004000	Distillate Oil	< 1	23	11	< 0.01	0.05	0.02
2102005000	Residual Oil	0	0	0	0	0	0
2102006000	Natural Gas	27	686	412	0.06	1.51	0.91
2102007000	Liquefied Petroleum Gas	0	0	0	0	0	0
210200xxxx	**Total : All Fuels**	**28**	**715**	**430**	**0.06**	**1.59**	**0.96**

References

EIA, 2006a. U.S. Department of Energy, Energy Information Administration, *State Energy Data 2002*, Issued June 2006.

EIA, 2006b. U.S. Department of Energy, Energy Information Administration, *Natural Gas Navigator*, accessed August 2006, available at http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_ dcu_SDE_m.htm

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EIIP, 1999b. Emission Inventory Improvement Program, Area Sources Committee, *Residential & Commercial/Institutional Fuel Oil and Kerosene Combustion*, *Area Source Method Abstracts*, Chapter 5, April 1999.

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EPA, 2000. U.S. Environmental Protection Agency, *Factor Information Retrieval Data System (FIRE) 6.23*, October 2000.

3.4.3 Residential Fossil Fuel Combustion

The residential fossil fuel combustion category includes all small boilers, furnaces, and other heating units used at residences since point sources do not include residential dwellings. Any fuels used for residential non-road equipment (e.g., residential lawn and garden, recreational equipment) are assumed to be obtained through retail service stations and therefore included in the EIA's transportation fuel consumption sector.

The fuel types included in this source category are distillate oil, natural gas, liquefied petroleum gas (LPG), kerosene, and coal. The LPG product used for domestic heating is composed primarily of propane. Residual oil is not reported by EIA for the residential sector. Sources of natural gas and LPG emissions for the residential sector include space heating, water heating, and cooking. Sources of distillate oil and kerosene emissions are space and water heating (EIIP, 1999b). Area source emissions from residential fuel combustion are reported under the following area source SCCs:

Table 3-44. SCCs for Residential Fuel Combustion

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104002000	Stationary Source Fuel Combustion	Residential	Bituminous/Sub-Bituminous Coal	Total: All Combustor Types
2104004000	Stationary Source Fuel Combustion	Residential	Distillate Oil	Total: All Combustor Types
2104006000	Stationary Source Fuel Combustion	Residential	Natural Gas	Total: All Combustor Types
2104007000	Stationary Source Fuel Combustion	Residential	Liquified Petroleum Gas (LPG)	Total: All Combustor Types
2104011000	Stationary Source Fuel Combustion	Residential	Kerosene	Total: All Heater Types

Activity Data

The preferred EIIP methodology for estimating emissions from residential fossil fuel combustion sources is to gather fuel consumption data from surveys of local distributors. Because of limited time and resources, the preferred method was not used. For this inventory, emissions for the residential fossil fuel combustion source categories were estimated using the alternative emission methodologies found in the EIIP Residential & Commercial/Institutional Fuel Combustion Area Source Method Abstracts (EIIP, 1999a; EIIP, 1999b; and EIIP, 1999c).

The EIA *State Energy Data 2002* (EIA, 2006a) provided Delaware fuel consumption in data tables through EIA's website for all fuel types of interest to this category. No residential sector coal consumption was identified by EIA for Delaware. Therefore, no emissions from the use of coal were assigned to the residential sector.

The EIIP method recommends using the number of homes heating with each fuel and HDD data to spatially allocate state activity data to the county-level. Year 2002 total HDDs for the counties in Delaware are; 5,667 for Kent County, 5,901 for New Castle County, and 5,560 for Sussex County. Since the 2002 data do not indicate a substantial difference in annual HDDs among the three counties, DNREC only used the number of homes heating with each fuel in allocating state fuel combustion to counties. Natural gas consumption was allocated to the using the year 2000 county-to-state proportions of the number of homes using utility gas for heating (BOC, 2002). LPG consumption was allocated using the number of homes using bottled or tank LPG for heating (BOC, 2002). The Bureau of Census data are only available every 10 years.

Emission Factors

Emission factors for the residential fossil fuel combustion category were obtained from several sources. Emission factors are provided in Tables 3-45.

Table 3-45. Emission Factors for Residential Fuel Combustion

Fuel Type	Emission Factors			Units	Data Source
	VOC	NO_x	CO		
Distillate Oil	0.7	18	5	Lb/1000 gal.	EPA, 1998
Natural Gas	5.5	94	40	Lb/million cu. ft	EPA, 1998
Liquefied Petroleum Gas	0.5	14	1.9	Lb/1000 gal.	EPA, 1998
Kerosene	0.7	17.4	4.8	Lb/1000 gal.	EPA, 2000

Temporal Allocation

To estimate monthly emissions for residential distillate fuel oil and LPG combustion, the EIIP Area Source Method Abstracts (EIIP, 1999b for distillate oil and EIIP, 1999c for LPG) recommend breaking out fuel use into water heating and space heating components. This method is explained in detail in the Commercial/Institutional Fuel Combustion category. For residential use of natural gas, 2002 monthly consumption was obtained from EIA (EIA, 2006b). For residential use of kerosene, EIIP indicates that kerosene is used for space heating only (EIIP, 1999b). Therefore, monthly emissions from kerosene use were estimated by applying monthly to annual heating degree-days values.

The weekly allocation profile for the residential sector was based on activity occurring seven days per week as defined in EPA's *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone* (EPA, 1991). The monthly throughputs and the weekly allocation were used to calculate the SSWD allocation factor for each fuel type.

Controls

There are no controls in Delaware for residential fossil fuel combustion. Therefore CE, RE, and RP were set to zero.

Sample Calculations and Results

An example calculation of annual VOC emissions for residential fossil fuel combustion for fuel type x at the county-level follows:

$$E_x = FC_{s,x} \times \left(\frac{HU_{county}}{HU_{state}} \right) \times EF_x$$

where:

E_x	=	county-level VOC emissions for fuel type x
$FC_{s,x}$	=	state annual fuel consumption (EIA data) for fuel type x
HU_{county}	=	county-level housing units using fuel type x
HU_{state}	=	state-level housing units using fuel type x
EF_x	=	VOC emission factor for fuel type x

Table 3-46. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Residential Fossil Fuel Combustion

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2104002000	Coal	0	0	0	0	0	0
2104004000	Distillate Oil	15	374	104	0.01	0.27	0.07
2104006000	Natural Gas	26	449	191	0.02	0.34	0.14
2104007000	Liquefied Petroleum Gas	10	293	40	0.01	0.31	0.04
2104011000	Kerosene	1	24	7	< 0.01	< 0.01	< 0.01
21040xxxxx[a]	**Total : All Fuels**	**52**	**1140**	**341**	**0.04**	**0.91**	**0.26**

[a] Does not include residential wood combustion (SCC 2104008000)

References

BOC, 2002. U. S. Department of Commerce, Bureau of Census, *2000 Census of Population and Housing, Summary Tape File 3A*, Washington, DC, Issued September and October 2002.

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EPA, 2000. U.S. Environmental Protection Agency, *Factor Information Retrieval Data System (FIRE) 6.23*, October 2000.

