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2002 Base Year Ozone State Implementation Plan Emissions Inventory for VOC, NOx, and CO for the State of Delaware

D R A F T

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ACRONYMS & ABBREVIATIONS

ACD	administrative completeness determination
AFS	Air Facility System
AIM	architectural and industrial maintenance
AP-42	EPA Compilation of Air Pollution Emission Factors
AQMS	Delaware Air Quality Management Section (DNREC)
ARP	Delaware Accidental Release Prevention Program (DNREC)
ASTM	American Society for Testing and Materials
ATP	Anti-tampering Program
ATV	all-terrain vehicle
BEA	Bureau of Economic Analysis
BEIS	Biogenic Emission Inventory System
BELD	Biogenic Emissions Landcover Database
BOC	Bureau of Census
C&D	Chesapeake and Delaware
CAF	county allocation factor
CARB	California Air Resources Board
CD	compact disc
CE	control efficiency
CEM	continuous emission monitor
CERR	Consolidated Emissions Reporting Rule
CFR	Code of Federal Register
CG	cloud-to-ground
CGA	cylinder gas audit
CH_4	methane
CMLF	Cape May-Lewes Ferry
CMV	commercial marine vessel
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CTG	Control Techniques Guideline
cu yd	cubic yard
D&B	Dun & Bradstreet
DAA	Delaware Aeronautics Administration
DAFB	Dover Air Force Base
DARS	Data Attribute Rating System
DATAS	Delaware Air Toxics Assessment Study
DDA	Delaware Department of Agriculture
DDPR	Division of Parks and Recreation (DNREC)
DE	Delaware
DE ANG	Delaware Air National Guard
DE ARNG	Delaware Army National Guard
DE DOL	Delaware Department of Labor
DE F&W	Division of Fish & Wildlife (DNREC)
DelDOT	Delaware Department of Transportation

ACRONYMS & ABBREVIATIONS continued

DENS	Delaware Environmental Navigator System
DMV	Delaware Division of Motor Vehicles (DelDOT)
DNREC	Department of Natural Resources and Environmental Control
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
DOF	Delaware Division of Forestry (DDA)
DPC	Delaware Population Consortium
DRBA	Delaware River and Bay Authority
DSC	Delaware State Climatologist
DSFM	Delaware State Fire Marshal
DSWC	Division of Soil and Water Conservation (DNREC)
DWT	dead weight tonnage
E&C	Engineering and Compliance Branch (DNREC-AQMS)
EDMS	Emissions and Dispersion Modeling System
EF	emission factor
EGAS	Economic Growth Analysis System
EGR	exhaust gas recirculation
EGU	electric generating unit
EIA	Energy Information Administration
EID	Delaware Emission Inventory Development Program (DNREC-AQMS)
EIIP	Emission Inventory Improvement Program
EO	ethylene oxide
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERG	Eastern Research Group
ETS	Emissions Tracking System
FAA	Federal Aviation Administration
FCI	fuel consumption index
FHWA	Federal Highway Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIPS	Federal Information Processing Standards
FIRE	Factor Information Retrieval System
FLF	fuel-loading factor
FP & GC	fuel pressure and gas cap test
g	gram
GAF	geographic allocation factor
GIS	geographical information system
GSE	ground support equipment
GTM	gross ton-miles
GVWR	gross vehicle weight rating
HAP	hazardous air pollutants
HC	hydrocarbon
HDD	heating degree-day
HDDV	heavy-duty diesel vehicle

ACRONYMS & ABBREVIATIONS continued

HDGV	heavy-duty gas vehicle
HDV	heavy-duty vehicle
hp	horsepower
HPMS	Highway Performance Monitoring System
HPV	high-profile violator
IC	intra-cloud
ICAO	International Civil Aviation Organization
IFO	Intermediate Fuel Oil
I/M	Inspection and Maintenance
IPP	Inventory Preparation Plan
KC	Kent County (Delaware)
LandGEM	Landfill Gas Emissions Model
lb	pound
LDGT	light-duty gas truck
LDGV	light-duty gas vehicle
LDT	light-duty truck
LDV	light-duty vehicle
LEV	low-emission vehicle
LFG	landfill gas
LPG	liquefied petroleum gas
LTO	landing/takeoff
LUST	leaking underground storage tank
MACT	maximum achievable control technology
MANE-VU	Mid-Atlantic – Northeast Visibility Union
MARAMA	Mid-Atlantic Regional Air Management Association
MC	method code (*i*-STEPS)
Mg	megagram
MMBtu	million British thermal units
mph	miles per hour
MRI	Midwest Research Institute
MSW	municipal solid waste
N	nitrogen
NAAQS	National Ambient Air Quality Standard
NAICS	North American Industry Classification System
NCC	New Castle County (Delaware)
NCDC	National Climatic Data Center
n.e.c.	not elsewhere classified
NEI	National Emissions Inventory
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFDC	National Fire Data Center
NH_3	ammonia
NIF	NEI Input Format
NMOC	non-methane organic compound
NO	nitric oxide

ACRONYMS & ABBREVIATIONS continued

NO_x	oxides of nitrogen
NPCA	National Paint and Coatings Association
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
OBD	on-board diagnostics
OEM	original equipment manufacturer
OHV	off-highway vehicle
OIT	Office of Information Technology (DNREC)
OMNI	OMNI Environmental Services, Inc.
ORIS ID	Office of Regulatory Information System Identification
ORVR	on-board refueling vapor recovery
OTAQ	Office of Transportation Air Quality (USEPA)
OTC	Ozone Transport Commission
OTR	Ozone Transport Region
OWB	outdoor wood boiler
PCV	positive crankcase ventilation
pdf	portable document format
Pechan	E.H. Pechan & Associates, Inc.
PEI	Periodic Emissions Inventory
PFC	portable fuel container
PIA	Printing Industries of America, Inc.
$PM_{2.5}$-PRI	particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers
PM_{10}-PRI	particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers
ppm	parts per million
ppmw	parts per million by weight
POTW	publicly-owned treatment works
POW	Port of Wilmington
PRI	Public Research Institute
P/V	pressure/vacuum
QA	quality assurance
QC	quality control
R&D	research and development
RATA	relative accuracy test audit
RE	rule effectiveness
RP	rule penetration
rpm	revolutions per minute
RSD	Regulatory Support Document
RSZ	reduced speed zone
RTO	regenerative thermal oxidizer
RVP	Reid vapor pressure
RWC	residential wood combustion
SARA	Superfund Amendments and Reauthorization Act

ACRONYMS & ABBREVIATIONS continued

SC	Sussex County (Delaware)
SCC	source classification code
SCR	selective catalytic reduction
SEPTA	Southeast Pennsylvania Transportation Authority
SI	spark ignition
SIC	Standard Industrial Classification code
SIP	State Implementation Plan
SM	Synthetic Minor permit classification
SNCR	selective non-catalytic reduction
SO_2	sulfur dioxide
SSWD	summer season weekday
TAF	temporal allocation factor
TCEQ	Texas Commission on Environmental Quality
TDM	travel demand model
Tg	teragram
TG	touch-and-go
THC	total hydrocarbons
TIM	time-in-mode
TMB	Delaware Tanks Management Branch (DNREC)
T/O	test only
TOC	total organic carbon
TPD	tons per day
TPH	total petroleum hydrocarbons
TPY	tons per year
TRI	Toxics Release Inventory
TSDF	treatment, storage, and disposal facility (hazardous waste)
U.S.	United States
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VMT	vehicle miles traveled
VOC	volatile organic compound
WWTP	wastewater treatment plant

SECTION 1

2002 OZONE PRECURSOR INVENTORY OVERVIEW AND SUMMARY

In 1997, the U.S. Environmental Protection Agency (EPA) promulgated a revised National Ambient Air Quality Standard (NAAQS) for ground-level ozone at a concentration of 0.08 ppm averaged over eight hours. The new standard supersedes the 1-hour ozone standard of 0.12 ppm (EPA, 2005). All three of Delaware's counties (Kent, New Castle, and Sussex) have been designated non-attainment for the 8-hour standard based on 2000-2002 monitoring data. All three counties were included in the Philadelphia-Wilmington-Atlantic City non-attainment area which is listed as a "moderate" area with an attainment date of June 15, 2010 (EPA, 2003). The 8-hour standard went into effect on June 15, 2004 following final non-attainment area boundary designations (EPA, 2004).

EPA established calendar year 2002 as the base year inventory for the new ozone standard (EPA, 2002a), thus requiring states with 8-hour ozone non-attainment areas to submit as part of their State Implementation Plan (SIP) a comprehensive, accurate, and current base year inventory of actual emissions of ozone-causing pollutants from all sources. Ozone-causing pollutants, also known as ozone precursors, include volatile organic compounds (VOCs), oxides of nitrogen (NO_x), and carbon monoxide (CO).

This report documents Delaware's completed 2002 statewide inventory of ozone precursors for all sources including the following five major source sectors: stationary point, stationary non-point, on-road mobile, non-road mobile, and natural.

1.1 Project Management

The Delaware Air Quality Management Section (AQMS) of the Department of Natural Resources and Environmental Control (DNREC) manages Delaware's SIP. The Emission Inventory Development (EID) Program within the Planning Branch of AQMS was responsible for preparing the 2002 base year ozone precursor inventory.

Internal planning began in September 2002, with focus on the 2002 point source inventory reporting cycle taking place in March/April of 2003. Due to a staffing shortage, the EID Program sought contractual assistance for developing the inventory, and in November 2002 began the open bid procurement process. AQMS contracted with E.H. Pechan and Associates (Pechan) based in Durham, North Carolina, who joined the project in August 2003.

1.1.1 Project Manager

The overall project manager was David Fees, Program Manager for the EID Program. Responsibilities included:

- Procuring contractual services to assist inventory effort;
- Managing the contract with Pechan;
- Identifying overall inventory goals, objectives, and deadlines;
- Maintaining the official, approved Quality Assurance Project Plan (QAPP);

- Overseeing the development of the IPP;
- Approving estimation methodologies recommended by staff and the contractor;
- Reviewing emission estimation work;
- Coordinating quality control and quality assurance efforts;
- Conducting project meetings; and
- Ensuring that deadlines were met.

1.1.2 Point Sources Technical Lead

The point source technical planning and review was performed by John Outten, a senior environmental scientist for the EID Program. Responsibilities included:

- Identifying point source inventory goals, objectives, and deadlines;
- Establishing the universe of facilities to inventory;
- Overseeing the development of the survey forms and instructions;
- Providing training and guidance to industry representatives;
- Setting up the on-line electronic reporting system and working with DNREC's Office of Information Technology in preparing the on-line reporting capabilities;
- Performing a technical review of emissions data submitted by facilities;
- Working with facility representatives to correct errors;
- Managing the point source inventory database; and
- Overseeing quality control of point sources data.

1.1.3 Point Sources Support

Support of the point source inventory was performed by Marian Hitch, a senior environmental specialist for the EID Program. Responsibilities included:

- Gathering facility general information on facilities to be surveyed;
- Assisting in developing survey forms and instructions;
- Preparing and mailing reporting packages;
- Receiving and organizing reports submitted by facilities;
- Entering data into the point source inventory database;
- Performing an administrative review of all reports received;
- Tracking reporting status of each facility; and
- Preparing and organizing documentation for the point source inventory.

1.1.4 Contractor Assistance

The project leader for Pechan was Randy Strait, Director of Southeast Operations. Mr. Strait also assisting EID staff with the point source inventory development. Due to staff shortages within EID, Pechan took the lead for developing stationary non-point sources (led by Steve Roe, Senior Scientist), on-road mobile sources (led by Maureen Mullen, Senior Chemical Engineer), and non-road mobile sources (led by Kirstin Thesing, Environmental Scientist). Responsibilities included:

- Establishing the list of source categories in each sector to inventory;

- Establishing prioritization of categories;
- Researching available emission estimation methods and supplying recommendations to the project manager;
- Developing survey instruments for categories to be surveyed;
- Gathering activity data through request letters and other means as was necessary to obtain the data required for the selected methods;
- Developing databases and/or spreadsheets necessary to manage data and calculate emissions;
- Preparing and organizing documentation in support of emission estimates;
- Performing quality control of the data; and
- Ensuring that timelines were met.

1.1.5 Non-point Sources Support

Support of the non-point source inventory was performed by Harry Jeudy, an engineer who joined the EID Program in September 2003. Responsibilities included:

- Assisting Pechan in obtaining activity data;
- Reviewing emission calculations;
- Preparing report documents; and
- Compiling supporting documentation.

1.1.6 Quality Assurance Coordinators

Quality assurance outside the EID Program was conducted by Dr. Frank Gao, senior engineer for the Planning Branch within AQMS, and Philip Wheeler, mobile sources planner for the Planning Branch. Dr. Gao is responsible for developing control strategies for attainment of the 8-hour ozone standard. Mr. Wheeler is responsible for transportation conformity and on-road mobile projection inventories. Both are knowledgeable of VOC and NO_x sources, emission estimation methodologies and controls in their respective areas of expertise.

Quality assurance responsibilities associated with the 2002 inventory included evaluating emission estimation methodologies, reviewing model input and output files, assessing application of controls, rule effectiveness and rule penetration, and reviewing emission totals.

1.2 Inventory Planning

Calendar year 2002 was established not only as the base year for ozone attainment planning, but also as the base year for both fine particulates and regional haze SIP planning. In addition, 2002 was designated by AQMS to include a detailed air toxics inventory in support of dispersion modeling as part of a statewide air toxics assessment study. Finally, in 2002 EPA promulgated the Consolidated Emissions Reporting Rule (CERR), which established new reporting requirements for State and local agencies (EPA, 2002b).

As a result of these several purposes, the 2002 inventory included all criteria pollutants and their precursors (VOC, NO_x, CO, SO_2, PM_{10}-PRI, $PM_{2.5}$-PRI, and NH_3) and all Hazardous Air Pollutants (HAPs) identified in Section 112(b)(1) of the Clean Air Act.

To summarize, the 2002 Delaware air emissions inventory was developed with several purposes in mind. These included a:

- Base year ozone precursor inventory for non-attainment of the 8-hour standard;
- Base year fine particulate and regional haze inventory;
- Modeling inventory for the Delaware Air Toxics Assessment Study (DATAS);
- Milestone demonstration year inventory for the 1-hour ozone standard; and to
- Meet the CERR requirements.

As of June 15, 2005, the 1-hour ozone standard was revoked and replaced by the 8-hour standard. Therefore, milestone demonstrations under the 1-hour standard are no longer required.

With the several purposes for the 2002 inventory identified, the EID Program, with the assistance of its contractor, developed an Inventory Preparation Plan (IPP) for each source sector except natural sources. The source sectors include point sources, non-point sources, on-road mobile sources, and non-road sources. The IPPs identified the following:

- **Data quality needs** – established the level of quality needed to ensure the inventory would meet the several inventory purposes;
- **Inventory parameters** - identified the pollutants to be inventoried, the geographic coverage, and the spatial and temporal resolution;
- **Emission sources –** enumerated all sources within the geographic area that emit one or more of the pollutants to be inventoried;
- **Estimation methodologies –** researched and selected the method to be used for each source category, based on quality of method output, quality and availability of method inputs, importance of category to the overall inventory, and time and resource constraints;
- **Data collection –** identified data collection methods based on estimation methodologies chosen;
- **Data management –** identified data management methods, including data storage, data calculations, and data table outputs;
- **Documentation –** identified the expected level of documentation necessary in support of the inventory; and
- **Quality assurance/quality control (QA/QC) –** established QC procedures to reduce errors and increase the completeness and accuracy of the emission estimates, and established QA procedures to demonstrate that data quality needs had been met.

1.2.1 Data Quality Needs

The development of the modeling inventory for the DATAS project represented the most rigorous and detailed of the several inventories that were developed for 2002. Since criteria pollutant data (i.e., VOCs and particulate matter) were speciated in many instances to arrive at air toxic emissions, the criteria pollutant emissions were developed to the same level of detail as the air toxics. In achieving the data quality needs for DATAS, most requirements for the other purposes were met.

The 2002 ozone precursor inventory as a SIP element represents a Type II inventory per EPA guidance (EIIP, 1997). The inventory will provide support for AQMS planners as they develop control strategies believed necessary to achieve attainment of the 8-hour ozone standard. Percent reductions as part of progress plans are developed from the base year. For both of these uses, it is important the inventory individually assign emissions to very specific sources (identified by Source Classification Codes, or SCCs) in order to delineate reductions to be gained through implemented control measures.

Data quality needs pertaining to accuracy, completeness, representativeness, and comparability were considered and documented as part of the IPP development process. Special effort was given to the larger point sources and those area sources contributing most significantly to emissions of VOCs and/or NO_x.

Qualitative assessments of accuracy are described in the respective source sector sections of the report. However, quantitative measures of uncertainty (such as the Data Attribute Rating System, or DARS scores) were not employed in the developed of this inventory.

Representativeness was considered a priority of the inventory, as well as an area where AQMS could make a difference. Considerable effort was given to obtaining local activity data (and to a lesser extent, local emission factors) for estimating non-point source emissions. Point source emission thresholds for VOCs and NO_x were established much lower than typical definitions of major sources in order to increase point source backouts within some highly uncertain area source category emission estimates.

Completeness was also considered a priority of the inventory and was best exemplified by a 100% point source reporting rate (after considerable follow-up with some facilities.) Comparability was not considered as much of a priority as it has been in past periodic emission inventories, since this inventory is a base year. AQMS believes the development of a base year inventory represents the best opportunity to apply the most current estimation methods and not be constrained by using methods applied in the past.

1.2.2 Inventory Parameters

The inventory parameters defined by the ozone precursor inventory needs include the following:

- **Inventory year –** the base year inventory is calendar year 2002;
- **Pollutants –** ozone precursors include VOCs, NO_x, and CO;
- **Source coverage –** all sources, including point, stationary non-point, mobile, non-road, and natural sources;
- **Spatial resolution –** for purposes of developing a SIP inventory for ozone precursors, county level emissions for all non-point sources and geocoded point source emissions;
- **Geographic coverage –** since all counties in Delaware are in non-attainment of the 8-hour ozone standard, a statewide inventory was developed; and
- **Temporal resolution –** annual and typical summer season weekday emissions were developed.

EPA issued guidance to state and local agencies indicating that for purposes of meeting the CERR requirements with respect to biogenic emissions, that an agency could accept EPA's development of biogenic emissions in lieu of submitting its own biogenics inventory. AQMS accepted the biogenic emissions as developed by EPA, and is incorporating those emission estimates into this report.

For purposes of this inventory, VOCs and NO_x are defined in Regulation 1101 of the Delaware Regulations Governing the Control of Air Pollution (DNREC, 1993). Only those VOCs that participate in atmospheric photochemical reactions are included in the VOC emissions quantified in this report. Speciated VOC data were obtained from point sources, to verify that the VOC total included only reactive VOCs. The definition of VOCs in Regulation 1101 includes a list of non-reactive and negligibly-reactive compounds.

The typical summer season weekday emissions are based on Delaware's definition of peak ozone season, which is June 1 through August 31. Activity data for point and non-point sources were obtained and developed for each month of the year and/or monthly temporal allocation profiles were developed. Details of temporal resolution development are presented in detail within each source sector section of the report.

1.2.3 Emission Sources and Estimation Methodologies

Previous point and non-point source inventories, the National Emission Inventory, the Emission Inventory Improvement Program (EIIP) emission estimation methodology documents and other reports and studies were used in identifying source categories and methodologies. Particularly for area sources, Pechan often recommended and utilized methods and data from recent work performed by the State of California. Details of the methods used are presented in each source sector section of the report.

Besides removing emissions of non-reactive VOCs from the inventory, emissions from regulated sources, both point and non-point, were adjusted for rule effectiveness and rule penetration, where applicable. Rule effectiveness (RE) reflects the level of compliance with any particular regulation. Rule penetration (RP) represents the percent of sources within a source category that are subject to the rule that requires control.

1.2.4 Data Collection and Management

For all source categories the gathering of local activity data represented a major task spread over many months. For point sources, most facilities reported their emissions through the use of an on-line reporting system. Data entered into the on-line system were transferred to the AQMS *i*-STEPS® database for review and correction.

Microsoft Excel spreadsheets were employed for managing activity data and calculating emissions from stationary area sources and some non-road categories. A consistent set of tabs within each source category spreadsheet included activity data, point source data (if applicable, for backouts), emission factors, controls, emission calculations, NIF formats, and notes on QA/QC procedures.

On-road mobile source emissions were calculated using the MOBILE6 model. Emissions for most of the non-road vehicles and equipment categories were calculated using the NONROAD model. Emissions data were transferred from *i*-STEPS® (point sources), from the non-point spreadsheets, and from the model outputs to NIF files in Microsoft Access tables. These tables were transmitted to the National Emission Inventory (NEI) by June 1, 2004 to meet the reporting requirements of the CERR.

1.3 Inventory Development

Once the IPPs were finalized, the EID Program staff and Pechan began to develop the inventory. For point sources, the EID Program developed a set of criteria to use in establishing the universe of facilities required to report. These criteria are presented in detail in the point source section of this report. Reporting packages were sent to each facility meeting one or more of the reporting criteria. An extensive amount of review and follow up was performed on the point source data submitted by facilities.

For non-point sources, the first main task involved gathering activity data for each source category. In many cases, these data were obtained from Delaware-specific sources. In some cases the activity data were developed through the allocation of a portion of a national activity dataset (i.e., national paint sales) to Delaware. Basic demographic data were also used for some source categories and are presented in Table 1-1. Once activity data were obtained, spreadsheets were developed to manage the data and combine the activity data with the selected emission factors to obtain uncontrolled emissions. Finally, for those sources where controls applied, emissions were adjusted to account for control efficiency, rule effectiveness, and rule penetration.

Table 1-1. 2002 Demographic Data for Delaware

Demographic Parameter	Kent	New Castle	Sussex	Statewide
Population[a]	131,069	512,360	163,946	807,375
Households[a]	49,127	191,787	66,471	307,385
Land Area (square miles)	594	439	950	1,983
Annual VMT (million miles)[b]	1,406	5,338	2,091	8,835

[a] (DPC, 2003); [b] DelDOT, 2004.

For several non-point source categories, models were used to develop either emission factors (i.e., MOBILE6) or final emissions (NONROAD). In the use of these models, activity data were included in the model input files. For any type of data used by the model for which Delaware-specific data did not exist, the model used the system defaults. Details about Delaware-specific and default parameters are discussed in the on-road and non-road sections. The models account for controls, some of which reflect controls specific to Delaware.

1.4 Quality Assurance/Quality Control

Quality assurance and quality control were conducted throughout the inventory development process and at multiple levels. For instance, Pechan established a QA/QC tab in each area source spreadsheet. Review by Pechan staff other than those working on the source category and follow-up corrections were documented within the spreadsheet. A second layer of quality control involved the review of all non-point source spreadsheets by the EID project manager. The QA coordinators performed one final review of the activity data, estimation methods, calculations, and emission totals.

1.5 Documentation Organization

This report presents detailed discussions of the emission estimation methods, data sources, and quality control/assurance procedures used to compile the 2002 ozone precursor inventory. At the end of each source category write up is a list of references. The inventory preparation plans, calculation spreadsheets, model input and output files, QA/QC reports, and other supporting documentation are contained on a CD included in the front sleeve of this report. Much of the documentation that is referenced in the report but not contained on the CD has been compiled in electronic and hard copy files located at the AQMS offices in Dover, Delaware and are available for review by the public.

1.6 Emissions Summary

The following emission summaries present the entire 2002 emission inventory for VOCs, NO_x, and CO, broken down by (1) annual and summer season weekday values, (2) for each of Delaware's three counties, and (3) by source sector. Natural sources are presented separately from anthropogenic sources of emissions. Throughout this document, annual emissions are reported in tons per year (TPY), and summer season weekday emissions are reported in tons per day (TPD). Summer season weekday emissions are also referred to as peak ozone season daily emissions.

1.6.1 Emissions from Anthropogenic Sources

Table 1-2. 2002 Annual and SSWD VOC, NO_x, and CO Emissions by County

County	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Kent	5,292	10,314	39,090	16.86	34.50	111.98
New Castle	18,100	30,748	144,691	58.66	107.22	405.47
Sussex	10,278	16,059	64,127	40.02	57.37	190.50
Statewide	**33,672**	**57,122**	**247,909**	**115.53**	**199.08**	**707.94**

Figure 1-1. VOC Summer Daily Emissions by County

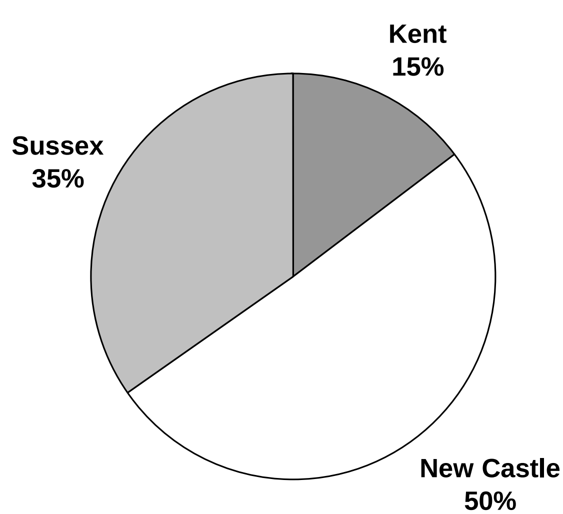


Figure 1-2. NO_x Summer Daily Emissions by County

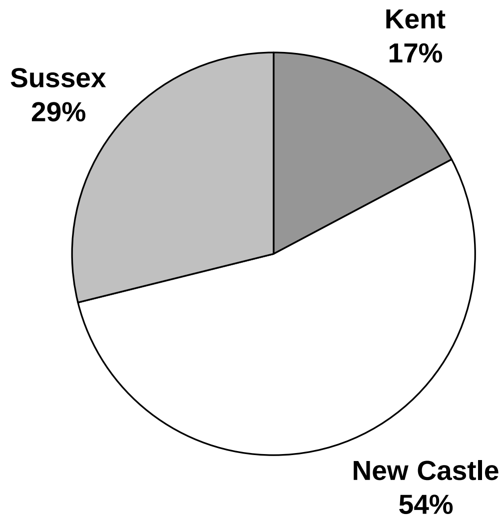


Table 1-3. 2002 Annual and SSWD VOC, NO_x, and CO Emissions by Source Sector

County	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Point	4,773	16,372	9,612	23.31	74.09	36.77
Non-point	10,316	2,427	8,618	33.08	3.17	7.24
On-road	10,564	21,341	160,761	32.37	69.03	396.87
Non-road	8,019	16,982	68,918	26.77	52.79	267.06
Statewide	**33,672**	**57,122**	**247,909**	**115.53**	**199.08**	**707.94**

Table 1-4. 2002 Kent County Annual and SSWD VOC, NO_x, and CO Emissions by Source Sector

County	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Point	133	1,064	436	0.49	5.06	1.73
Non-point	1,786	359	1,602	5.75	0.45	2.76
On-road	1,737	4,182	25,991	5.45	13.97	66.61
Non-road	1,636	4,709	11,061	5.17	15.02	40.88
Statewide	**5,292**	**10,314**	**39,090**	**16.86**	**34.50**	**111.98**

Figure 1-3. VOC Summer Daily Emissions by Source Sector

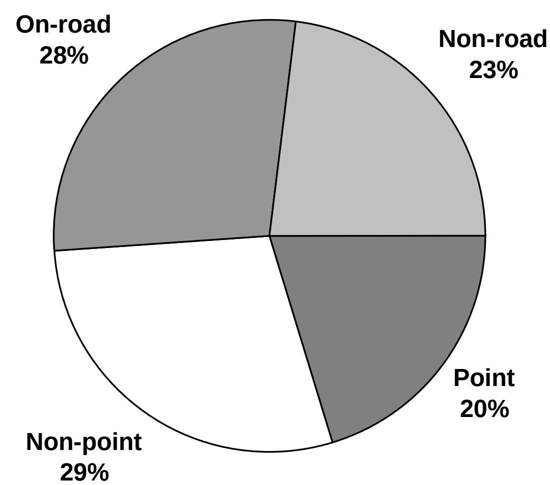


Figure 1-4. NO_x Summer Daily Emissions by Source Sector

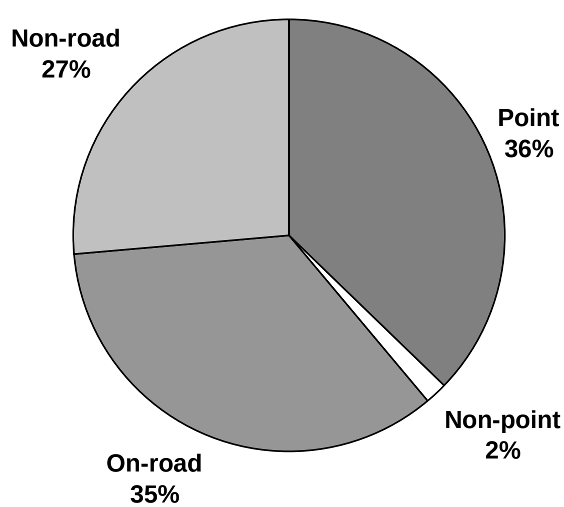


Table 1-5. 2002 New Castle County Annual and SSWD VOC, NO_x, and CO Emissions by Source Sector

County	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Point	2,687	9,157	8,530	9.42	44.09	32.60
Non-point	6,236	1,513	4,194	20.02	1.95	2.10
On-road	5,762	11,799	93,358	16.98	36.56	217.37
Non-road	3,415	8,279	38,609	12.24	24.62	153.40
Statewide	**18,100**	**30,748**	**144,691**	**58.66**	**107.22**	**405.47**

Table 1-6. 2002 Sussex County Annual and SSWD VOC, NO_x, and CO Emissions by Source Sector

County	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Point	1,952	6,151	645	13.40	24.95	2.44
Non-point	2,293	554	2,822	7.31	0.77	2.38
On-road	3,065	5,360	41,412	9.95	18.50	112.89
Non-road	2,968	3,994	19,248	9.36	13.15	72.79
Statewide	**10,278**	**16,059**	**64,127**	**40.02**	**57.37**	**190.50**

1.6.2 Emissions from Natural Sources

Table 1-7. 2002 Annual and SSWD VOC, NO_x, and CO Emissions for Natural Sources by County

County	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Kent	9,139	251	886	60.76	1.27	5.18
New Castle	6,332	159	636	42.92	0.81	3.87
Sussex	11,109	354	1,272	70.26	1.78	7.03
Statewide	**26,580**	**764**	**2,794**	**173.94**	**3.86**	**16.08**

1.7 References

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.