3.4.4 Residential Wood Combustion

Residential wood combustion (RWC) is defined as wood burning that takes place at residences, primarily in woodstoves and fireplaces. Residential wood burning occurs either as a necessary source of heat or for aesthetics. Wood burning emissions for all indoor wood-fired equipment (fireplaces, woodstoves, pellet stoves, central systems) are reported under the first SCC below:

Table 3-47. SCCs for Residential Wood Combustion

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104008000	Stationary Source Fuel Combustion	Residential	Wood	Total: Woodstoves and Fireplaces
2104008070	Stationary Source Fuel Combustion	Residential	Wood	Outdoor Wood Burning Equipment

Woodstoves were further delineated into conventional woodstoves, EPA-certified catalytic woodstoves, and EPA-certified non-catalytic woodstoves. Central systems include indoor furnaces/boilers and outdoor wood boilers (OWB). Note that while OWBs are located outside they are included under the indoor equipment SCC because the heat and hot water are transmitted to the indoor living space. Outdoor equipment includes outdoor fireplaces, fire pits, wood-fired barbecues, and other wood-burning equipment (e.g., chimineas). This is a new SCCs assigned by EPA in March 2004.

Emissions data were taken from the Mid-Atlantic and Northeast Visibility Union (MANE-VU) RWC emission inventory project conducted by OMNI Environmental Services and an earlier MANE-VU project conducted by Pechan. OMNI developed county-level annual emission estimates for several types of indoor wood-fired equipment. Emissions from outdoor equipment were estimated by DNREC utilizing data from both the OMNI and the Pechan projects. Details on the development of emission estimates are available in a series of technical memoranda published by both firms and can be found on the Mid-Atlantic Regional Air Management Association (MARAMA) website.

Activity Data

The following data are important to estimating emissions from residential wood combustion:

- the number of wood-burning devices used for primary or supplemental heat,
- the amount of wood (in cords) used per device, and
- the density of cordwood on a dry-weight basis.

Indoor Equipment

OMNI relied on multiple sources to determine the number of units used in Delaware for each equipment type. One of the sources was the Delaware Department of Agriculture's *Report on the 1995 Delaware Fuelwood Surve*y (DDA, 1995). Emissions from fireplaces for aesthetic purposes were not included by OMNI in the inventory, which, according to OMNI, represents less than ten percent of cordwood used in fireplaces (OMNI, 2006b).

OMNI relied on several sources to determine the amount of wood burned per equipment type. For the MANE-VU region, three heating degree-day (HDD) categories (low, medium, and high) were established for the purpose of developing wood usage per equipment type from survey data conducted by Pechan during the first MANE-VU project. All three Delaware counties were assigned to the low HDD category. Wood usage used per season per unit for each type of indoor equipment (except pellet stoves) was calculated by OMNI at the HDD level using the Pechan survey data. Pellet stove fuel usage was based on national shipments of pellets allocated to the MANE-VU region.

OMNI developed an average cordwood weight (dry basis) for Delaware based on the percentage of each tree species present in Delaware and published values for cord weight by species. Details of OMNI's methods for estimating the number of wood-burning devices used for heat, the amount of wood burned per equipment type, and the average cordwood weight can be found in OMNI's Technical Memorandum #1 (OMNI, 2006a).

Outdoor Equipment

The number of outdoor wood-burning devices and the amount of wood burned per device were developed by Pechan for the first MANE-VU project based on survey data (Pechan and PRS, 2004). The average cordwood weight developed by OMNI was used to calculate mass of wood burned in Delaware.

Emission Factors

OMNI developed emission factors for all equipment types based on averaging all credible emission factors found in the literature. Since there are no emission factors for outdoor equipment, the emission factors for fireplaces burning cordwood were used. OMNI presents the criteria for selecting credible emissions factors and lists all references to the emission factors in their Technical Memorandum #2 (OMNI, 2006b), available on the MARAMA website. Emission estimates for indoor equipment for each county in Delaware are also presented in Technical Memorandum #2.

Temporal Allocation

Monthly and weekly profiles were developed by Pechan based on survey results (Pechan, 2004). Separate SSWD allocation factors were developed for indoor and outdoor equipment and for each county.

Controls

There are no control programs that would apply to this source category. The use of low emission EPA-certified woodstoves was taken into account through the development of equipment populations and emission factors associated with these equipment types. Therefore, CE, RP, and RE were all set to zero.

Sample Calculations and Results

From the MANE-VU inventory, an example calculation follows of annual emissions (E_{xy}) for indoor equipment type (x) for pollutant (y) at the county level follows:

$$E_{xy} = (WE_x)(AC_x)(EF_{xy})\, 1/2000$$

where:

WE_x	=	the number of units of equipment type x used for heat in the county
AC_x	=	the per unit annual wood use (tons) for equipment type x
EF_{xy}	=	emission factor or equipment type x and pollutant y
1/2000	=	conversion from lb to ton

Table 3-48. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Residential Wood Combustion

SCC	Category Description	Annual (TPY) VOC	Annual (TPY) NO_x	Annual (TPY) CO	SSWD (TPD) VOC	SSWD (TPD) NO_x	SSWD (TPD) CO
2104008000	Indoor Equipment	634	68	3561	0.09	0.01	0.50
2104008070	Outdoor Equipment	45	7	357	0.10	0.01	0.77
2104008xxx	**Total : All Equipment**	**679**	**75**	**3918**	**0.19**	**0.02**	**1.26**

References

DDA, 1995. *Report on the 1995 Delaware Fuelwood Survey*, Delaware Forest Service, Department of Agriculture, May 1995.

Pechan, 2004. *Final Report: MANE-VU Residential Wood Combustion Emission Inventory*, prepared by E.H. Pechan & Associates, Inc. under contract to the Mid-Atlantic Regional Air Management Association, June 2004.

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OMNI, 2006a. *Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region: Technical Memorandum 1 (Activity)*, Final, under contract to the Mid-Atlantic Regional Air Management Association, August 2006.

OMNI, 2006b. *Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region: Technical Memorandum 2 (Emission Inventory)*, Final, under contract to the Mid-Atlantic Regional Air Management Association, August 2006.

3.5 Open Burning

Emission estimation methodologies are described in this section for the following categories:

- Residential and Land Clearing Debris Burning,
- Prescribed Burning,
- Structural Fires,
- Vehicle Fires, and
- Wildfires.

3.5.1 Residential and Land Clearing Debris Burning

Open burning is the purposeful burning of materials for the purpose of waste disposal. This category includes the burning of household trash (also known as municipal solid waste, or MSW), residential yard waste, and land clearing debris. Area source emissions from residential and land clearing debris burning are reported under the following area source SCCs:

Table 3-49. SCCs for Residential and Land Clearing Debris Burning

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2610000100	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Leaf Species Unspecified
2610000400	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Brush Species Unspecified
2610000500	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Land Clearing Debris
2610030000	Waste Disposal, Treatment, and Recovery	Open Burning	Residential	Household Waste

Activity Data

Activity data developed as part of a MANE-VU open burning emission inventory project was used for the residential open burning portion of this category (Pechan, 2003a). There are three primary variables of interest in developing open burning activity data: the fraction of households burning; the frequency of burning; and the average amount of waste per burn. Open burning activity estimates recorded from a survey as part of the MANE-VU project were used directly to estimate activity for the surveyed jurisdictions. For the non-surveyed areas, default activity data derived from all survey responses were applied based on urban/rural classifications of each MANE-VU census tract (Pechan, 2003a). Households are defined as detached single-family unit dwellings. The activity variables developed from the survey were applied to detached single-family household counts from the 2000 Census to obtain census tract-level activity (BOC, 2002).

The burning of land clearing debris is prohibited by DNREC's open burning regulation, except for the purpose of preparing land for crops or livestock. DNREC was unable to obtain activity estimates of open burning of land clearing material for agricultural purposes from the county agricultural extension services. While the burning of land clearing debris for non-agricultural purposes is prohibited, the activity still takes place. Therefore, emissions for land clearing debris burning were estimated based on the number of acres disturbed by residential, commercial and roadway construction (Pechan, 2003b).

This method does not account for emissions from the burning of crop residue. However, conversations with the Delaware Department of Agriculture reveal this activity is not normally practiced in Delaware.