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, 1997. *Quality Assurance Procedures, Volume VI*, EPA-454/R-97-004f, Emission Inventory Improvement Program, Quality Assurance Committee, July 1997.

EPA, 2002a. *2002 Base Year Emission Inventory SIP Planning: 8-hour Ozone, $PM_{2.5}$, and Regional Haze Programs*, Letter from L. Wegman and P. Tsirigotis, U.S. EPA, Office of Air Quality Planning and Standards, to Regional Air Division Directors, November 18, 2002.

EPA, 2002b. *Consolidated Emissions Reporting*, Federal Register – Vol. 67 No. 111 page 39602, June 10, 2002.

EPA, 2003. Designation Letter from Donald Welsh, Regional Administrator, Region 3, Philadelphia, PA to Ruth Ann Minner, Governor of Delaware, December 3, 2003.

EPA, 2004. *Final Rule to Implement the 8-hour Ozone National Ambient Air Quality Standard – Phase 1*, Federal Register – Vol. 69 No. 84 page 23951, April 30, 2004.

EPA, 2005. *Identification of Ozone Areas for Which the 1-hour Standard Has Been Revoked and Technical Correction to Phase 1 Rule*, Federal Register – Vol. 70 No. 148 page 44470, August 3, 2005.

SECTION 2

STATIONARY POINT SOURCES

The point source inventory represents facility-specific data for larger stationary sources. Emissions data for all other source categories are reported at the county level. Point sources typically include large industrial, commercial and institutional facilities. Manufacturing facilities, within the industrial sector, comprise the majority of all reporting point sources. The institutional sector includes hospitals, universities, prisons, military bases, landfills, and wastewater treatment plants.

Unlike other source sector emissions which are estimated by AQMS, point source emissions data are submitted to AQMS by the facilities. Emissions are reported at the process level and include both confined (stack) emission points as well as unconfined (fugitive) emission sources. A key aspect of point source data is the inclusion of facility coordinates to accurately allocate emissions spatially within a county for purposes of performing air dispersion modeling.

The planning and execution of the point source inventory was accomplished in the following chronological manner:

- Define the purposes of the inventory (already defined in Section 1 of this report);
- Establish the reporting criteria and list of facilities to survey;
- Obtain inventory data from facilities;
- Perform administrative and technical review of data received from facilities;
- Seek resubmissions/corrections from facilities based on data review;
- Perform internal data manipulation (i.e., apply rule effectiveness, remove non-reactive VOCs, create summer season weekday emission values); and
- Prepare inventory data files, report, and supporting documentation.

Quality control/assurance is not listed in the chronology above since these activities were performed throughout the point source inventory development process. Quality control/assurance efforts are presented throughout this section and in the quality assurance section of this report.

Since there may be overlap between point sources and stationary non-point source categories, one final activity required of the point source inventory staff is to provide point source back out data where appropriate. Point source back out data includes emissions, throughput, or employees, depending on the non-point source category methodology.

2.1 Reporting Criteria

Based on the purposes of the 2002 inventory, the following criteria were established within the point sources inventory preparation plan (IPP) (DNREC, 2003) for defining the universe of facilities to be surveyed:

- Facilities that held a Title V permit in 2002;

- Any facility with emissions of VOCs greater than 5 TPY for any of the years 1999, 2000, or 2001, as previously reported to the AQMS inventory program;
- Any facility falling into one of the following industry sectors:
  - Hot-mix asphalt plants,
  - Hospitals that use ethylene oxide for sterilization,
  - Electric generating units (EGUs); and
  - Facilities using anhydrous ammonia as a refrigerant;
- Any facility for which AQMS does not have previous inventory data that appears may be a significant source.

Subsequent to establishing these criteria, chrome plating was considered important to the air toxics study due to emissions of hexavalent chromium. A review of the permit and Maximum Achievable Control Technology (MACT) standard files revealed four facilities in Delaware that perform chrome plating. These facilities were included in the overall point source inventory; however, these facilities have no reported ozone precursor emissions and are not included in this inventory.

Prior to the establishment of these criteria, AQMS considered including all facilities within the following additional industry sectors:

- Hazardous waste treatment, storage, and disposal facilities (TSDFs);
- Publicly-owned treatment works (POTWs);
- Bulk petroleum plants;
- Dry cleaners;
- Active and inactive landfills;
- Feed mills (for particulates);
- Concrete plants (for particulates);
- Sand and gravel operations (for particulates); and
- Chrome plating operations (considered after the development of the reporting criteria.)

TSDFs – The number of TSDFs within Delaware has steadily declined in the past ten years and recent inventories indicated emissions were very low. The Solid and Hazardous Waste Management Branch of DNREC was contacted to determine the list of TSDFs within the State. As of 2002, there were three TSDFs operating in Delaware. All three sites were located at facilities that already met other reporting criteria. These facilities were asked to report emissions for their TSDF. Therefore, TSDFs were not included in the point source inventory specifically as an industry sector. Finally, two of the TSDFs were storage only, and have since closed.

POTWs - Other than one Title V permitted facility (Wilmington WWTP), POTWs were considered an insignificant source of criteria and air toxic pollutants. Rather than including POTWs within the point source inventory, throughput data available from the Division of Water Resources NPDES program was used to estimate emissions for each facility, then aggregated to the county level in the stationary non-point source inventory.

Bulk petroleum plants - After reviewing internal records (EPCRA Tier II data) and contacting several bulk plants, AQMS determined that very little throughput at these facilities includes highly volatile products such as gasoline. Emissions from less volatile products, such as distillate and residual oils, were too small to be considered for inclusion in either the point or stationary non-point source inventories.

Dry cleaners – Dry cleaners in Delaware predominantly use perchloroethylene as the cleaning solvent. Perchloroethylene is a negligibly-reactive VOC, and is not included in the VOC emissions from dry cleaners within this ozone precursor inventory. With more than 80 facilities throughout Delaware, the number of facilities was considered too large and emissions too small to include as point sources. Therefore, dry cleaners were handled as an area source with VOC emissions aggregated to the county level.

Active and inactive landfills – All active municipal solid waste landfills in the State (one per county) and one large inactive landfill are Title V permitted facilities and thus already meet the reporting criteria. The remaining inactive landfills throughout Delaware have not accepted waste for nearly 20 years as of 2002, and VOC emissions from these sites are minimal. Therefore, inactive landfills were not included in the point source inventory. County-level estimates of VOC emissions from inactive landfills were included in the non-point source inventory.

Feed mills, concrete plants, and sand and gravel operations – These industry sectors were considered a source of particulate matter, both from material handling processes and fugitive dust (i.e., storage piles). Many large feed mills in Delaware already met the criteria for reporting as a Title V facility due to combustion emissions from process boilers and grain dryers. The lack of quality emissions data (i.e., emission factors) for feed mills persuaded AQMS from inventorying smaller feed mills. Lack of data was also the reason for not further considering concrete plants. Sand and gravel plants were surveyed under the stationary non-point sources inventory, but eventually dropped from it due to lack of useful data.

2.2 Initial List of Facilities

Once the reporting criteria were establish, AQMS point source inventory staff compiled an initial list of facilities to be compared against the reporting criteria. A list of facilities that were Title V (TV) or Synthetic Minor (SM) permitted facilities at the end of 2002 was provided by the Engineering and Compliance Branch of AQMS. AQMS staff included all of these facilities (150) in the initial list.

Facilities within the emission inventory database that were not designated as TV or SM were evaluated against the criterion of five tons of annual VOC emissions in any of the three years prior to 2002. This review resulted in the addition of two facilities to the initial list. As stated previously, four chrome plating operations were added to the list of point sources.

The following additional data sources were reviewed to identify facilities that might have met one or more of the reporting criteria:

- Toxics Release Inventory (TRI, SARA 313) – 1999 through 2001 data;
- Hazardous Chemical Inventory (Tier II, SARA 312) – 2001 data;
- AQMS Accidental Release Prevention (ARP) Program facility list.

AQMS inventory staff reviewed the three most recent years of TRI data, and found that all facilities within TRI with more than five tons per year air emissions of VOC compounds were already included in the initial list due to TV or SM status. However, when the 2002 TRI data were made available in late 2003, AQMS decided to include several facilities for purposes of the air toxics project. In doing so, the individual compounds reported by these facilities to TRI were also reported as VOCs or particulates, as appropriate. The review of TRI data resulted in the addition of four facilities to the initial list.

The Tier II data were reviewed mainly to identify facilities that used anhydrous ammonia. As a result of the passage of the new fine particulate standard, ammonia, which is a precursor to the formation of ammonium sulfates and nitrates, was elevated to the status of a criteria pollutant (similar to how VOCs are viewed in the formation of ozone.) Furthermore, the ARP Program within AQMS maintains a list of facilities that have a significant amount of anhydrous ammonia stored on site, due to the acute hazard ammonia poses should a catastrophic release occur. Finally, telephone listings were reviewed for otherwise unidentified ice suppliers and ice skating rinks. Altogether, 23 facilities not already on the initial list were added to capture potential ammonia emissions.

The complete initial list included 183 facilities. A spreadsheet was developed by AQMS point source staff containing a record of every facility included on the initial list of facilities. The spreadsheet includes the reason the facility was placed on the initial list. For facilities that were inventoried, the spreadsheet indicates which reporting criteria were met. The spreadsheet is included in the supporting documentation contained on a CD accompanying this report.

2.3 Facilities Inventoried

The facilities on the initial list were evaluated using the reporting criteria established in the IPP. As stated previously, additional criteria specifically based on air toxic emissions were included.

Title V facilities are required to report regardless of the amount of emissions. Therefore, all 85 Title V facilities were included in the final list of point sources, unless a facility was closed for the entire 2002 calendar year. The list of Synthetic Minor facilities were evaluated against the reporting criteria. As a result, 28 of the 65 SM facilities were dropped from further consideration since no criterion was met.

Eight facilities thought to be using anhydrous ammonia reported using another type of refrigerant or otherwise did not use anhydrous ammonia. These facilities were not included in the final list of point sources. It is important to note there were several facilities that used anhydrous ammonia as a refrigerant but reported no ammonia system recharge (the approximation used to determine that emissions had occurred) for 2002. These facilities were retained in the final list of point sources, even though emissions are reported as zero.

Three facilities were identified as being closed prior to calendar year 2002. Three non-SM facilities were evaluated against the reporting criteria and were determined to not meet the criteria. Finally, a mobile crusher used at several hot-mix asphalt plants was identified as its own facility in the initial list of facilities. However, since for purposes of the point source inventory, all emissions must be assigned to a fixed site, emissions from the crusher were assigned to the facility at which it operated the majority of the time.

The final list included 140 facilities inventoried. Of these, 121 facilities reported emissions of ozone precursors, and thus are included in the 2002 base year ozone SIP inventory.

2.4 Survey Methods

In October 2002, the AQMS point source inventory staff began developing the survey methods and preparing reporting packages to be mailed to each facility. AQMS used two primary methods to gather information from most facilities for the 2002 inventory. Facilities either used an on-line reporting system or submitted paper activity data reporting forms. These two methods are described in detail below.

2.4.1 Electronic Reporting

Starting with the 2001 reporting cycle, AQMS has offered electronic reporting of emissions data through the Internet. The system is known as Terminal Server Satellite ***i***-STEPS®. Facilities have used Satellite ***i***-STEPS® software for reporting since 1995. Prior to the 2001 reporting cycle, facilities were given the Satellite ***i***-STEPS® software and a database containing the emission inventory reporting structure for their facility on magnetic media. The software and database was installed on a computer at the facility. Facilities would create and mail to AQMS a submission diskette containing their inventory data. With on-line reporting, the software and database remains on DNREC's server. The Internet provides the connection to the user's computer.

For the 2001 inventory year, AQMS offered a one-day training to facility representatives to provide guidance on how to use the new on-line reporting system and to reacquaint facilities with the Satellite ***i***-STEPS® reporting scheme. ***i***-STEPS® is the point source emission inventory data management system that AQMS has used since 1992 and is currently licensed to DNREC by MACTEC Federal Programs.

For the 2002 reporting cycle, the Terminal Server Satellite ***i***-STEPS® application was updated with the latest FIRE and AP-42 emission factors. Satellite ***i***-STEPS® is capable of calculating emissions based on information supplied on process throughput, operating schedule, and controls. A database specific to each facility was generated based on previously submitted inventories and other information (i.e., permitting files). Information expected to remain the same from year to year was pre-populated in the database, while throughput and emissions data were zeroed out. Facilities were expected to update pre-populated information as necessary and enter 2002 data for fields that were zeroed out.

2.4.2 Activity Data Reporting Forms

AQMS had learned over the years that staff at some smaller facilities had limited or no access to the Internet, had no experience with Internet reporting, or in some cases were lacking in computer skills. For these facilities, the process of using Satellite ***i***-STEPS® was cumbersome and sometimes resulted in late reporting and incomplete or erroneous data. For those facilities with uncomplicated processes, AQMS developed one to two-page activity data report forms to simplify the reporting process. The activity data supplied by facilities, such as operating schedule and monthly throughputs, were used by AQMS staff to calculate emissions based on FIRE emission factors or material balance methodologies.

Activity data reporting forms were developed for the following processes:

- Boilers;
- Stationary diesel engines;
- Hot-mix asphalt production;
- Ammonia refrigeration;
- Ethylene oxide sterilization; and
- Chrome plating.

For facilities that used the activity data forms, AQMS already had detailed process and stack information on file. The activity data report forms are included in the supporting documentation contained on a CD accompanying this report.

2.4.3 Other Methods

In a limited number of cases where on-line reporting or the use of the activity data forms were not appropriate or useful, information was obtained from the facility via telephone, e-mail, fax or site visit. As an example, Metachem Products closed in 2002 and no technical staff was available during the data collection period. However, the president of the company was contacted and was able to provide 2002 production figures. AQMS staff calculated emissions for 2002 for non-combustion processes by scaling the reported 2001 emissions based on production level ratios.

Emissions data for seven facilities were obtained solely from TRI reports. These facilities were included in the 2002 inventory as a result of the DATAS project. For six of these facilities, the reported TRI chemicals were VOCs. These facilities were retained in the ozone precursor SIP inventory.

Regardless of the survey methods used to obtain data from facilities, all data were entered into one database within ***i***-STEPS®.

2.5 Data Collection

Reporting packages were mailed in March 2003 to facilities identified as meeting one of more of the established reporting criteria. Two Synthetic Minor facilities that were sent reporting packages were subsequently dropped from further consideration based on conversations with the facilities.

Some facilities were identified for inclusion in the point source inventory after the initial reporting cycle began. These included one ammonia refrigeration facility, four chrome plating operations, and seven TRI reporting facilities. The TRI facilities were not contacted by AQMS point source inventory staff. Emissions data were obtained from the DNREC TRI database.

Table 2.1 provides the number of facilities inventoried by each survey method.

Table 2-1. Inventory Methods

Inventory Method Used	Number of Facilities
On-line reporting	86
Activity data report forms	44
Toxics Release Inventory	7
Other methods	3
Dropped from inventory[a]	3

[a]Dover Downs Entertainment and Kuehne Chemical. Tilcon mobile crusher was removed as a separate facility and allocated to one of Tilcon's facilities.

2.5.1 On-line Reporting

Terminal Server Satellite ***i***-STEPS® software reporting packages were sent to 82 facilities by certified mail on March 7, 2003. An additional six facilities received the mailing over the next month. Two of the 88 facilities receiving the reporting packages for on-line submissions were subsequently handled through the use of activity data report forms and one facility was dropped from further consideration (Kuehne Chemical). Finally, one facility (Pinnacle Foods), that originally received activity data reporting forms, reported using the on-line system.

The reporting package contained a cover letter and five pages of instructions. The reporting package is included in the supporting documentation. The instructions contained information on how to access the Terminal Server Satellite ***i***-STEPS®, user initials and passwords, AQMS contact information, information specific to the 2002 inventory, and an AQMS web page address where additional inventory documents were available. These documents included:

- *Issues, Updates and FAQs for Terminal Server Satellite* ***i****-STEPS®*;
- *Common Errors and Useful Information*;
- A power point presentation of the 2001 emission inventory training; and
- A detailed, 23-page set of instructions that provided information about the emission inventory structure and each data element.

A database was set up and customized for each facility based on the process structure previously established for the facility. For new facilities using Satellite ***i***-STEPS®, the reporting structure was created by AQMS point source inventory staff with input from the facility. The database was pre-populated with general information about the facility, as well as a few other data elements not expected to change from year to year, such as stack parameters and design capacity. Other data elements were left blank or zeroed out, such as annual process rate, percent sulfur and ash of fuel burned, operating schedule, throughputs, capture and control efficiencies, and emission estimates.

Generally, it was the large, complex facilities with multiple processes that reported on-line. For facility representatives new to emissions inventory reporting or who had not reported in some time, AQMS inventory staff worked with them to understand the inventory structure. In three instances this included an on-site visit by AQMS staff. Assistance by phone or e-mail in completing the inventory was offered on an on-going basis for many facilities. Representatives from five facilities visited the AQMS offices seeking assistance. Terminal Server Satellite ***i***-STEPS® on-line reporting allowed point source inventory staff to work with a facility simultaneously on-line to resolve any issues a facility may have encountered.

The inventory information requested from facilities for the 2002 inventory is described in several EPA publications including *Emission Inventory Requirements for Ozone State Implementation Plans and Emissions Inventory Guidance* (EPA, 1991a) and *Emissions Inventory Improvement Program (EIIP), Volume II* (EPA, 1997). Facilities were requested to speciate non-combustion VOC emissions, allowing AQMS staff to back out any non-reactive compounds from the reported VOC total when necessary. All emissions were reported at the process level. Facilities were required to provide emission calculations and documentation in the Notes window within Terminal Server Satellite ***i***-STEPS® or in writing when submitting their certified emissions.

Terminal Server Satellite ***i***-STEPS® has built-in system checks for out of range values as well as relational errors. Field specific data entry checks were done by the software at the time the data was entered or when an attempt was made to save the data. The system prompted the user to make the needed corrections. In most cases a record could not be saved until all edit checks were satisfied. System functions and checks include:

- Data can be entered through the use of look-up tables;
- Data entered directly must match information in the look-up table;
- Total percent quarterly throughputs must be between 95 and 101;
- Alpha-numeric checks;
- Enforced relational database integrity;
- Mandatory field alerts;
- Stack assignment check (each process must have an assigned stack); and
- Automated emissions calculations.

Once a facility completed entering its data and information, the user had the ability to run the following reports:

- Group level emissions (facility summary);
- Process unit level emissions summary; and
- Detailed report (contains all entered and calculated data).

Facilities used the three reports to verify data they have entered and the emissions reported and/or calculated by the Terminal Server Satellite ***i***-STEPS®. Reports could be displayed to the screen or created as an Adobe Acrobat pdf file which is then automatically e-mailed to the user.

The process summary report provided emissions of each criteria pollutant for each process within an emissions unit. The detailed report lists the data following the Terminal Server Satellite ***i***-STEPS® structure and contains all information that the facility entered as well information the system used to organize the inventory information or calculate emissions.

The facility summary report tabulates criteria pollutant emissions for each emission unit with a facility total at the bottom. This report also served as the emission certification page and thus contains a signature area for the "Responsible Official". When AQMS received a signed copy of this report, indicating the facility had completed the reporting process, AQMS set the Terminal Server Satellite ***i***-STEPS® to read-only for the facility.

Examples of the three reports are included on the CD accompanying this report.

2.5.2 Activity Data Reporting Forms

Activity data reporting packages were sent by certified mail to 37 facilities on March 14, 2003. An additional eight facilities received the mailing over the next several months. Two facilities that originally were expected to report on-line reported using the activity data forms. Conversely, one facility switched from activity forms to on-line reporting. One facility receiving the activity data reporting forms was dropped from further consideration and the Tilcon mobile crusher, which reported using the activity data forms, was removed as a separate facility.

The reporting packages included a cover letter, general facility information page, and the appropriate activity data reporting form(s) for each facility. The general facility information sheet contained preprinted general information about the facility. This information included facility name, mailing address, contact name, SIC and NAICS codes and phone and fax numbers. Facilities made corrections and returned these sheets along with their activity reports.

Those facilities targeted for ammonia refrigeration and chrome plating received activity data reporting forms only for ammonia usage and chrome plating activity, respectively. AQMS did not request data on any other processes that these facilities might have (i.e., a heater or boiler). All other facilities were mailed the appropriate activity data reporting forms for all emission processes at these facilities. Assistance in completing the activity reports was offered on an on-going basis. Assistance was given via telephone calls, e-mail, facsimile and on-site visit.

2.6 Inventory Tracking

A log book was maintained to record and track the reporting status of the 133 facilities receiving a reporting package. The log book contained the facility name and identification number, the facility contact, the date the reporting package was mailed to the facility, the certified mail return receipt number and date it was returned, the original due date, an extension date, if given, the date the submission was received by AQMS, and notes on phone or e-mail communications with the facility.

In addition to the 2002 inventory log book, a Microsoft® Excel spreadsheet was maintained to track each facility from the initial mailing through all tracking and review steps including the final QA/QC process. Communications with facilities are noted in the spreadsheet, especially when facilities failed to meet their deadlines. On several occasions facility management was contacted by AQMS to resolve difficulties and get the reporting process back on track. Besides two facilities that were dropped from further consideration, all facilities supplied either complete emissions data on-line or activity data on hard copy reporting forms.

2.7 Administrative Review

As soon as submissions were received, the review process began. The Administrative Completeness Determination (ACD) was performed as the first step in the review process. The ACD consisted of a one-page checklist which begins the audit trail associated with the review process. The ACD checklist was developed by the AQMS point source inventory staff over many years as a QA/QC tool for ozone SIP inventories. A checklist is completed and maintained in each facility file. An ACD is prepared for all facilities, whether Terminal Server Satellite ***i***-STEPS® or the activity data reporting forms were used to prepare their submission.

2.7.1 On-line Submissions

The ACD performed on on-line submissions included the following steps:

Review cover letter - Facilities were asked to identify in their cover letter any operational changes and the impact such changes had on emissions. AQMS staff reviewed the cover letter noting any significant changes and highlighted it for future reference.

Emissions comparison - The 2002 facility-wide reported emissions for each criteria pollutant were compared to the 1999 Periodic Emission Inventory or to the most current information available. Significant differences between the two years were identified, investigated, and documented. Reviewing past and present detailed reports, process additions and deletions were compared, identified and highlighted for further investigation. If sufficient information was not provided in the cover letter, the facility was contacted to explain the differences. Emission comparisons and operational changes were compiled within a text document, which is included in the supporting documentation.

Accidental releases - Facilities were asked to identify accidental releases either through the assignment of a separate accidental release process or an explanation in their cover letter as to the accounting of the release(s) in their inventory. Throughout 2002, AQMS staff created a file of accidental releases for which DNREC received knowledge through incident reports and news articles. This information was checked against accidental releases identified in the emission inventory reports.

Other ACD checks – AQMS staff verified that the emission certification report (facility summary) was signed by the Responsible Official. Any request for confidential business information was forwarded to the AQMS paralegal staff for review. The tracking spreadsheet was updated to include any communications with the facilities and to document when the ACD was completed for each facility and when all issues, if any, were resolved. The completed ACD, cover letter, signed emissions summary page, submitted supporting calculation sheets, notes and other correspondence (i.e., e-mails) were placed in the facility file.

2.7.2 Activity Data Reporting Forms

Activity data report form information was used to update facility general information and calculate emissions. Information from the activity reports were entered into the Terminal Server

Satellite ***i***-STEPS® database by AQMS staff. The database maintained an audit trail (user identification and date stamp) of data added to the system.

For some activity data, emissions were equated directly to the activity data based on a mass balance approach. For example, all ethylene oxide (EO) used by hospitals for sterilization was assumed to be released to the atmosphere. Therefore, EO emissions were equated to EO purchased. Other activity data were used by the database to calculate emissions based on emission factors contained in the database. Fuel combustion throughputs for small boilers and generators were used in this way. Once emissions were estimated for a facility that reported activity data, the 2002 emissions could be compared to data from previous years.

All Title V permitted facilities are required to submit a signed emissions certification report as part of their permit requirements. For those Title V facilities that reported activity data, the AQMS point source inventory staff generated the emissions summary page based on emissions calculated within ***i***-STEPS® and mailed it to the facility for signature by the Responsible Official. The ACD was not complete until the signed emissions summary page was returned to AQMS and the signature verified. The date the emissions summary page was mailed to a facility was documented within the tracking spreadsheet, as well as the due date for receiving the signed document. Finally, the actual date it was received was recorded.

The tracking spreadsheet was updated to include any communications with the facilities and to document when the ACD was completed for each facility and when all issues, if any, were resolved. The completed ACD, signed emissions summary page, notes and other correspondence (i.e., e-mails) were placed in the facility file. The tracking spreadsheet is included in the supporting documentation accompanying this report.

2.8 Reported Data and Estimating Emissions

The 2002 stationary point source inventory included all criteria pollutants and their precursors (VOC, NO_x, CO, SO_2, PM_{10}-PRI, $PM_{2.5}$-PRI, and NH_3) and all hazardous air pollutants (HAPs). AQMS requested non-combustion HAP data from facilities for the purpose of identifying non-reactive VOCs important to the ozone precursor inventory and to serve as a check for VOC totals.

AQMS required facilities to report data to the process level, identified by an eight-digit Standard Classification Code (SCC). Key data reported included SCC identification, product or fuel throughput, operating schedule, control equipment information (type, capture efficiency and control efficiency), stack parameters (height, diameter, flow rate, velocity and temperature), and emission factors, if FIRE factors were not used. Monthly activity data (throughputs and operating schedules) were reported to provide the temporal resolution needed to calculate summer season daily emissions of VOC, NO_x and CO. Data collected was consistent with EPA's *Procedures Volume I* (EPA, 1991b), the Consolidated Emissions Reporting Rule (EPA, 2002), *Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Air Quality Standards (NAAQS) and Regional Haze Regulations* (EPA, 2005) (hereafter referred to as *Emissions Inventory Guidance*), and EIIP documents.

2.8.1 Emission Estimation Methods

Annual emissions could either be calculated within ***i***-STEPS® using uncontrolled emission factors, throughput data, and control data, or outside the system using mass balance, stack tests, or other means. Terminal Server Satellite ***i***-STEPS® allowed for the use of nine emission estimation methods, which are presented in Table 2-2.

Table 2-2. *i*-STEPS® Emission Estimation Methods

***i*-STEPS®** **Method Code**	**Basis for Emissions Estimate**
1	Stack test data[a]
2	Material balance
3	Use of emission factor outside of ***i***-STEPS® or use of EPA TANKS software
4	Best engineering judgment
5	State or local agency emission factor
6	New construction/not yet operational (zero emissions)
7	Source closed/operation ceased (zero emissions)
8	***i***-STEPS® default emission factor
9	Facility-supplied emission factor

[a] includes Continuous and Predictive Emission Monitoring

Annual emissions are calculated by the database when Method Codes (MC) 8 or 9 is designated. The monthly fuel or process throughput rates obtained from the facility are summed to an annual rate and then applied to the relevant emission factor, either the system default (MC8) or one supplied by the facility (MC9). This calculation produces an annual emissions estimate in tons per year. Annual emissions may be calculated outside of ***i***-STEPS® with only the annual emissions entered in ***i***-STEPS®. Annual emissions calculated outside of ***i***-STEPS® are identified in the database by MC1 through MC4. Facilities were asked when deriving annual emissions from stack tests to take into consideration operating conditions during the stack tests, such as load and control efficiency, and be aware when stack test conditions were not representative of operating conditions in 2002.