To estimate the acres disturbed by road construction, the State expenditure for capital outlay was obtained from the Federal Highway Administration for six roadway types (FHWA, 2003). To estimate the miles of roadway constructed, dollars-to-mile conversion factors were used. Once the new miles of road constructed were estimated, the miles were converted to acres for each of the six road types using acres disturbed per mile conversion factors (MRI, 1999):

The state-level estimates of acres disturbed were distributed to the counties using building permit data (housing starts), which is a good indicator of the need for new roads. Building permit data were obtained from the U.S. Census Bureau.

To estimate the acres disturbed by residential construction, activity data were estimated based on regional (Northeast, Midwest, South, and West) monthly housing starts for all housing types obtained from the BOC (BOC, 2002). Regional housing starts were allocated to Delaware counties using county-level building permit data available from the BOC for 2002. To estimate the total acres disturbed by residential construction, conversion factors were applied to the housing starts data.

To estimate the acres disturbed by commercial construction, activity data were estimated based on the value of construction put in place. To estimate the state value of construction put in place, a regional value for the South Atlantic region (which includes Delaware) was obtained from the BOC (BOC, 2004). The regional value of construction put in place was allocated to these states using a state-to-region proportion of non-residential construction employment data from the Bureau of Census County Business Patterns (BOC, 2001). Employment data from the Delaware Department of Labor (DE DOL) was use to allocate the state value of construction put in place to each county (Lindgren, 2004). A conversion factor was applied to the construction valuation data to estimates the number of acres disturbed by non-residential construction.

The acreage for each type of construction was added to obtain a county-level estimate of total acres disturbed by land clearing. County-level emissions from land clearing debris were then calculated by multiplying the total acres disturbed by construction by a weighted consumption factor and emission factor. Average consumption factors, shown in Table 3-50, were weighted according to the percent contribution of each type of vegetation class to the total land area for each county. The consumption factors for slash hardwood and slash softwood have been adjusted 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. The Biogenic Emissions Landcover Database, Version 2 (BELD2) in EPA's Biogenic Emission Inventory System (BEIS) contains acreage data on the number of acres of hardwoods, softwoods, and grasses by county. Table 3-51 provides the final weighted fuel consumption factors by county.

Table 3-50. Average Land Clearing Debris Consumption Factors

Fuel type	Fuel consumption factor (tons/acre)
Hardwood	99
Softwood	57
Grass	4.5

Table 3-51. Final Weighted Fuel Consumption Factors by County

County	Fuel consumption factor (tons/acre)
Kent	21.2
New Castle	31.3
Sussex	30.4

Emission Factors

For residential open burning, emission factors were compiled from various sources including the Emission Inventory Improvement Program (EIIP) document covering open burning, EPA's *Compilation of Air Pollution Emission Factors* (AP-42), as well as other open burning studies (EIIP, 2001; EPA, 1995).

For land clearing debris burning, emission factors were obtained from the EIIP document on open burning (EIIP, 2001). Table 16.4-2 of the EIIP document contains emission rates for criteria pollutants.

Temporal Allocation

Temporal allocation profiles from the MANE-VU inventory project were used to calculate monthly and weekly emission profiles for residential burning (Pechan, 2003a). Leaf burning was assumed to not take place during the ozone season. Due to county-level differences in control programs (see below) there are different monthly temporal allocation profiles for brush burning in Kent and New Castle versus Sussex County.

No data were found to estimate monthly or seasonal emissions from land clearing. Therefore, uniform distributions were assumed for monthly and weekly allocation.

Controls

Delaware's *Regulation 13* prohibits the open burning of residential municipal solid waste and leaves, so the CE and RP for these categories are 100%. For brush burning, Kent and New Castle counties have a seasonal ban (June through August). Therefore, in these counties a CE of 100% is applied. Rule penetration for brush burning in Kent and New Castle was estimated to be four percent, since only six percent of the total annual activity is estimated to occur in the summer months, coupled with an assumption that a portion (two percent) of the activity would be shifted to other months due to the ban. For brush burning in Sussex County, no control programs apply; so CE, RE, and RP are set to zero.

An RE value of 96.8% was estimated for residential MSW and yard waste open burning, based on survey data from the MANE-VU inventory project (Pechan, 2003a). However, DNREC had concerns that this regional RE value overestimates actual compliance levels in rural portions of the state, especially for MSW and leaf waste burning. As such, DNREC used an RE value of 80% for calculating MSW and leaf burning emission. An RE value of 96.8% was thought to be representative for brush burning, and was used for brush burning emission calculations.

Delaware prohibits the open burning of land clearing debris, but the rule includes an exemption that allows burning if the land will be used for agricultural purposes. Therefore an RP of less than 100% will apply. In addition, DNREC is aware of violations of this rule by parties claiming, but not legally eligible for, the agricultural exemption. DNREC recommends an RP and RE value of 90% for calculating emissions for Kent and Sussex counties and 100% for New Castle County (Fees, 2004). A CE of 100% applies to the burning of land clearing debris because what is not burned (due to the rule) does not create emissions.

Sample Calculations and Results

An example calculation of annual uncontrolled emissions for residential open burning category x and pollutant y at the county level (E_{xy}) follows:

$$E_{xy} = (D)(F)(N)(M)(EF_{xy})\left(\frac{1}{2000}\right)$$

where:

D	=	number of dwellings (detached single-family homes) in the county (unitless)
F	=	fraction of households burning (unitless)
N	=	number of burns per household per year (1/household-yr)
M	=	mass of waste per burn (ton)
EF_{xy}	=	emission factor for category x and pollutant y (lb/ton)
1/2000	=	conversion from lb to ton

Table 3-52. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Residential and Land Clearing Debris Open Burning

		Annual (TPY)			SSWD (TPD)		
SCC	Category Description	VOC	NO_x	CO	VOC	NO_x	CO
2610000100	Leaves	6	1	22	0	0	0
2610000400	Brush	15	4	107	0.01	< 0.01	0.04
2610000500	Land Clearing Debris	51	22	739	0.14	0.06	2.03
2610030000	Household Waste (MSW)	6	9	129	0.01	0.02	0.28
26100xxxxx	**Total : Open Burning**	**77**	**36**	**998**	**0.16**	**0.08**	**2.35**

References

BOC, 2001. *2001 County Business Patterns*, U.S. Department of Commerce, Bureau of Census, Washington, DC, obtained from website January 2004, available at http://censtats.census.gov/cbpnaic/cbpnaic.shtml.

BOC, 2002. *2000 Census of Population and Housing, Summary Tape File 3A.* U.S. Department of Commerce, Bureau of Census, Washington, DC, issued September and October 2002.

BOC, 2004. *Value of Construction Put in Place for Private Nonresidential Building, by Geographic Division and Type of Construction: 1973 to 2002*, U.S. Department of Commerce, Bureau of Census, Washington, DC, obtained from website January 2004, available at http://www.census.gov/const/C30/tableS1.pdf.

EIIP, 2001. *Open Burning, Volume III*, Chapter 16, Emission Inventory Improvement Program, Area Sources Committee, April 2001.

EPA, 1995. *Compilation of Air Pollution Emission Factors, Volume I: Stationary Point and Area Sources*, Fifth Edition, AP-42 (GPO 055-000-00500-1), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1995.

Fees, 2004. D. Fees, Air Quality Management Section, Delaware Department of Natural Resources and Environmental Control, "Burning Land Clearing Debris," email sent to K. Thesing, E.H. Pechan & Associates, Inc., dated April 27, 2004.

FHWA, 2003. *Highway Statistics 2002*, Federal Highway Administration, U.S. Department of Transportation, to be released December 2003.