For MC8 or MC9, emissions are calculated by the database through the use of a default or facility-supplied emission factor using the following equation for pollutant x:

$$E_a = [(Q_a) * (EF_x) * (FP) / 2000] * (1-CE_x)$$

$$E_d = (Q_a) * (PQ_{ss} /100) / D_{ss}$$

where:

E_a = Annual emissions, tons per year
E_d = Summer season daily emissions, pounds per day
Q_a = Annual process throughput
EF_x = Emission factor for pollutant x

FP	=	Fuel parameter, such as percent sulfur or ash content
CE_x	=	Overall capture and control efficiency
PQ_{ss}	=	Percent summer season throughput
D_{ss}	=	Days operated in the summer season (June, July, and August)

When a facility chooses MC8 for a process, ***i***-STEPS® automatically selects the emission factor associated with the process SCC and calculates the emissions. For MC9, facilities were required to document facility-supplied emission factors. The emission factor must be documented by the facility or otherwise verified by AQMS. If not, AQMS replaced it with the current ***i***-STEPS® SCC emission factor. Facilities may choose to calculate emissions outside of ***i***-STEPS® and enter the emissions using MC3. If an emission factor is used by the facility to calculate the emissions, the factor must be documented by the facility or otherwise verified by AQMS. If not, AMQS changed the record to an MC8.

i-STEPS® is programmed to calculate summer season weekday daily emissions for VOC, NO_x, and CO at the process level. The calculation method involves applying the percentage of annual throughput for the June 1 through August 31 ozone season to the annual emissions estimate. The resulting value is divided by the number of days a process is operated during the ozone season, and then multiplying by 2000 lbs/ton to report daily emissions in pounds. If the emissions were not calculated by the system because of missing or erroneous data needed for the calculation, the system prompts the user to make the necessary corrections.

2.9 Technical Review

Once issues from the completeness determination were resolved, the technical review would begin. The detailed report was the principal document used for the technical review. As with the ACD, the detailed report was printed for each facility and maintained in the facility file. The report included information necessary to check process-level annual emissions and summer season daily emissions for VOC, CO, and NO_x. The report allowed AQMS inventory staff to identify missing, suspicious or conflicting data. Any critical issues were identified and noted on the report. Corrections were made on the report as well as within the database.

Questionable data, missing information, and the correction of errors were handled in several ways. In all cases the AQMS staff maintained a paper or electronic trail of changes made by staff or the facility. When a problem was identified, such as missing data, a typographic error, or other simple errors in the data, a phone call or e-mail to the facility was usually sufficient to resolve and document the issue. Usually no other correspondence was needed. For submissions where there were extensive problems, a facility usually met with AQMS staff to outline the issues and to develop ways to address the problems.

An example of a detailed report is provided in the supporting documentation. The detailed report contains the following information:

- General facility information
- Narrative descriptions of the following: group/point, process, SCC, SCC units, and pollutant;

- Design capacity and standard design capacity units;
- Operating schedule, percent quarterly throughputs, and fuel sulfur and ash content;
- Monthly and annual throughputs provided in the SCC units described;
- Process-level annual emissions for all pollutants for each process;
- Stack ID and parameters;
- Emission calculation method;
- Abatement equipment information, including capture and control efficiencies for each pollutant;
- Calculations and documentation entered by the facility into a Notes field; and
- A summary page of facility-wide annual emissions for each pollutant in the facility's database.

The detailed report contains six sections, including facility general, group/point (emissions unit), process unit (including stack information), process unit controls, process unit emissions and a facility emissions summary. The review of each section is described in detail below.

2.9.1 Facility General

The detailed report includes the following general information: facility name, facility site identification number, mailing address, year of inventory, Standard Industrial Classification (SIC) Code, American Industry Classification System (NAICS), contact person and phone number. Any questionable information, such as SIC, NAICS or an incorrect inventory year, was noted and resolved.

2.9.2 Group/Point (Emissions Unit)

Group information defines a piece of equipment, a group of related processes, or a particular activity at a facility. Data elements provided in this section of the detailed report are reviewed individually and in context with other information in this section.

A description of the equipment or activity is provided along with the design capacity and design capacity units. If the design capacity is missing for combustion equipment, an attempt is made to determine the design capacity of the equipment by reviewing permits or contacting the facility.

The operating schedule was reviewed for missing or inconsistent data. The days per week and weeks per year values were used to determine reasonableness for the number of days operating during the peak ozone season (June, July and August.) As an example, if the process operating schedule was given as seven days per week, 52 weeks per year, then the number of days operated during the peak ozone season would be expected to be 92 days. Although the three month ozone season contains 92 days, 91 days was used as the maximum number of days in the ozone season. The 91 days have historically been used for Delaware ozone SIP inventories and was consistent with early ozone SIP guidance developed by EPA. Hours per day and normal daily start and end times were also provided. The annual hours operated is calculated by ***i***-STEPS® from the hours per day, days per week and weeks per year the facility enters into the system. A facility could override this calculated value by entering the actual number of hours operated for the year, if the facility had accurate records.

The percent quarterly throughput was corroborated with operating information. ***i***-STEPS® enforced a range of between 95 and 101 percent for the sum of the four quarterly throughputs. A review of the database indicated that all sums of the quarterly throughputs were within the range of 98 to 101 percent. In order to be consistent with the National Emissions Inventory system requirements, the first, second and fourth quarter percent throughputs were adjusted so the total would equal 100 percent. The third quarter (summer season) was not adjusted, since it was assumed the facility would have provided an accurate summer season value.

2.9.3 Process Unit

Information provided in this section of the detailed report was reviewed individually and in context with other information in this section and related sections such as the group/point and stack information sections. Process unit information includes the process description, stack identifier, Source Classification Code (SCC), SCC description, percent sulfur and ash (for combustion units), and monthly throughput for most processes.

The process description field is a text field that is used to better define a process than can be defined by the SCC. A determination was made whether the process description provided by the facility was consistent with the SCC description. As an example, the process description may mention No.6 oil for a piece of combustion equipment; and therefore the SCC description must be for combustion equipment burning No.6 oil.

In most cases monthly throughputs were provided by facilities. ***i***-STEPS® sums the monthly throughputs and stores the value in the annual throughput field. In cases where there were significant changes in the group-level emissions as compared to a previous year, the annual throughputs were compared to previous data. The previous annual throughput is written on the detailed report for future reference. If the comparison of throughput explains the difference in emissions, such as fuel switching, or an increase or decrease in fuel usage, this was noted on the Administrative Completeness Determination page and added to the tracking spreadsheet.

Each SCC has associated standard units as defined by EPA in its master list of SCCs and are contained within ***i***-STEPS®. Facilities are given the option within ***i***-STEPS® to change the units to make them appropriate to the data they are reporting. AQMS staff compared the SCC units as reported by the facility to the standard units. If the two values did not match, AQMS staff determined if the revised units were properly applied in the emission calculations.

2.9.4 Stack Parameters

Each stack has an identification number and description assigned by AQMS. The stack parameters provided in the detailed report include height above ground, stack diameter, and exit gas temperature, velocity, and flow rate. If emissions were considered fugitive, then ***i***-STEPS® requires only a stack identification number, a release point type (fugitive) and a height value. A default of ten feet was used for stack height when no fugitive height was provided.

If no stack information was provided for a process unit, AQMS would use stack information provided for the process in previous years and make the appropriate link within ***i***-STEPS®

between the stack and process unit records. If no previous year stack data existed in the database, a stack record was created and linked to the process based on permit file information or subsequent discussions with the facility. During data entry of the process unit record by facilities, Terminal Server Satellite ***i***-STEPS® flashed a warning message, if a stack had not been identified for the process.

2.9.5 Process Unit Control Equipment

The detailed report contained a section for control information for controlled processes. A control device identification number, an EPA control device code, pollutant-specific capture and control efficiencies, and a description of the abatement equipment provided by the facility are displayed in the detailed report.

Control issues were flagged and resolved if possible. VOC and NO_x control devices were evaluated to determine if the control efficiency fell within a range expected for the identified control device.

2.9.6 Process Unit Emissions

Pollutants for each process were listed. The pollutant code (Chemical Abstracts Service number or the National Emission Inventory Input Format (NIF) version 3.0 code), pollutant name, the emission estimation method code, emission factor, the overall capture and control efficiencies, and annual emissions in tons per year are displayed in the detailed report.

The capture and control efficiencies were compared to the process unit control section. Issues associated with pollutant code or capture and control efficiencies were flagged, investigated, and resolved.

This section was flagged for further review if there was a throughput in the process unit section but emissions were not provided. If emissions were expected, but not provided, the process unit emissions for a previous year (usually 1999) were checked. Usually, in cases such as this, the facility provided an explanation in the process unit or process emissions Notes field. An example of this would be when CEMs are used for NO_x emissions from combustion sources that utilize more than one type of fuel. All NO_x emissions would be reported under the major fuel burned. The secondary fuel would have a throughput, but no process unit NO_x emissions.

2.9.7 Facility Pollutant Emissions Summary

Facility-wide emissions for each pollutant were provided in tons per year in this section of the detailed report. This is used primarily for reference, for comparison to other inventory years, or to compare to TRI reported air releases.

2.9.8 Database Queries, Reports and Spreadsheets

Besides the detailed report, numerous database queries, reports and spreadsheets were created to identify information that appeared to be missing, in error or inconsistent with other related information. This included analysis of related operating schedule information. Another analysis compared the total non-combustion VOC emission estimate for a process to the sum of the individual VOC compounds reported. Air emissions of specific VOCs reported to TRI were compared to the inventory data.

2.9.9 Ozone Season QA/QC Report

The ozone season QA/QC report allowed AQMS staff to identify missing, suspicious or conflicting data needed for the ozone SIP inventory. The report was also used to compare ozone season throughput and operating schedule data to process-level annual emissions for all pollutants listed and process-level ozone season daily emissions for VOC, NO_x and CO. The ozone season QA/QC report expanded on the information provided in the detailed report and presented the ozone SIP information in a more organized and concise form.

The ozone season QA/QC report was also used to identify issues missed in the detailed report review, database queries and spreadsheets, in addition to flagging problems introduced during subsequent modifications and updates to the database. ***i***-STEPS® calculates and stores summer season weekday (SSWD) daily emission values in pounds per day. As a check, the QA/QC report calculates SSWD daily emission values for each process using data in the database independent of the ***i***-STEPS® calculation routine. Both values are printed on the report for comparison. An example of the report is provided in the supporting documentation.

2.9.10 Review of NO_x Emissions from EGUs and Other Large Sources

AQMS staff conducted a review of NO_x emissions from all electric generation units (EGUs) that report emissions data based on CEMs to EPA’s Emissions Tracking System (ETS). ETS contains emissions data to EPA’s Acid Rain Program and to the Ozone Transport Commission’s (OTC) NO_x Budget Program. AQMS staff compared 2002 ETS emissions to emissions reported to AQMS. A spreadsheet was developed for this review and contained the facility name, EGU description, ORIS ID, annual emissions reported to AQMS and to ETS, and the five-month ozone season emissions reported to ETS for the NO_x Budget Program.

There were 17 EGUs that reported under the Acid Rain Program. Emissions from these units could be directly compared to annual emissions reported to AQMS. These units also reported five-month ozone season emissions under the NO_x Budget Program. There were 17 additional units that reported to ETS only under the NO_x Budget Program. For these EGUs, annual emissions are not provided to ETS. For those units that only reported five-month ozone season emissions, an annual estimate was needed to directly compare to the facility reported value. A NO_x emission factor was calculated in pounds of NO_x emissions/MMBtu using the five-month emission amount divided by the heat content of the fuel listed in ETS for the five months. Annual emissions were then calculated by applying this factor to the annual fuel heat content reported in ***i***-STEPS®.

NO_x emission estimates were compared and the results were added to the spreadsheet. Any significant discrepancies were resolved and an explanation added to the spreadsheet. AQMS staff determined annual NO_x emissions in ETS for one unit at Conectiv Edge Moor and one at the Premcor Refinery were significantly inflated due to default maximum load values as required by EPA when the CEM is not functioning properly. AQMS staff worked with these facilities to determine the best estimate of actual NO_x emissions for the inventory. In another instance a facility included NO_x emissions associated with a testing period of the EGU, which was not reported to EPA.

There were six additional non-EGUs reported under the NO_x Budget Program. These units were located at the Premcor Refinery and were evaluated using the same methodology as above. Three facilities do not report emissions from their EGUs to ETS. These include Invista, City of Seaford, and City of Lewes. Invista used stack test data to develop site-specific emission factors. The City of Seaford used FIRE emission factors within ***i***-STEPS®. The City of Lewes provided fuel throughputs on the activity data report forms and FIRE emission factors were applied by AQMS.

2.10 Methods for Correcting Erroneous Data

Questionable data, missing information, and the correction of errors were addressed in several ways. In all cases AQMS maintained a paper or electronic trail of changes made by staff or the facility. When a problem was identified, such as missing data, typographic error, or other simple errors in the data, a phone call or e-mail usually was sufficient to resolve and document the issue. Usually no other correspondence was needed.

If an issue had a significant impact on the facility's reported total emissions, AQMS may request documentation that the facility acknowledged the change in the emissions. The documentation may be in the form of a letter, e-mail, or facsimile from the facility. Title V facilities were required to resubmit a new emissions summary report signed by the Responsible Official.

For submissions where there were extensive problems, a facility may have been asked to meet with AQMS staff to outline the issues and to develop ways to address the problems. Once issues had been discussed and resolved, the facility may have been asked to resubmit information through the on-line reporting system. AQMS staff would reopen the facility's record within the Terminal Server Satellite ***i***-STEPS® on-line system to allow access for corrections and updates.

If issues were unable to be resolved with the facility, AQMS staff updated or modified the information submitted by the facility to the extent needed to develop emission estimates. This usually was acknowledged in correspondence with the facility.

2.11 Facility Site and Stack Coordinates

Accurate geographical coordinates were essential to the air toxics modeling project. Therefore, coordinates were verified for all facilities that reported for the 2002 inventory. Coordinates were verified through the use of high-resolution aerial photography that DNREC had previously placed in GIS. Existing site coordinates contained in ***i***-STEPS® were plotted and superimposed on the aerial photography. Staff from the Engineering and Compliance (E&C) Branch met with inventory staff and reviewed the resulting facility locations on the aerial photographs. E&C staff were knowledgeable enough with the layout of the facilities they permit to identify them on the photographs. Based on the permitting engineer's advice, the facility point was moved, if necessary, to place it over the geographic center of emissions activity at the facility. For several facilities, ground reconnaissance was performed to verify a facility's location.

In addition to verifying the site coordinates, many stacks were individually identified on the aerial photographs and points were plotted for these stacks. For stacks and vents that were not able to be identified, the site coordinates were assigned to those stacks by default.

2.12 Database Management

The 2002 point source inventory database was managed using ***i***-STEPS® for Microsoft® SQL Server 5.0 data management system, associated utilities and applications including the Terminal Server Satellite ***i***-STEPS® on-line system and Microsoft® Access. Microsoft® Access was used to create queries and reports from the SQL tables. After the administrative review and a check of reasonableness of the facility-wide emissions were completed for most facilities, a copy of the Terminal Server database was produced as an archive of data reported by the facilities. A second database was created as the 2002 production database for purposes of developing the ozone SIP inventory. This database was accessed and managed using the Agency ***i***-STEPS®.

DNREC's Office of Information Technology (OIT) provides computer network support and routine database management functions. Joseph Handley, Application Support Specialist, of the OIT office served as liaison between AQMS inventory staff and OIT. Mr. Handley also helped with user network, Internet connectivity, and firewall issues.

i-STEPS® utilizes relational databases and contains functions and utilities to maintain database integrity. There are field-sensitive look up tables, and data element and record validation routines that ensure valid data and enforce database integrity. The application also incorporates warning messages for non-critical, but important, ozone SIP inventory data elements and records. The system has a record level audit trail that records changes made to the records, identifies the user and the date the change was made. In addition, there are comment/note windows for each record where text can be added by the user and AQMS staff to clarify information provided or supply additional documentation.

The ***i***-STEPS® data management system allows AQMS staff to identify the type of inventory being developed, in this case an ozone precursor inventory. This designation enforced required fields and record validation routines, and pop-up error and warning messages specific to the ozone inventory. The designation also activated routines that calculated summer season daily emission estimates for VOC, CO and NO_x.

2.13 Final Data Manipulation

Upon completion of the technical review and verification of the data within the production database, AQMS staff removed any non-reactive VOC emissions from the VOC totals and applied rule effectiveness to controlled sources. These two tasks are described below in detail.

2.13.1 Removal of Non-Reactive VOCs

Facilities were required to report speciated non-combustion VOC emissions. The definition of volatile organic compounds within AQMS Regulation 1 (DNREC, 1999) identifies the organic compounds that are considered to be negligibly reactive in the photochemical process of forming ozone. AQMS inventory staff verified whether or not these compounds were included in the process VOC emissions. The non-reactive VOCs were identified and subtracted from the emissions estimates at the process emissions level. This was done prior to rule effectiveness adjustments. Table 2-3 lists the processes with the four highest emissions of reported non-reactive VOC emissions.

Table 2-3. Significant Emissions of Non-Reactive VOCs for 2002

Facility Name	Process	Pollutant	TPY
Maritrans	Crude Oil Lightering	Methane and Ethane	324
General Motors	Misc. Solvent Usage	Acetone	18
DuPont Experimental Station	R&D	Acetone	4.22
Sunoco Refinery	CO_2 Recovery Unit	Methane	4.0

2.13.2 Rule Effectiveness

EPA has had a longstanding requirement that ozone SIP inventories consider and account for rule effectiveness (RE). AQMS staff initially made RE determinations in accordance with the *Guidelines for Estimating and Applying Rule Effectiveness for Ozone/CO State Implementation Plan Base Year Inventories* (EPA, 1992). Revised RE guidance was published in August 2005 and incorporated into *Emissions Inventory Guidance* (EPA, 2005).

Given the large number of stationary point sources contained within an emission inventory, EPA did not expect that state and local agencies would immediately implement the revised guidance for all sources and source categories. Therefore, for the 2002 inventory, it was acceptable to EPA to use either RE guidance. However, EPA encouraged all state and local agencies to use the revised guidance as soon as possible, because EPA believes it will lead to higher quality emission estimates for controlled sources. AQMS decided to reevaluate processes subject to RE using the revised guidance.

Rule effectiveness, as it pertains to point sources, is meant to adjust emissions upward to account for the inability of process control equipment to always operate to the level required by regulation or as stated by the facility. For point sources, RE is applied to the overall control efficiency of each controlled pollutant at the process level. Therefore, the appropriate RE is based on considerations unique to the controlled source.

Identifying Processes for RE Determination

Delaware's 2002 point source inventory had nearly 1,300 processes with emissions of at least one ozone precursor. Only processes with a control device or an applied control technique were considered for RE. Since there are no controls for VOC emissions from combustion sources, only non-combustion VOC emission sources were evaluated. Processes evaluated for RE in past inventories were also considered because AQMS has found that facilities sometimes report controlled emissions but do not indicate the controls or control efficiency. Without control information, AQMS may be led to believe the emissions are uncontrolled and thus would not be identified for an RE determination. Finally, due to the significant level of effort to make an RE determination, processes with controlled emissions less than 0.1 tons were not evaluated for RE.

Point Source Rule Effectiveness Criteria

The new RE guidance recommends that State and local agencies assess a facility against a set of factors in each of five RE value ranges. An RE value should be selected from within the range that best characterizes the facility. Within each range there are three tiers of factors in order of importance:

- The most important factors that influence rule effectiveness,
- Other important factors, and
- Other factors.

Each factor is presented below with a description of the general methods employed by AQMS relative to each factor.

Most Important Factors

- Monitoring - AQMS generally relies on parametric data for most facilities unless CEMs (and associated accuracy testing) are required by a regulation. For larger facilities without CEMs, AQMS generally require a stack test every five years.
- Compliance history - Eight quarters of compliance history for calendar years 2001 and 2002 were obtained.

Other Important Factors

- Type of inspection - AQMS often uses stack test data for compliance determinations. AQMS also conducts boiler efficiency tests and collects parametric data (i.e., temperature of a thermal oxidizer, pressure drop across a baghouse, etc.)
- Operation and maintenance (O&M) – O&M records are reviewed during inspections.
- Unannounced inspections – Generally inspections are announced.
- Actions against violators – AQMS has the authority to impose punitive measures against a facility found to be in violation of Delaware's air quality regulations, including Title V and other permitted facilities. Many fines are levied against facilities each year.

Other Factors

- Compliance certification - Most point sources are subject to Title V or other types of compliance certification.

- Inspection frequency - AQMS generally inspects sources more often than is required under the Compliance Monitoring Strategy agreement with EPA Region 3. AQMS is required to perform a TV inspection every 2 years and a SM inspection every 3 years.
- High Profile Violator (HPV) policy - In 2001 and 2002, AQMS was in the early stages of implementing EPA's HPV program.
- Operator training - Formal training for control equipment operators is not implemented consistently and is generally not a permit requirement.
- Media publicity - All enforcement actions are posted to the DNREC website and some of these actions are published in the media.
- Regulatory guidance - Workshops or information package mailings were not done routinely.
- Inspector training – AQMS staff are trained on an as-needed basis.
- Testing methods and schedule - AQMS has specific testing guidelines and schedule, and testing is based on established protocols.
- Follow-up inspections –Follow-up inspections were conducted, when necessary.

Relevant Compliance Information

The new EPA rule effectiveness guidance (EPA, 2005) states, *"The best way to obtain information on the compliance history of a source is to speak with the compliance and enforcement staff at your agency that is most familiar with the facility."* Although the point source inventory staff conducted the RE evaluations, they consulted with staff and managers from the Engineering and Compliance (E&C) Branch of AQMS. Inventory staff requested from the E&C Branch the compliance history as was entered into EPA's Air Facility System (AFS) database for the years 2001 and 2002. The compliance information provided included descriptions and outcomes of on-site inspections, off-site records reviews, cylinder gas audits (CGAs), recent stack tests, and relative accuracy test audits (RATAs). CGAs and RATAs are associated with units equipped with CEMs. Also provided were copies of Delaware's Federal fiscal year 2001, 2002, and 2003 compliance monitoring plans and reports. A spreadsheets was created to compile the compliance evaluations, stack test results, and RATA and CGA information to organize and expedite the RE evaluation. The RE spreadsheet is included with the supporting documentation contained on a CD accompanying this report.

The new EPA rule effectiveness guidance (EPA, 2005) also states, *"First and foremost, an agency responsible for emissions inventory preparation should attempt to obtain facility-specific data from as many sources as possible, and use the collected information to make a refined source or source category RE determination."* Delaware facilities are requested to provide documentation along with the emissions estimates. Facilities were also asked to explain in the cover letter the reasons for significant facility-wide increases or decreases in emissions from previous years. In cases where this information was not provided and this information was needed for the RE evaluation, the facilities were contacted and in most cases the information was provided.

The compliance plans were reviewed as well as the compliance monitoring reports (semi-annual and end-of-year.) Inventory staff met with a manager in the E&C Branch to gain an understanding of AQMS policies and procedures used in compliance evaluations and inspections. The results of the calendar year 2001 and 2002 compliance summary indicate all TV facilities were inspected at least once during the two year period, meeting EPA requirements. In addition, 64 % of TV facilities were inspected two or more times in the same time period, which is significantly more than EPA requirements. All SM facilities were inspected at least once during the same period and 55% of them were inspected two or more times. The inspection frequency of SM facilities significantly exceeds the EPA requirement of one inspection every three years.

Rule effectiveness determinations made in the 1999 ozone precursor inventory were evaluated to understand the reasons for applying a particular value. If the reasons were still valid, they were considered in light of the new RE guidance document.

When an RE of 100% May Apply

There were several situations where a 100% RE was appropriate and thus no adjustment of the emissions was made. The use of a continuous emission monitor accounts for actual emissions regardless of whether the emissions meet permit limits or stated control device efficiencies. In some instances, the control device or technique had sufficient safeguards to account for any control device equipment failure, such as an automatic shutdown device. For control techniques, such as the use of VOC-compliant paints, the use of mass balance accounted for all possible emissions, as long as the use of compliant paints was verified and there were no add-on controls. Some facilities chose to report an in-use control device efficiency lower than the stated manufacturer's efficiency in order to account for periods of less than optimum control. Other facilities based emission on their permitted control efficiency, which is usually lower than demonstrated efficiencies. Therefore, these facilities were in effect already applying an adjustment to their emissions and AQMS decided to not apply any additional adjustment to the emissions.

Application of RE to CO Sources

The RE evaluation process was organized by pollutant. In the 2002 database, there were 4,600 emission records for VOC, NO_x, and CO, including records with zero reported emissions. Zero emissions existed either because a process did not operate in 2002 or the emissions were assigned to another process. As an example, for a boiler that burns several types of fuel, each boiler/fuel type combination is considered a process. However, emissions may not be known by the facility per each fuel type, as in the case when CEMs are used to determine actual emissions.

There were 1,055 CO emission records in the inventory database; however, only two emission records could be considered controlled. The only source that employed CO controls in 2002 was the Premcor Refinery. The refinery had two CO boilers operating in 2002. In accordance with the *1987-1991 Interim Regional Emission Inventories* (EPA, 1993) these boilers were treated as processes and not as control devices, because they burned CO as a fuel. Therefore, an RE of 100% was used for these boilers.

Application of RE to NO_x Sources

Of the 940 combustion NO_x emissions records, RE was applied to all emission sources having post-combustion NO_x controls, including selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR). However, emissions from all units in Delaware with post-combustion controls were reported based on CEM data, thus a 100% RE was applied for these units.

Many external combustion boilers had combustion NO_x controls, such as low-NO_x burners, low excess air, flue gas recirculation and over-fire air. Most facilities used the uncontrolled AP-42 emission factors to estimate emissions. The use of uncontrolled emission factors is a conservative estimate of emissions if a low-NO_x burner is used. Either a facility is not taking credit for NO_x combustion controls or the emissions were uncontrolled. Therefore, AQMS staff did not further adjust emissions.

Several facilities used stack tests as the basis for estimating emissions. In these cases, the emission estimates were nearly identical to what the emissions would have been if the uncontrolled emission factors were used. Therefore, emissions were not adjusted. One facility operated two ultra-low-NO_x boilers. Since emissions from these units were monitored through the use of a NO_x CEM, 100% RE applied. One facility identified low-NO_x burners for two boilers and estimated emissions using the controlled low-NO_x burner emission factor. The boilers were relatively new and the facility was found to be in compliance. Given the integral nature of a low-NO_x burner to the combustion process (as opposed to post-combustion control), an RE of 100% was considered appropriate.

Three non-combustion NO_x emissions records were identified in the database, two of which were controlled. Rule effectiveness was applied to both of the controlled sources. Based on the RE evaluation, NO_x emissions were adjusted as follows:

General Chemical - Nitrate production area emissions are reported as having a 15% NO_x control efficiency. The emission estimate was not sufficiently documented. The facility was found out of compliance for 47 off-site compliance evaluations, one on-site evaluation and one full compliance evaluation. Therefore an RE adjustment of 80% was applied to estimate emissions.

SPI Polyols – This facility operates a NO_x scrubber associated with nitric acid usage. Emissions were estimated using undocumented facility information, which appeared to be based on 15 years old stack tests. The control efficiency was stated as 27.7%. Therefore an RE adjustment of 80% was applied to estimate emissions.

The application of rule effectiveness increased statewide NO_x emissions by 0.22 TPY statewide.

Application of RE to VOC Sources

There were 2,602 VOC emission records in the inventory database. Emission records for sources known to be uncontrolled were eliminated from further consideration. As a rule, tanks have some type of control and therefore were retained in the list of emission sources for RE consideration. For reasons mentioned earlier, records with controlled emissions less than or equal to 0.1 TPY were not evaluated for RE adjustment. Including tanks, there were 243 controlled VOC emission records with emissions above 0.1 TPY.

Storage tanks comprised over half of the 243 emissions records. AQMS inventory staff instructed facilities to estimate tank emissions using EPA's TANKS software (EPA, 2003). The software uses chemical, meteorological, roof fitting, and rim seal data to generate emission estimates for several types of storage tanks, including vertical and horizontal fixed roof tanks, internal and external floating roof tanks, domed external floating roof tanks and underground tanks. Emissions for eight VOC emission records were not estimated using the TANKS software. However, in all cases uncontrolled emission factors were used. The TANKS software does not provide an overall control efficiency to determine uncontrolled emissions needed for RE adjustments. Therefore, AQMS did not apply RE to reported VOC tank emissions.