Lindgren, 2004. 2002 County-level Employment Data for Delaware, Lindgren, Debbie, Delaware Department of Labor, personal communication with M. Spivey, E.H. Pechan & Associates, Inc., February 2004.

MRI, 1999. *Estimating Particulate Matter Emissions from Construction Operations, Final Report*, prepared for the Emission Factor and Inventory Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, prepared by Midwest Research Institute, September 1999.

Pechan, 2003a. *Open Burning in Residential Areas, Emissions Inventory Development Report*, prepared by E.H. Pechan & Associates, Inc, under contract to the Mid-Atlantic Regional Air Management Association, June 2003.

Pechan, 2003b. *Documentation for the Draft 1999 National Emission Inventory (Version 3.0) for Criteria Air Pollutants and Ammonia: Area Sources*, prepared by E.H. Pechan & Associates, Inc, under contract to the U.S. Environmental Protection Agency, Research Triangle Park, NC, March, 2003.

3.5.2 Prescribed Burning

Prescribed burning is defined as fire applied in a knowledgeable manner to vegetation (i.e., forest, field, marshes) on a specific land area under selected weather conditions to accomplish predetermined, well-defined management objectives. It is a process that consumes various ages, sizes, and types of flora. Prescribed burning is used as a land management practice to establish favorable seed beds, remove competing underbrush, accelerate nutrient cycling, control of pests and alien species, promote native species (plant and animal) and contribute other ecological benefits. In Delaware, prescribed burning is primarily used as a management tool to control non-native phragmites growth in wetland/marsh areas and to rehabilitate fallow fields. Emissions from prescribed burning are reported under the following area source SCC:

Table 3-53. SCC for Prescribed Burning

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2810015000	Miscellaneous Area Sources	Other Combustion	Prescribed Burning	Total

Activity Data

Activity data for prescribed burning are the number of acres burned by county. Also necessary for the calculation of prescribed burning emissions are fuel-loading factors based on the weight and type of consumable vegetation per acre. Note that there is no EIIP methodology for estimating emissions from prescribed burning.

DNREC approves applications to conduct prescribed burns. DNREC maintains the information in a database that contains the location of the burn, date and duration of each burn, the number of acres, and the type of vegetation. Table 3-54 shows the number of burns and the number of acres burned by county for 2002. The estimates of acres burned are approximate based on information provided in the prescribed burn database.

Table 3-54. 2002 Prescribed Burns Approved by County

County	No. of Burns	Acres Burned
Kent	9	420
New Castle	11	1450
Sussex	2	70

The Delaware Division of Forestry (DOF) fuel-loading factors (FLFs) used to calculate emissions for the 1999 inventory were used to calculate the 2002 emissions (DNREC, 2002) and are provided in Table 3-55. The FLFs are the same for all counties. For marshes and wetlands where the vegetation is mixed or unspecified, an average FLF based on those of phragmites and short grass was used. For fields where the vegetation is a mix of brush, woody growth, weeds and/or grasses, the same average FLF was used. Finally, for a burn area that is a mixture of marshes and fields, the average FLF was used.

The following table shows the vegetation types and fuel-loading factors for prescribed burns reported in the prescribed burning database for 2002:

Table 3-55. 2002 Fuel-Loading Factors by Vegetation Type

Vegetation Type	Fuel-Loading Factor (ton/acre)
Phragmites	5.5
Marsh[a]	4.25
Fallow fields[a]	4.25
Grasses	3.0

[a]An average of phragmites and short grass FLFs

Emission Factors

Emission factors are provided in Table 3-56 based on those developed by EPA in June 2003 (EPA, 2003) for the calculation of prescribed burning emissions for the National Emissions Inventory (NEI). Emissions were calculated for each burn. Annual emissions are the sum of the emissions calculated for each burn.

Table 3-56. Emission Factors for Prescribed Burning

Pollutant	Emission Factor (lb/ton burned)
VOC	13.6
NO_x	6.2
CO	289

Temporal Allocation

The date of each prescribed burn, as provided in the prescribed burn database for 2002, was used to calculate SSWD emissions. For 2002, all prescribed burns occurred between January 1 and May 1. Therefore, SSWD emissions were zero.

Controls

There are no control programs that apply to this source category. Therefore, CE, RE and RP were set to zero.

Sample Calculations and Results

An example emissions calculation for pollutant x for one prescribed burning event follows:

$$E_x = (AC)(FLF)(EF_x)\left(1/2000\right)$$

where:

AC	= number of acres burned (acre)
FLF	= fuel loading for vegetation type burned (ton/acre)
EF_x	= emission factor (lb/ton)
1/2000	= conversion factor (lb to ton)

Table 3-57. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Prescribed Burning

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2810015000	Prescribed Burning	67	31	1425	0	0	0

References

DNREC, 2002. Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, *1999 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NO_x and CO*, 2002.

EPA, 2003. *Data Needs and Availability for Wildland Fire Emissions Inventories - Short-term Improvements to the Wildland Fire Component of the National Emissions Inventory*, prepared for U.S. EPA, Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division, Emission Factor and Inventory Group by EC/R Inc., June 2003.

3.5.3 Structure Fires

Structure fires covered in this inventory are accidental fires that occur in residential and commercial structures as well as the burning of standing buildings for firefighter training. Accidental structure fires result from unintentional actions, equipment malfunction, arson, or natural events. Structural materials (i.e., wood, insulation, roof shingles, siding), and the contents of structures (i.e., furniture, carpets, clothing, paper, plastics), can burn in an accidental fire. Only structural materials remain to be burned during training exercises. Emissions from structure fires are reported under the following area source SCCs:

Table 3-58. SCCs for Structure Fires

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2810030000	Miscellaneous Area Sources	Other Combustion	Accidental Structure Fires	Total
2810035000	Miscellaneous Area Sources	Other Combustion	Firefighter Training Fires	Total

Activity Data

EPA's EIIP Volume III presents three methodologies for calculating structure fire emissions. The preferred methodology is to gather locality-specific structure fire activity data from local or state fire marshals or fire and public safety departments. The preferred method was used for firefighter training. For accidental structure fires, emissions were estimated using an alternative emission methodology found in EIIP Volume III (EIIP, 2001) based on per capita activity data.

To estimate the number of accidental structure fires in Delaware, DNREC multiplied Delaware's county-level population, obtained from the Delaware Population Consortium (DPC, 2003), by a per capita factor on the number of fires. The number of fires per capita in 2002 was based on an estimated 519,000 total U.S. fires reported in 2002 and a U.S. population of 288.4 million, averaging 1.8 fires per 1,000 people (BOC, 2003 and NFDC, 2003).

DNREC approves applications to conduct training burns. DNREC maintains the information in a database that contains the location, type and size of structure, date, and duration of the burn.

The number of county-level accidental structure fires were multiplied by a fuel-loading factor (FLF) of 1.53 tons/fire to obtain tons of material burned (DNREC, 2002). DNREC used information from the EIIP to estimate the FLF. The FLF includes estimates of both structure loss and content loss. A default assumption of 7.3% structure and content loss was used in the development of the accidental structure fires FLF.

For training fires, combustible contents are assumed to be limited to non-removable materials (i.e., kitchen and bathroom fixtures, cabinets). Also, a 100% loss of the structure and contents is assumed for the estimation of a FLF. The FLF used for firefighter training fires is 14.7 tons/fire (DNREC, 2002). A summary of training burns by county is provided in Table 3-59.

Table 3-59. 2002 Firefighting Training Burns by County

County	Annual No. of Burns	Summer Season No. of Burns	Summer Season Weekday No. of Burns
Kent	34	0	0
New Castle	3	0	0
Sussex	115	18	15

Emission Factors

Emission factors for structure fires are from EPA's *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone* (EPA, 1991).

Table 3-60. Emission Factors for Structural Fires

Pollutant	Emission Factor (lb/ton burned)
VOC	11
NO_x	1.4
CO	60

Temporal Allocation

Monthly emissions for accidental structure fires were estimated using seasonal distributions of residential and non-residential fires reported in the U.S. Fire Administration National Fire Data Center's report, *Fire in the United States* (NFDC, 1999). The most current data available is for the year 1996. Weekly allocations were assumed to be uniform.

All firefighting instructional burns that took place in June, July, or August on a weekday were included in the calculation of the SSWD daily value. Emissions were estimated for each burn that took place on a weekday in the peak ozone season (15 burns), summed, and averaged over the number of weekdays in the ozone season (65 days).

Controls

Aside from the approval process for firefighter training, there are no known controls in Delaware for structure fires. Therefore, CE, RP, and RE were all set to zero.

Sample Calculations and Results

An example calculation of annual emissions at the county level for pollutant x follows for structure fires:

$$E_x = (AC)(FLF)(EF_x)\left(\frac{1}{2000}\right)$$

where:

AC	=	number of fires within the county (fires/yr)
FLF	=	fuel loading factor (ton burned/fire)
EF_x	=	emission factor for pollutant x (lb emitted/ton burned)
1/2000	=	conversion from lb to ton

Table 3-61. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Structure Fires

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2810030000	Accidental	12	2	67	0.03	< 0.01	0.17
2810035000	Firefighter Training	12	2	67	0.02	< 0.01	0.10
281003xxxx	**Total : Structure Fires**	**25**	**3**	**134**	**0.05**	**0.01**	**0.27**

References

BOC, 2003. U. S. Department of Commerce, Bureau of Census, *2002 Population Estimates*, Washington, DC, accessed November 2003, available at http://eire.census.gov/popest/data/states/ST-EST2002-ASRO-01.php.

DNREC, 2002. Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, *"1999 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NO_x and CO"*, 2002.

DPC, 2003. Delaware Population Consortium, *"Annual Population Projections, Version 2003.0,"* September 23, 2003.

EIIP, 2001. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Inventory Improvement Program, *"EIIP, Volume III, Chapter 18: Structure Fires,"* January 2001.

EPA, 1991. U.S. Environmental Protection Agency, Office Of Air Quality Planning and Standards, *"Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone,"* EPA-450/4-91-016, Research Triangle Park, NC, May 1991.

NFDC, 1999. Federal Emergency Management Agency, U.S. Fire Administration, National Fire Data Center, *Fire in the United States: 1987-1996*, Washington, DC, FA-216, August 1999, available at http://www.usfa.fema.gov/downloads/pdf/publications/fius11th.pdf.

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3.5.4 Vehicle Fires

This category 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. Emissions from vehicle fires are reported under the following area source SCC:

Table 3-62. SCC for Vehicle Fires

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2810050000	Miscellaneous Area Sources	Other Combustion	Motor Vehicle Fires	Total

Activity Data

The preferred EIIP methodology for estimating emissions from vehicle fires is to gather locality-specific vehicle fires activity data from local or state fire marshals or fire and public safety departments (EIIP, 2000).

DNREC obtained the 2002 number of vehicle fires, by county, from the Delaware State Fire Marshal (DSFM, 2004) and are presented in Table 3-63. Non-roadway fires such as off-road, heavy equipment, rail, water, and air transportation fires were not included in the county totals.

Table 3-63. 2002 Vehicle Fires by County

County	No. of Fires
Kent	153
New Castle	242
Sussex	112

DNREC multiplied the number of vehicle fires in Delaware by a fuel-loading factor to obtain tons of material burned. A conservative assumption is that an average vehicle has 500 pounds of components that can burn in a fire (CARB, 1995). This assumption is based on a 3,700 pound average vehicle weight.

Emission Factors

Emission factors for vehicle fires are from EPA's *AP-42, Compilation of Air Pollutant Emission Factors -- Volume I: Stationary Point and Area Sources* (EPA, 1996). The emission factors are for open burning of automobile components including upholstery, belts, hoses, and tires. Table 3-64 lists the vehicle fire emission factors used in this inventory.

Table 3-64. Emission Factors for Vehicle Fires

Pollutant	Emission Factor (lb/ton burned)
VOC[a]	32
NO_x	4
CO	125

[a] reported as non-methane organic carbon (NMOC)

Temporal Allocation

Vehicle fires are assumed to take place uniformly throughout the year.

Controls

There are no control programs for this category. Therefore, CE, RP, and RE were all set to zero.

Sample Calculations and Results

An example calculation of annual emissions at the county level for pollutant x follows for vehicle fires:

$$E_x = (AC)(FLF)(EF_x)\left(\frac{1}{2000}\right)$$

where:

- AC = number of fires within the county (fires/yr)
- FLF = fuel loading factor (ton burned/fire)
- EF_x = emission factor for pollutant x (lb emitted/ton burned)
- 1/2000 = conversion from lb to ton

Table 3-65. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Vehicle Fires

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2810050000	Motor Vehicle Fires	2	< 1	8	0.01	< 0.01	0.02

References

CARB. 1995. California Environmental Protection Agency: Air Resources Board, "*Emission Inventory Procedural Manual, Vol. III: Methods for Assessing Area Source Emissions,*" 1995.

DSFM, 2004. Delaware State Fire Marshal. *2002 Mobile Property Fires*, February 2004.

EIIP, 2000. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Inventory Improvement Program, "Area Source Category Method Abstract, Vehicle Fires," May 2000.

EPA, 1996. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Compilation of Air Pollutant Emission Factors—Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42, Section 2.5, Open Burning*, 1996.

3.5.6 Wildfires

A wildfire is a natural combustion process that consumes various ages, sizes, and types of flora growing outdoors in a geographic area. Conditions in Delaware (i.e., rainfall amount, vegetation and soil type) are typically not conducive to the propagation of wildfires. However, 2002 was a drier and hotter than normal year, and consequently wildfires did occur in both forested and marsh areas. Emissions from wildfires are reported under the following area source SCC:

Table 3-66. SCC for Wildfires

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2810001000	Miscellaneous Area Sources	Other Combustion	Forest Wildfires	Total

Activity Data

Activity data for wildfires are the number of acres burned. Also necessary for the calculation of wildfire emissions are fuel-loading factors based on the weight and type of consumable vegetation per acre. There is no EIIP methodology for estimating emissions from wildfires.

Wildfire data for 2002 were obtained from the Delaware Division of Forestry (DOF). The DOF maintains the information in a database that contains the county, date, acres, vegetation type, and cause of the burn. A summary of wildfires by county is provided in Table 3-67.

Table 3-67. 2002 Wildfires by County

	Annual		Summer Season Weekdays	
County	No. of Fires	Total Acres	No. of Fires	Total Acres
Kent	6	162.5	5	158.5
New Castle	2	4	0	0
Sussex	22	1492.45	4[a]	4.25[a]

[a] 3 fires, totaling 8.1 acres, in Sussex County took place on a summer weekend

The DOF fuel-loading factors (FLF) used to calculate emissions for the 1999 inventory were used to calculate the 2002 emissions (DNREC, 2002) and are provided in Table 3-68. The FLFs are the same for all counties.

Emission Factors

Emission factors are based on those developed by the EPA in June 2003 (EPA, 2003) for calculating wildfire emissions for the NEI and are presented in Table 3-69.