VOC air emissions data for six facilities reporting to the Toxic Release Inventory were included in the inventory. The chemical-specific TRI information indicated controls at two facilities. However, since process-level data is not available through TRI, there was insufficient information to make an RE determination on these two facilities. Therefore, RE was not applied to TRI-reported emissions.

Once tanks and TRI facilities were removed from further consideration, 87 controlled emission records remained. Of the 87 emission records, an RE of 100% was applied to 70 records (at 29 facilities) while the remaining 17 emission records (at five facilities) were given an RE of less than 100%. In addition to the reasons stated previously for when AQMS selected an RE of 100%, all 29 facilities that received an RE of 100% were in compliance for calendar years 2001 and 2002. Detailed determinations for each of the 29 facilities can be found in the RE/compliance spreadsheet included on the CD accompanying this report.

For the 17 remaining emission records, VOC emissions were adjusted for RE at the following facilities:

Formosa Plastics – The facility based its vinyl chloride monomer emissions on stack tests that were later determined to be invalid. The facility did not perform a second set of stack tests in the required time period. The facility was also found to be out of compliance during four off-site compliance evaluations. The facility could not demonstrate compliance, therefore an RE of 84% was applied to the vinyl chloride incinerators.

FP International - Compliance evaluations of this facility identified numerous deficiencies. One of the deficiencies included operating a regenerative thermal oxidizer (RTO) below the required temperature for 97 three-hour periods. There were also minor RTO outages and the facility did not keep a continuous record of RTO temperatures. While the facility did report accidental releases, which may have account for the RTO outages, the facility could not demonstrate compliance, therefore an RE of 84% was applied to the thermal oxidizer.

GE Energy - The facility was found to be out of compliance during an inspection and the facility was unable to document their stated control efficiency. An RE of 90 % was applied to the print line thermal oxidizer.

Metachem Products - For many years there had been concerns about the emissions reported for numerous processes at Metachem. The facility closed in May 2002 and did not submit a 2002 inventory. AQMS staff calculated 2002 emissions for this facility using production data for 2002 and previous inventory information. In previous inventories, controlled process emissions were adjusted based on an 80% RE. As of the beginning of 2002, the facility was a high profile violator (HPV) and was out of compliance for three on-site compliance evaluations during 2001. Based on these considerations, an RE of 80% was applied to the controlled sources.

Premcor Refinery– Premcor provided one emission estimate for a collection of controlled processes associated with wastewater treatment. For years, the facility has based this overall control efficiency on a 1993 memorandum which references benzene NESHAP controls. The facility has not provided any documentation on the controls or how the emissions were calculated. An RE of 80% has historically been applied to these processes and was used again for 2002.

The application of rule effectiveness increased statewide VOC emissions by 189 TPY.

Rule Effectiveness Calculations

Where a control device was used and emissions were estimated using an emission factor within ***i***-STEPS®, annual and peak ozone season daily emissions adjusted for RE were calculated using the ***i***-STEPS® emissions calculation utility. Once the RE value was entered into the appropriate field, ***i***-STEPS® automatically calculated the emissions using the *Procedures, Volume I* (EPA, 1991b) relationship.

$$E_{re} = [(Q_a) * (EF_x) / 2000] * [1 - (CE_x * RE)]$$

where:

E_{re}	=	Annual emissions adjusted for RE, tons per year
Q_a	=	Annual process throughput
EF_x	=	Uncontrolled emission factor for pollutant x
CE_x	=	Overall capture and control efficiency
RE	=	Rule effectiveness factor

Where a control device was used and emissions were estimated outside of ***i***-STEPS®, the annual and peak ozone season daily emissions adjusted for RE were calculated using the following equation from *Emissions Inventory Guidance* (EPA, 2005):

$$E_{re} = E_{unc} * [1 - (CE_x * RE)]$$

where:

E_{re}	=	Annual emissions adjusted for RE, tons per year
E_{unc}	=	Uncontrolled emissions
CE_x	=	Overall capture and control efficiency
RE	=	Rule effectiveness factor

In some instances, uncontrolled emissions had to first be calculated from controlled emissions provided using the supplied overall control efficiency as follows:

$$E_{unc} = E_c / (1 - CE_x)$$

where:

E_{unc}	=	Uncontrolled emissions
E_c	=	Controlled emissions
CE_x	=	Overall capture and control efficiency

2.14 NIF File Creation and Review

Once non-reactive VOCs were accounted for and rule effectiveness applied, NIF 3.0 files in Microsoft® Access format were generated from the ***i***-STEPS® database. EPA's Basic Format and Content Checker (versions 3.0 and 3.1) were run numerous times on the eight NIF 3.0 point source inventory Access tables. All issues identified by the checker for mandatory and necessary fields were reviewed and resolved. The resolutions of the issues were as follows:

- A value was in error and the information was corrected; or
- A value was outside ranges determined by EPA, however the value was determined to be reasonable and correct based on information available. Upon completion of the review process less than a dozen records contained data that continued to fall outside the established ranges; or
- The operating hours per year did not match the calculated product of operating hours per day, days per week, and weeks per year. AQMS allows facilities to indicate their actual annual hours of operation independent of the typical operating schedule. Since the difference represents more accurate information, no further action was taken; or
- An SCC was flagged as being invalid. A check of EPA's master list of SCCs indicated the flagged values (five SCCs) are valid, so no further action was taken.

There are some non-mandatory/non-necessary fields of data in the NIF files that were flagged by the checker. Since AQMS does not populate these fields, no further action was taken.

2.15 Source Sector Discussions

All facilities associated with hot-mix asphalt production and electric generation are included in the 2002 ozone precursor point source inventory. Details of these two industry sectors are presented below.

2.15.1 Hot-mix Asphalt Plants

Hot-mix asphalt (also known as asphaltic concrete or blacktop) production facilities have been historically tracked and permitted by the Department as point sources. There were 11 facilities in Delaware in 2002 and these are all included in the point source inventory. Delaware facilities employ both drum mixer and rotary dryer processes in the production of hot-mix asphalt. The appropriate SCCs were used to identify these processes. In 2002, the 11 facilities collectively emitted 22 tons of VOC, 55 tons of NO_x, and 157 tons of CO.

The activity data forms were used to obtain throughput data from hot-mix asphalt plants. Data from the completed forms were entered into ***i***-STEPS® and standard emission factors were used based on the SCC provided by the facility to calculated emissions within ***i***-STEPS®. For one facility, Pure Green Industries, AQMS developed a site-specific emission factor based on recent stack test data, then applied this factor to the asphalt production reported by the facility.

Many of these facilities also had crushing operations powered by diesel engines. The emissions of VOC, NO_x and CO for these diesel engines were estimated based on reported fuel usage and

FIRE 6.24 emission factors. Five Tilcon facilities shared a mobile crusher that moved from facility to facility. Emissions for the mobile crusher were allocated to the Tilcon facility that utilized the crusher the most.

Hot-mix asphalt plants were requested to report their use of cutback asphalt in the manufacturing of “cold patch”, which is a product able to remain workable at ambient temperatures. Data on cold patch production were used to estimate VOC emissions from cutback asphalt within the non-point source sector.

2.15.2 Electric Generating Units (EGUs)

Delaware EGUs are represented by two large generating stations (NRG Indian River Power Plant and the Conectiv Edge Moor/Hay Road complex), a number of smaller private and municipal units, two industrial generators (Premcor Refinery and Invista), and several Conectiv peaking units. In total, there are 45 EGUs located at 15 facilities included in the point source inventory. EGUs in Delaware include external combustion boilers, combustion turbines and reciprocating diesel engines. Small diesel generators used by businesses and institutions for emergency backup power and load management are not included in this discussion, and are generally not reported to the point source inventory. 2002 NO_x emissions from EGUs are presented in Table 2-4.

NO_x emissions from all EGUs represent 73% of the statewide annual NOx emissions. While the amount of annual emissions from peaking units is small relative to the large power plants, their contribution to summer season daily emissions can be significant. Most peaking units operate exclusively during the summer, and operation is typically limited to a few hours per week, which significantly increases their daily contribution. In addition, since peaking units are operated to meet periods of high demand, their operation often coincides with very hot and muggy summer days when air quality is most likely to experience an exceedance of the ozone standard.

2.15.3 Emissions by Source Sector

Table 2-5 provides statewide VOC, NO_x, and CO annual and summer season daily emissions grouped by source sector as defined by the first three digits of the SCC codes assigned to each process. The source sectors include various combustion and manufacturing processing, material storage and transfer operations, solvent evaporation, and solid waste disposal.

Petroleum product transfers account for 39% of the statewide point source VOC emissions. Surface coating operations and petroleum industry processes and storage account for 21% and 12% of the statewide VOC emissions, respectively. NO_x emissions are almost exclusively a result of fuel combustion with 96% of the statewide NO_x emissions coming from utilities (see discussion above) and industrial sources. Fuel combustion is responsible for 43% of the statewide CO emissions. One chemical manufacturer emits 30% of the state total CO emissions and refineries account for an additional 11%.

Table 2-4. 2002 NO_x Emissions for Electric Generating Units

Facility Name	Unit Description	NOx TPY	NOx TPD
City of Dover McKee Run	Boiler #1	23	0.39
	Boiler #2	22	0.34
	Boiler #3	345	1.94
City of Dover Van Sant	Turbine	13	0.17
NRG Energy Center Dover	Boiler	484	1.38
	Turbine #1	5	0.15
	Turbine #2	3	0.09
Warren F. Beasley Power Station	Turbine	5	0.04
Kent County Total		**899**	**4.50**
Conectiv Christiana	Turbine #11	13	0.51
	Turbine #14	13	0.52
Conectiv Delaware City	Turbine #10	9	0.31
Conectiv Edge Moor	Boiler #3	748	2.38
	Boiler #4	1,096	3.25
	Boiler #5	1,289	13.94
	Turbine	5	0.31
Conectiv Hay Road	Turbine #1	93	0.50
	Turbine #2	145	0.73
	Turbine #3	205	1.09
	Turbine #5	30	0.21
	Turbine #6	55	0.43
	Turbine #7	38	0.30
Conectiv Madison Street	Turbine	1	0.23
Conectiv West Substation	Turbine	8	0.22
Premcor Refinery (formerly Motiva Enterprises)	Boiler #1	370	1.00
	Boiler #2	205	0.60
	Boiler #3	342	0.97
	Boiler #4	419	1.14
	Turbine #1	63	0.56
	Turbine #2	34	0.20
New Castle County Total		**5,181**	**29.41**
City of Lewes Power Plant	Reciprocating Unit #1	1	0.11
	Reciprocating Unit #2	1	0.11
City of Seaford Power Plant	Reciprocating Unit #1	18	0.17
	Reciprocating Unit #2	17	0.16
	Reciprocating Unit #3	14	0.14
	Reciprocating Unit #4	14	0.14
	Reciprocating Unit #5	0	0
	Reciprocating Unit #6	21	0.23
Invista (formerly DuPont Seaford)	Boiler #1	311	1.50
	Boiler #2	634	2.03
	Boiler #3	547	1.92
NRG Indian River Power Plant	Boiler #1	666	2.43
	Boiler #2	621	2.58
	Boiler #3	663	3.41
	Boiler #4	2,365	8.83
	Turbine #10	4	0.32
Sussex County Total		**5,897**	**24.09**
STATE TOTAL		**11,977**	**58.00**

Table 2-5. 2002 Annual VOC, NO_x, and CO Emissions by Industry Sector

SCC	SCC Description	TPY		
		VOC	NO_x	CO
101	External Comb. Boilers - Electric Generation	82	9,172	581
102	External Combustion Boilers - Industrial	264	5,610	3,311
103	Ex. Comb. Boilers – Comm./Institutional	7	152	92
105	External Comb. Boilers - Space Heaters	2	36	10
201	Internal Comb. Engines - Electric Generation	20	818	114
202	Internal Combustion Engines - Industrial	3	44	12
203	Internal Combustion Engines – Comm./Inst.	1	14	3
204	Internal Comb. Engines - Engine Testing	2	23	6
301	Chemical Manufacturing	377	88	2,888
302	Food and Agriculture	14	30	3
303	Primary Metal Production	67	125	624
305	Mineral Products	49	44	155
306	Petroleum Industry	467	133	1,013
308	Rubber and Misc. Plastics Products	100	6	< 1
312	Machinery, Misc.	0	0	< 1
315	Photo. Equipment/Health Care/Labs	4	0	0
330	Textile Products	38	0	0
385	Cooling Tower	< 1	0	0
390	In-process Fuel Use	< 1	1	< 1
399	Misc. Manufacturing	19	< 1	< 1
401	Organic Solvent Evaporation	11	0	0
402	Surface Coating Operations	997	8	8
403	Petroleum Product Storage at Refineries	128	0	0
404	Petroleum Liquids Storage (non-Refinery)	10	0	0
405	Printing/Publishing	126	0	0
406	Transport/Marketing of Petroleum Products	1,879	5	13
407	Organic Chemical Storage	9	0	0
408	Organic Chemical Transportation	5	0	0
490	Organic Solvent Evaporation	37	< 1	< 1
501	Solid Waste Disposal - Government	13	1	14
502	Solid Waste Disposal – Comm./Institutional	25	29	84
503	Solid Waste Disposal - Industrial	18	32	664
651	Inorganic Chemicals Manufacturing	< 1	0	0
684	Miscellaneous Processes (Chemicals)	0	0	16
	Statewide Total	**4,773**	**16,372**	**9,612**

2.16 Emissions by Facility

Facility-level annual and summer season daily emissions for the 121 facilities included in the 2002 ozone SIP inventory are provided by county in Tables 2-6 through 2-8. Emissions in these tables have been adjusted for rule effectiveness, where appropriate. For recent facility name changes, the former name is included in parentheses.