Table 3-68. 2002 Fuel-Loading Factors by Vegetation Type

Vegetation Type	Fuel-Loading Factor (ton/acre)
Conifer forest	5.0
Marsh[a]	4.25
Deciduous/Conifer Mix[b]	4.25
Deciduous forest	3.5

[a]An average of phragmites and short grass FLFs
[b]An average of conifer and deciduous forest FLFs

Table 3-69. Emission Factors for Wildfires

Pollutant	Emission Factor (lb/ton burned)
VOC	13.6
NO_x	6.2
CO	289

Temporal Allocation

All wildfires that took place in June, July, or August on a weekday were included in the calculation of the SSWD daily value. Due to the sporadic nature of wildfires, the summer season daily value was estimated not on the number of summer season weekdays when a wildfire took place (seven for 2002), but rather averaged across all summer weekdays (65 for 2002). As an example of the sporadic nature of wildfires, only four fires were reported by DOF for 2003, and none of these were within the peak ozone season.

Controls

There are no control programs that apply to this source category. Therefore, CE, RE and RP were set to zero.

Sample Calculations and Results

Annual emissions are the sum of the emissions calculated for each wildfire. An example calculation of emissions for each individual wildfire for pollutant x follows:

$$E_x = (AC)(FLF)(EF_x)\left(1/2000\right)$$

where:

AC	=	total wildfire acres burned (acre)
FLF	=	average fuel loading for vegetation type burned (ton burned/acre)
EF_x	=	emission factor for pollutant x (lb emitted/ton burned)
1/2000	=	lb to ton conversion factor

Table 3-70. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Wildfires

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2810001000	Wildfires	48	22	1020	0.07	0.03	1.53

References

DNREC, 2002: Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, *1999 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NOx and CO*, 2002.

EPA, 2003. *Data Needs and Availability for Wildland Fire Emissions Inventories - Short-term Improvements to the Wildland Fire Component of the National Emissions Inventory*, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division, Emission Factor and Inventory Group by EC/R Incorporated, June 2003.

3.6 Miscellaneous Sources

Emission estimation methodologies are described in this section for the following categories:

- Bakeries,
- Catastrophic/Accidental Release,
- Commercial Cooking,
- Inactive Landfills,
- Leaking Underground Storage Tanks, and
- Publicly Owned Treatment Works.

3.6.1 Bakeries

This category covers VOC emissions from yeast leavening of baked goods at commercial bakeries. Either the straight-dough or sponge-dough process accomplishes yeast leavening. Commercial bakeries use the sponge-dough process almost entirely and it has the longest fermentation time required in the bread baking cycle. Emissions from the straight-dough process are negligible compared to the sponge-dough process since this process is less commonly used in commercial bakeries. Emissions from bakeries are reported under the following area source SCC:

Table 3-71. SCC for Bakeries

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2302050000	Industrial Processes	Food and Kindred Products: SIC 20	Bakery Products	Total

Point source bakery emissions are reported under the 30203201 and 30203202 SCCs. However, no bakeries reported under the point source inventory.

Activity Data

The preferred EIIP methodology for estimating emissions from bakeries is to survey a representative sample of typical bakeries, and scale those results by employment data available from the BOC or from a state or local commerce department or labor office. Dun and Bradstreet data indicated a total of ten Delaware facilities in standard industrial classification (SIC) code 2051 (bread, cake, and related products); however less than half of these appear to be sizable operations (e.g., >$0.2MM/yr in revenue).

DNREC contacted the larger facilities to gather information on the amount of leavened dough baked each year by either the straight- or sponge-dough process. Of the six facilities contacted, two indicated that no baking takes place on the premises. The amount of dough produced was obtained for each of the other four facilities. Two facilities were not able to answer whether they used the straight- or sponge-dough process. For these two facilities, it was assumed that they use the straight-dough process. These activity data were paired with the VOC emission factors provided below (EIIP, 1999). DNREC did not scale the results of the survey data to the four remaining smaller bakeries, since it was not clear whether these facilities produce significant amounts of bread. In addition to the amount of dough baked, the survey also requested information on whether or not any emissions controls are in place. None of the surveyed bakeries have any emission control equipment. Each of the four facilities surveyed were allocated to the county in which they are located.

Emission Factors

The sponge-dough emission factor found in the EIIP document for baked goods is given as a range of five to eight pounds of VOC per 1000 pounds baked goods. The low end of the range was recommended by EPA; therefore 5 lb VOC/1000 lb baked goods using the sponge-dough process was used (EIIP, 1999). For products based on the straight-dough process, the EIIP recommends an emission factor of 0.5 lb VOC/1000 lb baked goods.

Temporal Allocation

Emissions from bakeries are not expected to vary substantially from season to season. Therefore, a uniform monthly allocation was assumed. Daily allocation was six days per week.

Controls

There are no control programs that apply to this source category. Therefore, CE, RE and RP were set to zero.

Sample Calculations

An example calculation for annual VOC emissions for facility x follows:

$$E_x = (AC)(EF)\left(\frac{1}{2000}\right)$$

where:

AC = annual dough baked (1000 lb)
EF = VOC EF for either the straight- or sponge-dough process (lb VOC/1000 lb dough baked)
1/2000 = conversion factor (pounds to tons)

Table 3-72. 2002 Statewide Annual and SSWD VOC Emissions for Bakeries

SCC	Category Description	VOC	
		TPY	TPD
2302050000	Bakery Products	1	< 0.01

References

EIIP, 1999. *Baked Goods at Commercial/Retail Bakeries, Area Source Method Abstracts*, Chapter 5, Emission Inventory Improvement Program, Area Sources Committee, July 1999.

3.6.2 Catastrophic/Accidental Releases

This category covers emissions occurring from catastrophic or accidental releases reported into the National Response Center (NRC) of the U.S. Coast Guard (USCG). Information on the date, location, and facility reporting the release are included. Also included are reported amounts of release. Emissions from these releases are reported under the following area source SCC:

Table 3-73. SCC for Catastrophic/Accidental Releases

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2830000000	Miscellaneous Area Sources	Catastrophic/Accidental Releases	All Catastrophic/ Accidental Releases	Total

Activity Data

The activity data were downloaded from the NRC web-site (USCG, 2004) including the date and location of the incident and the amount and type of material released. If an amount was not provided, no emissions were estimated. For releases of liquid volatile materials, DNREC assumed that 100% of the material evaporated as emissions.

Facilities reporting to DNREC under the point source program are required to report accidental releases separate from normal process operations. Since the NRC data provides the incident location and name of facility (for non-transportation accidents), the data could be cross-checked to point source data. Accidental releases reported by facilities under point sources were removed from area source activity data. All other accidental releases were reported under area sources and allocated to the county in which the incident took place.

Emission Factors

As mentioned above, releases of all volatile materials are assumed to be emitted into the air. Research was performed to identify an appropriate volatile fraction to apply to the estimated release quantity of semi-volatile materials (e.g., crude oil), if these materials were identified in the NRC data.

Temporal Allocation

Emissions were allocated based on the dates provided in the NRC database. Only one release occurred during the ozone season. The SSWD allocation factor was based on emissions from this incident and on a uniform weekly profile.

Controls

There are no control programs that apply to this source category. Therefore, CE, RE and RP were set to zero.

Sample Calculations and Results

An example calculation of emissions for release x follows:

$$E_x = (RM)(VF)\left(\frac{1}{2000}\right)$$

where: RM = release mass (lbs)
VF = volatile fraction
1/2000 = conversion from lb to ton

Table 3-74. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Catastrophic/Accidental Releases

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2830000000	Catastrophic/Accidental Releases	1	< 1	0	< 0.01	0	0

References

USCG, 2004. 2002 accidental releases of ammonia, downloaded from http://www.nrc.uscg.mil/foia.html, U.S. Coast Guard, accessed January 2004.

3.6.3 Commercial Cooking

The commercial cooking source sector is defined as the use of cooking equipment, including charbroilers, griddles, and deep fat fryers, in commercial food establishments. The following types of establishments will not be included in the inventory: residential or special-event cooking and charbroiling (e.g., county fairs, fundraising events) and cooking processes at institutional facilities (e.g., school or prison cafeterias). This inventory includes the following commercial cooking SCCs:

Table 3-75. SCCs for Commercial Cooking

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2302002000	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking -Charbroiling	Charbroiling Total
2302002100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Charbroiling	Conveyorized Charbroiling
2302002200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Charbroiling	Under-fired Charbroiling
2302003000	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Deep Fat Frying
2302003100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Flat Griddle Frying
2302003200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Clamshell Griddle Frying

Activity Data

There is no EIIP methodology for estimating emissions from commercial cooking. Emissions for this inventory were taken from the NEI (Pechan, 2003). In this effort, activity data were estimated based on data provided by a survey conducted by the Public Research Institute (PRI) for CARB (PRI, 2001). The survey data provide the following information by type of restaurant: the fraction of restaurants using each type of cooking equipment, the average number of pieces of each type of equipment, and the average pounds of specific types of meat cooked on each piece of equipment. These factors were applied to county-level facility counts from Dun & Bradstreet to estimate the total amount of meat cooked on each type of equipment (D&B, 2002).

Emission Factors

Emission factors for criteria pollutants are specific to the type of cooking equipment and the type of meat being cooked. The emission factors were based on the results of several studies as documented by Pechan (Pechan, 2003). The original form of the emission factors was grams/kilogram of meat for each equipment type (converted to lb/ton of meat). These emission factors were combined with the county-level activity data described above (ton meat/county for each equipment type) to estimate emissions.

Temporal Allocation

Uniform distribution of activity for weekly and monthly allocation was assumed.

Controls

There are no control programs that apply to this source category. Therefore, CE, RE and RP were set to zero.

Results

Table 3-76. 2002 Statewide Annual and SSWD VOC and CO Emissions for Commercial Cooking

SCC	Category Description	VOC		CO	
		TPY	TPD	TPY	TPD
2302002100	Commercial Cooking - Conveyorized Charbroiling	6	0.02	20	0.06
2302002200	Commercial Cooking - Under-fired Charbroiling	18	0.05	60	0.16
2302003000	Commercial Cooking - Deep Fat Frying	3	0.01	ND	ND
2302003100	Commercial Cooking - Flat Griddle Frying	2	0.01	5	0.01
2302003200	Commercial Cooking - Clamshell Griddle Frying	< 1	< 0.01	ND	ND
230200xxxx	**Total: Commercial Cooking**	**30**	**0.08**	**85**	**0.23**

References

D&B, 2002, *MarketPlace CD-ROM, Jan-Mar, 2002*, Dun & Bradstreet, Waltham, MA, 2002.

Pechan, 2003, *Methods for Developing a National Emission Inventory for Commercial Cooling Processes: Technical Memorandum*, prepared by E.H. Pechan & Associates, Inc., under contract to Emission Factor and Inventory Group, U.S. Environmental Protection Agency, Research Triangle Park, NC September 30, 2003.

PRI, 2001, *Charbroiling Activity Estimation, Draft Report*, prepared by Public Research Institute, Potepan, Michael, prepared for California Environmental Protection Agency, California Air Resources, Board, June 20, 2001.

3.6.4 Landfills (Inactive)

This category covers VOC emissions from closed landfills. Active landfills, and one large inactive landfill (Pigeon Point), reported as point sources. The Landfill Gas Emissions Model (LandGEM) version 2.0 was employed to estimate the air emissions from these landfills. The biodegradation of refuse in landfills produces landfill gas (LFG), mainly consisting of methane and carbon dioxide, with trace amounts (less than 1% of the total landfill gas) of non-methane organic compounds (NMOC). For landfills, NMOC is used as a surrogate for VOC.

The LFG generation rate, and thus the rate of air emissions from landfills, is highly variable from landfill to landfill. Emissions from landfills are reported under the following area source SCC:

Table 3-77. SCC for Inactive Landfills

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2620030000	Waste Disposal, Treatment, and Recovery	Landfills	Municipal	Total

Activity Data

Data for closed landfills were obtained from the DNREC Environmental Navigator System (DENS), a multi-program database of Delaware facility information available on-line. The information obtained from DENS included site name and address, present owner, dates when waste was accepted, and acreage in waste. Most of the landfills were owned and operated by municipalities (i.e., the six landfills in Sussex County) while several were commercial operations. Depth of waste (needed to calculate the amount of waste in place) was obtained by contacting the site owners.

Sites within DENS that were inactive for more than 25 years were assumed to emit negligible VOCs due to limited waste degradation beyond that time. Therefore, for the 2002 inventory, any landfill still accepting waste after 1976 was included in the activity data for estimating emissions. Table 3-78 includes a county summary of landfills included in this source category.

Table 3-78. Inactive Landfills by County

County	No. of Landfills	Total Acreage in Waste	Last Year Accepting Waste
Kent	1	100	1980
New Castle	4	71.5	1977 to 1987
Sussex	6	259.5	1979 to 1984

LandGEM2.0 estimates emission rates based on the equations and data provided in AP-42 Section 2.4 (EPA, 1997). The landfill gas generation rate in this model is based on a first order decomposition model, which estimates the landfill gas generation rate using two parameters: Lo, the potential methane generation capacity of the refuse, and k, the methane generation decay rate, which accounts for how quickly the methane generation rate decreases, once it reaches its peak rate. The methane generation rate is assumed to be at its peak upon placement of the refuse in the landfill. This model provides an opportunity to enter Lo and k values using actual test data and landfill specific parameters, or use default Lo and k values derived from test data collected in the course of research for federal regulations governing air emissions from municipal solid waste landfills.

The amount of refuse in the landfill is calculated for this model using site-specific characteristics of the landfill entered by the user, such as the years the landfill was in operation, the amount of refuse in place in the landfill, and the design capacity. No waste density data were available for landfills included in this source category. The LandGEM default waste density was used.

Emission Factors

The emission factor for NMOC was obtained from AP-42 (EPA, 1997). As mentioned above, NMOC is the surrogate for VOC.

Temporal Allocation

Emissions from this source category are not expected to vary substantially from season to season. Uniform monthly and weekly temporal allocations were assumed.

Controls

All inactive landfills are uncontrolled. Therefore, CE, RP, and RE were all set to zero.

Sample Calculations

The LandGEM Model for uncontrolled emissions was employed. The primary equation used to estimate LFG emissions follows (total LFG is determined by including the CO_2; NMOC emissions are a fraction of the total LFG emissions):

$$Q_{CH4} = L_o R(e^{-kc} - e^{kt})$$

where:

Q_{CH4}	=	methane generation rate at time, t (m^3/yr)
L_o	=	methane generation rate potential (m^3 CH_4/Mg refuse)
R	=	average annual refuse acceptance rate during active life (Mg/yr)
e	=	base log unit less
k	=	methane generation rate constant (yr^{-1})
c	=	time since landfill closure (yr; c = 0 for active landfills)
t	=	time since the initial refuse placement (yr)

Table 3-79. 2002 Statewide Annual and SSWD VOC Emissions for Inactive Landfills

SCC	Category Description	VOC	
		TPY	TPD
2620030000	Inactive Landfills	42	0.11

References

EPA, 1997. *Compilation of Air Pollutant Emission Factors, AP-42 Section 2.4, Municipal Solid Waste Landfills*, U.S. Environmental Protection Agency, 1997.

3.6.5 Leaking Underground Storage Tanks

Leaking underground storage tanks (LUSTs) are typically not considered a quantifiable source of air emissions until excavation and remediation efforts begin. The majority of air emissions from leaking underground storage tank site remediation occur during initial site action, which is typically tank removal. During tank removal, the leaking tank and the surrounding soil are removed and the soil is either placed in piles or evenly spread across the ground to allow volatilization of the contaminants into the atmosphere. Most of the contaminants are volatilized during the first day.

Table 3-80. SCC for Remediation of Leaking Underground Storage Tanks

SCC	Descriptor 1	Descriptor 3	Descriptor 8
2660000000	Waste Disposal, Treatment, and Recovery	Leaking Underground Storage Tanks	Total

Activity Data

The preferred method from EIIP was used (EIIP, 2001), which is to obtain local data on tank remediations. Information on tank remediations were obtained from a database provided by DNREC's Tanks Management Branch (TMB). The information within the LUST database did not contain site specific information including tank dimensions, amount of soil excavated and soil density and contamination concentration. To obtain this specific information, individual TMB hydrologists were contacted.

For emission estimation purposes, DNREC considered only LUSTs that contained volatile organic products. Gasoline was the only reported volatile material associated with remediations in 2002. Emissions from remediation of distillate oil-contaminated soils are considered negligible due to low volatility. Soils contaminated with low volatility hydrocarbons are typically taken off-site to be remediated by incineration. The number of site remediations in 2002 involving leaking gasoline tanks and the number of tanks (containing gasoline) removed at these sites are provided in Table 3-81.

Table 3-81. 2002 LUST Remediations by County

County	No. of Sites[a]	No. of Tanks Removed[b]
Kent	1	6
New Castle	3	5
Sussex	2	6

[a] Only sites with leaking gasoline tanks
[b] Only those tanks that contained gasoline

Emission Factors

Emissions were based on the assumption that all product contained in the excavated gasoline-contaminated soils volatilize on-site during the soil remediation. Data on the amount of soil excavated, the average concentration of total petroleum hydrocarbons (TPHs) within the soil excavated, the soil density, and the number of soil excavation and remediation days were provided by the TMB. For one remediation, the amount of soil excavated was not provided by the TMB. Therefore, a default value of 500 cubic yards per tank was used. The product of the amount of soil excavated, the density of the soil, and the contamination concentration on a percent weight basis yields the total amount of VOC contained in the excavated soil which is assumed to be released to the air over the duration of the remediation.

Temporal Allocation

For 2002, no tanks containing gasoline were removed during the ozone season, however exact dates when the soil was subsequently remediated were not available from the TMB. However, the LUST database does provide an inspection date when the TMB hydrologist performs the follow-up inspection to deem the site remediation complete. Using the bracket of time between the tank removal date and the hydrologist's inspection date, only one site remediation could fall within the 2002 peak ozone season. The assumption was made that emissions from this remediation did occur during the summer season. Emissions for this remediation were average over the peak ozone season (92 days).

Controls

The emissions are estimated as uncontrolled. Therefore, CE, RP, and RE were all set to zero.

Sample Calculations and Results

Annual VOC emissions are the sum of the emissions calculated for each site remediation. An example calculation of emissions for county x follows:

$$E_x = \sum_{i=1}^{n} (SE_i)(SD_i)(C_i)\left(1/2000\right)$$

where:

	SE_i	=	amount of soil excavated for remediation *i* (cu yd)
	SD_i	=	soil density (lb/cu yd)
	C_i	=	average concentration of TPH in the excavated soil (ppmw)
	1/2000	=	lb to ton conversion factor

Table 3-82. 2002 Statewide Annual and SSWD VOC Emissions for LUST Remediations

SCC	Category Description	VOC	
		TPY	TPD
2660000000	LUST Remediations	13	< 0.01

References

EIIP, 2001. Emission Inventory Improvement Program, Area Sources Committee, *Remediation of Leaking Underground Storage Tanks, Area Source Method Abstracts*, EIIP Volume III, May 2001.

3.6.6 Publicly-Owned Treatment Works

This source category accounts for fugitive emissions from publicly-owned treatment works (POTW). The wastewater collection system upstream of the POTW is open to the atmosphere and allows for volatilization of VOCs from the wastewater; however, estimating these emissions is beyond the scope of this category.

The magnitude of VOC emissions from POTWs depends on many factors such as the physical properties of the pollutants, pollutant concentration, flow rate, the temperature and pH of the wastewater, and the design of the individual collection and treatment units. All of these factors, as well as the general scheme used to collect and treat facility wastewater, have a major effect on emissions. Collection and treatment schemes are facility specific. The flow rate and organic composition of wastewater streams at a particular facility are functions of the processes used. The wastewater flow rate and composition, in turn, influence the sizes and types of collection and treatment units that must be employed at a given facility (EIIP, 1997).

There are 17 POTW facilities reported under the area source category. The Wilmington Wastewater Treatment Plant is the only facility included in the 2002 point source inventory. The point source POTW SCC is 50100701. VOC emissions from POTWs are reported under the following area source SCC:

Table 3-83. SCC for POTWs

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2630020000	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	Public Owned	Total Processes

The EIIP preferred method for estimating emissions from POTWs is the use of computer based emissions models (EIIP, 1997) such as EPA's WATER9 program. Use of the WATER9 program requires process-level details for each facility, as well as information on influent chemistry. Conducting facility-level surveys to gather wastewater chemistry data and to perform facility-specific modeling with the survey data was beyond the scope of this inventory. Instead, DNREC developed an inventory based on VOC data previously reported to DNREC by point source POTWs.

Activity Data

DNREC's Division of Water Resources provided wastewater flow rates and biosolids production for all 18 POTW facilities in Delaware. Wilmington and Kent County are the two largest POTWs, which comprise about 93% of Delaware's POTW daily flow (as stated above the Wilmington site is included in the point source inventory). Each POTW was assigned to the county in which it resides.

Emission Factors

The Wilmington Sewage Treatment Plant, the largest POTW in Delaware, reported VOC emissions to DNREC under the point source inventory. In addition, emissions for the Kent County Sewage Treatment Plant were estimated based on a previously reported VOC emission rate (lb VOC/million gallons of wastewater) reported for the 1999 inventory (Fees, 2004). Emission rates from these two facilities were averaged and applied to the other 16 POTWs. Since these data are specific to Delaware, these emission rates were favored over other sources of data.

Table 3-84. VOC Emission Factors for Delaware POTWs

Facility	Emission Factor ($lb/10^6$ gallons)
Wilmington	0.0344
Kent County	0.32
Other POTWs	0.1772[b]

[b] Developed as the average of the Wilmington and Kent County EFs

Temporal Allocation

POTWs are designed to run under steady state operation. Although flows may vary by day of the week and hour of the day, it is reasonable to assume uniform distribution of monthly and weekly emissions.

Controls

There are no control programs that apply to this source category. Therefore, CE, RE and RP were set to zero.

Sample Calculation

An example calculation of annual facility-level VOC emissions (tons/yr) for a POTW follows:

$$E = W \times EF \times 1/2000$$

where:

W	=	wastewater flow rate (million gallons/yr)
EF	=	emission factor (lb/million gallons)
1/2000	=	conversion from pounds to tons

Table 3-85. 2002 Statewide Annual and SSWD VOC Emissions for Publicly-Owned Treatment Works

SCC	Category Description	VOC	
		TPY	TPD
2630020000	POTWs – All Processes	1	< 0.01

References

EIIP, 1997. *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment, Volume II*, Chapter 9, Emission Inventory Improvement Program, Point Sources Committee, March 1997.

Fees, D. 2004. D. Fees, DNREC, Kent County WWTP 1999 Emission Estimates, Facsimile to Ying Hsu, E.H. Pechan & Associates, Inc. on February 6th, 2004