Table 2-6. 2002 Facility-Level Annual and SSWD VOC, NO_x, and CO Emissions for Kent County Facilities

Facility Name	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
Camdel Metals	7	0.03	0	0	0	0
City of Dover - McKee Run	4	0.03	392	2.70	35	0.29
City of Dover - Van Sant	< 1	< 0.01	13	0.17	4	0.05
Color-Box (Inland Paperboard and Packaging)	13	0.06	1	< 0.01	< 1	< 0.01
Delaware State University	< 1	< 0.01	4	< 0.01	3	< 0.01
Dover Air Force Base	38	0.10	57	0.15	26	0.05
Dow Reichhold	18	0.05	11	0.02	8	0.02
DSWA Central Landfill	7	0.02	14	0.04	265	0.73
Hanover Foods	< 1	< 0.01	9	< 0.01	1	< 0.01
Harris Manufacturing (General Clothing)	6	0.04	0	0	0	0
Hirsh Industries	19	0.08	1	< 0.01	1	< 0.01
ILC Dover	5	0.01	0	0	0	0
Kent General Hospital	< 1	< 0.01	2	0.01	1	< 0.01
Kraft Foods	< 1	0	7	0	3	0
NRG Energy Center Dover	2	< 0.01	492	1.63	25	0.21
Perdue Farms - Milford	< 1	< 0.01	15	0.06	2	0.01
Proctor & Gamble Dover Wipes	8	0.03	19	0.12	4	0.02
Tilcon - Bay Road	5	0.03	14	0.07	17	0.10
Tilcon - Horsepond Road	1	< 0.01	8	0.04	33	0.16
Warren F. Beasley Power Station	< 1	< 0.01	5	0.04	10	0.09
Kent County Total	**133**	**0.49**	**1,064**	**5.06**	**436**	**1.73**

Table 2-7. 2002 Facility-Level Annual and SSWD VOC, NO_x, and CO Emissions for New Castle County Facilities

Facility Name	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
Agilent - Little Falls (Hewlett-Packard)	1	< 0.01	0	0	0	0
A.I. DuPont Hospital	1	< 0.01	28	0.06	3	0.01
Air Liquide - Delaware City	3	0.01	0	0	5	0.01
American Minerals	16	0.06	1	< 0.01	< 1	< 0.01
Ametek	1	< 0.01	2	< 0.01	2	< 0.01
Amtrak Maintenance Facility	1	< 0.01	3	0.01	2	< 0.01
Arlon	1	< 0.01	0	0	0	0
AstraZeneca Pharmaceuticals	2	< 0.01	14	0.03	9	0.02
Christiana Hospital	1	0.08	36	1.62	4	0.34
Christiana Materials	1	0.01	3	0.03	10	0.06
Ciba Specialty Chemicals	26	0.07	9	0.02	28	0.06
Claymont Steel (Citisteel USA)	67	0.32	125	0.59	624	3.00
Clean Earth of New Castle	11	0.03	18	0.07	2	0.01
Conectiv - Christiana	< 1	< 0.01	26	1.04	< 1	0.01
Conectiv - Delaware City	< 1	< 0.01	9	0.31	< 1	< 0.01
Conectiv - Edge Moor	36	0.23	3,138	19.88	453	2.17
Conectiv - Hay Road	10	0.05	566	3.26	73	0.39
Conectiv - Madison Street	< 1	< 0.01	1	0.23	< 1	< 0.01
Conectiv - West Substation	< 1	< 0.01	8	0.22	< 1	< 0.01
Contractors Materials (New Castle Hot Mix)	2	0.02	2	0.01	9	0.07
Crowell	2	< 0.01	2	0.01	3	0.01
DaimlerChrysler	595	2.17	39	0.07	27	0.04
Dassault Falcon Jet	9	0.03	1	0	1	0
Del. Correctional Center - Smyrna	1	0.01	10	0.14	7	0.04
Delaware Recyclable Products	2	0.01	1	< 0.01	5	0.01
Diamond Materials	4	0.02	4	0.02	16	0.08
DSWA Cherry Island Landfill	12	0.03	< 1	< 0.01	3	0.01
DSWA Pigeon Point Landfill	3	0.01	1	< 0.01	14	0.04
DuPont - Chestnut Run	3	0.01	52	0.18	6	0.02
DuPont - Edge Moor	83	0.27	35	0.29	2,843	9.70
DuPont Experimental Station	8	0.05	208	0.91	22	0.12
DuPont Stine - Haskell Lab	2	0.02	46	0.43	8	0.07
DuPont Building - Wilmington	< 1	< 0.01	24	0.07	3	0.01
E-A-R Specialty Composites	5	0.02	1	< 0.01	< 1	< 0.01
Edgemoor Materials	2	0.01	2	0.01	4	0.02
FMC	< 1	< 0.01	< 1	< 0.01	2	0.01
Formosa Plastics	124	0.32	31	0.08	8	0.01
FP International	33	0.12	1	< 0.01	1	< 0.01
GE Energy – Pencader (Astropower)	14	0.05	0	0	0	0
General Chemical	2	< 0.01	91	0.38	22	0.05
General Motors	334	1.51	56	0.11	19	0.06
Hardcore Composites	< 1	< 0.01	0	0	0	0
Hercules Research Center	1	0.01	31	0.13	3	0.01

Continued next page

Table 2-7. continued

Facility Name	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
Honeywell International (Allied-Signal)	46	0.16	0	0	0	0
International Petroleum	6	0.02	5	0.04	1	0.01
Kaneka	19	0.05	5	0.01	67	0.18
Lafarge	10	0.05	69	0.32	27	0.13
Laidlaw	14	0.14	0	0	0	0
MacDermid	9	0.04	1	< 0.01	< 1	0
Magellan Terminals (Delaware Terminal)	1	< 0.01	4	0.01	1	< 0.01
Medal Air Liquide	1	< 0.01	0	0	0	0
Metachem Products (Standard Chlorine of Delaware)	20	0	0	0	0	0
Noramco	2	< 0.01	2	0.01	4	0.01
NVF Yorklyn	1	< 0.01	16	0.06	13	0.05
Occidental Chemical	1	0.01	48	0.25	28	0.16
Premcor Refinery (Motiva Enterprises)	829	2.35	3,555	10.59	3,858	14.66
Premcor Bulk Terminal (Motiva)	29	0.08	0	0	0	0
Printpack	107	0.28	4	0.01	4	0.01
PTFE Compounds	14	0.07	0	0	0	0
Pure Green Industries	< 1	< 0.01	1	0.04	2	0.02
Rohm & Haas Electronic Materials (Rodel)	23	0.10	5	0.08	3	0.02
Spatz Fiberglass	2	0.01	0	0	0	0
SPI Polyols	2	< 0.01	150	0.37	49	0.13
St. Francis Hospital	< 1	< 0.01	3	0.01	3	< 0.01
Sunoco	50	0.14	610	1.76	182	0.53
Tilcon - Terminal Avenue	3	0.02	4	0.02	13	0.07
Uniqema	11	0.04	3	0.01	5	0.02
Unisource Worldwide	13	0.05	1	< 0.01	< 1	< 0.01
University of Delaware - Newark	5	0.02	23	0.08	17	0.06
Veterans Administration Hospital	< 1	< 0.01	4	0.01	3	0.01
VPI Film (American Mirrex)	20	0.06	5	0.01	0	0
Westvaco	10	0.03	< 1	0	< 1	0
Wilmington Hospital	1	0.01	9	0.14	5	0.04
Wilmington Piece Dye	21	0.10	2	0.01	2	0.01
Wilmington WWTP	< 1	< 0.01	3	0.01	2	0.01
New Castle County Total	**2,687**	**9.42**	**9,157**	**44.09**	**8,530**	**32.60**

Table 2-8. 2002 Facility-Level Annual and SSWD VOC, NO_x, and CO Emissions for Sussex County Facilities

Facility Name	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
Allen Family Foods	< 1	< 0.01	7	0.02	1	< 0.01
Allen's Milling	< 1	< 0.01	10	0.03	3	0.01
City of Lewes Power Plant	< 1	0.01	3	0.21	1	0.06
City of Seaford Power Plant	4	0.04	83	0.85	18	0.18
DSWA Southern Landfill	9	0.02	20	0.05	263	0.72
Invista (DuPont Seaford)	14	0.04	1,563	5.67	43	0.13
Johnson Polymers	< 1	< 0.01	< 1	< 0.01	< 1	< 0.01
Justin Tanks	16	0.04	< 1	0	< 1	0
Kaye Construction	< 1	< 0.01	7	0.06	23	0.13
Marble Works	1	< 0.01	0	0	0	0
Maritrans	1,836	12.90	0	0	0	0
Mil-Del	2	0.01	0	0	0	0
Milford Memorial Hospital	< 1	< 0.01	3	0.04	1	0.01
Mountaire Farms - Frankford	< 1	< 0.01	10	0.02	1	< 0.01
Mountaire Farms - Millsboro	< 1	< 0.01	27	0.06	3	0.01
Mountaire Farms - Selbyville	< 1	< 0.01	13	0.04	1	< 0.01
Multi-Tech (D&B Industrial Group)	12	0.05	0	0	0	0
NRG Indian River Power Plant	34	0.19	4,320	17.57	249	1.01
Orient	1	0.01	0	0	0	0
Perdue Farms AgriRecycle	< 1	< 0.01	23	0.08	< 1	< 0.01
Perdue Farms - Bridgeville	< 1	< 0.01	8	0.02	1	< 0.01
Perdue Farms - Georgetown	< 1	< 0.01	20	0.08	2	0.01
Pinnacle Foods (Vlasic Foods)	12	0.04	9	0.04	1	< 0.01
Sea Watch International	< 1	< 0.01	15	0.07	3	0.02
Tilcon - Georgetown	3	0.02	6	0.03	14	0.06
Tilcon – Gumboro (I.A. Construction)	4	0.02	3	0.02	16	0.08
Sussex County Total	**1,952**	**13.40**	**6,151**	**24.95**	**645**	**2.44**

2.16.1 Sources of VOC Emissions

VOCs are emitted from a wide variety of combustion and non-combustion sources in Delaware. The largest point source of VOC emissions for 2002 is the crude oil lightering operation reported by Maritrans that occurs at an anchorage in the middle of the Delaware Bay within the boundaries of Sussex County. The emissions occur when crude oil is pumped from a supertanker to barges to reduce the draft of the supertanker so it is able to reach ports further up the river. The emissions are a result of the displacement of organic vapors within the barge when crude oil is transferred to the barge. Maritrans accounts for 38.5% of the statewide VOC emissions.

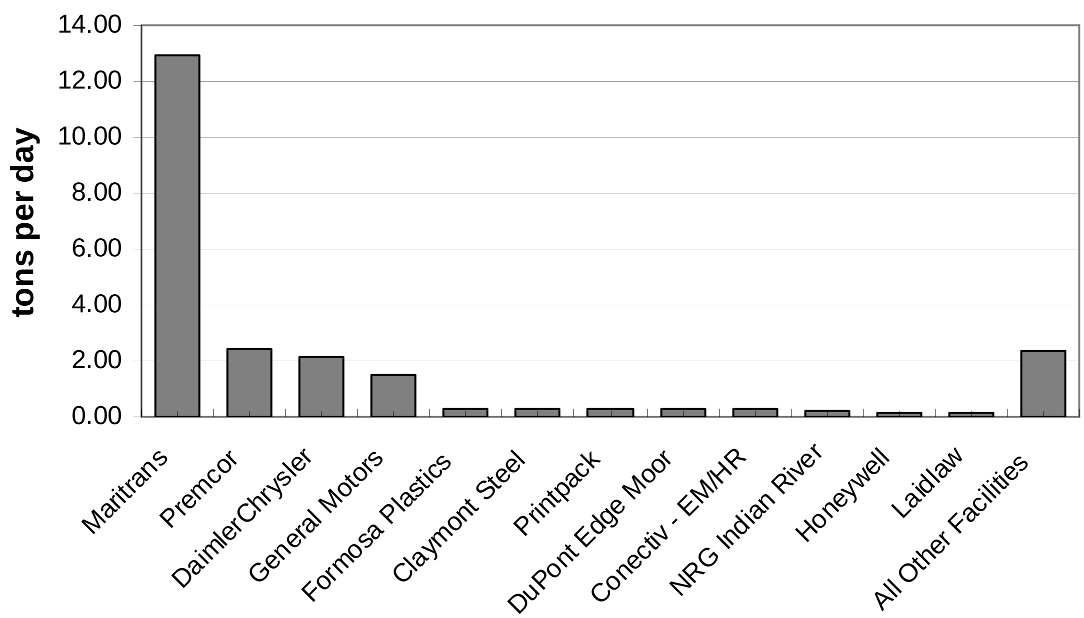
The second largest source of VOC emissions is the Premcor Refinery and its accompanying bulk terminal. The refinery and bulk terminal report emissions for several hundred processes, although only a few processes account for a large majority of emissions (85%), including the catalytic cracking unit, the fluidized coking unit, the wastewater treatment plant, and storage tanks. The third and fourth largest sources of VOC emissions in 2002 are the two automotive assembly plants in Delaware, DaimlerChrysler and General Motors, respectively. Coating operations represent the bulk of emissions from these two facilities.

The top twelve VOC sources, representing 90% of statewide VOC SSWD daily emissions for 2002 from point sources, are presented in Table 2-9 and in Figure 2-1.

Table 2-9. 2002 Facility Ranking of VOC SSWD Emissions

Facility Name	Major Activity	VOC	
		TPD	TPY
Maritrans	Crude Oil Lightering	12.90	1,836
Premcor Refinery & Terminal	Petroleum Refinery	2.43	858
DaimlerChrysler	Automotive Assembly Plant	2.17	595
General Motors	Automotive Assembly Plant	1.51	334
Formosa Plastics	PVC Manufacturing	0.32	124
Claymont Steel	Steel Manufacturing	0.32	67
Conectiv Edge Moor/ Hay Road	Electricity Generation	0.28	46
Printpack	Plastic Film Printing	0.28	107
DuPont Edge Moor	Titanium Dioxide Manufacturing	0.27	83
NRG Indian River Power Plant	Electricity Generation	0.19	34
Honeywell International	Specialty Chemicals	0.16	46
Laidlaw	Metal Wire Coating	0.14	14
All Other Facilities		2.33	630
Statewide Total		**23.31**	**4,773**

Figure 2-1. 2002 VOC SSWD Emissions by Facility



2.16.2 Sources of NO_x Emissions

As presented in Section 2.14.2, NO_x emissions from Delaware point sources are primarily from electricity generation. The two large electricity generation stations in Delaware, NRG Indian River Power Plant and the Conectiv Edge Moor/Hay Road complex, are the largest and second largest NO_x point sources for 2002. The third largest source of NO_x emissions is the Premcor refinery. A large majority of emissions (75%) from the refinery come from just a few processes, including the catalytic cracking unit, the fluidized coking unit, and four boilers used for electricity generation. The fourth largest source of NO_x emissions is the Invista nylon manufacturing facility (formerly DuPont Seaford). The facility operates three coal-fired boilers to create heat and electricity for use at the plant. These boilers emit more than 95% of the NO_x emissions reported by the facility for 2002.

The top ten NO_x sources, representing 90% of statewide NO_x SSWD daily emissions for 2002 from point sources, are presented in Table 2-10 and in Figure 2-2.

Table 2-10. 2002 Facility Ranking of NO_x SSWD Emissions

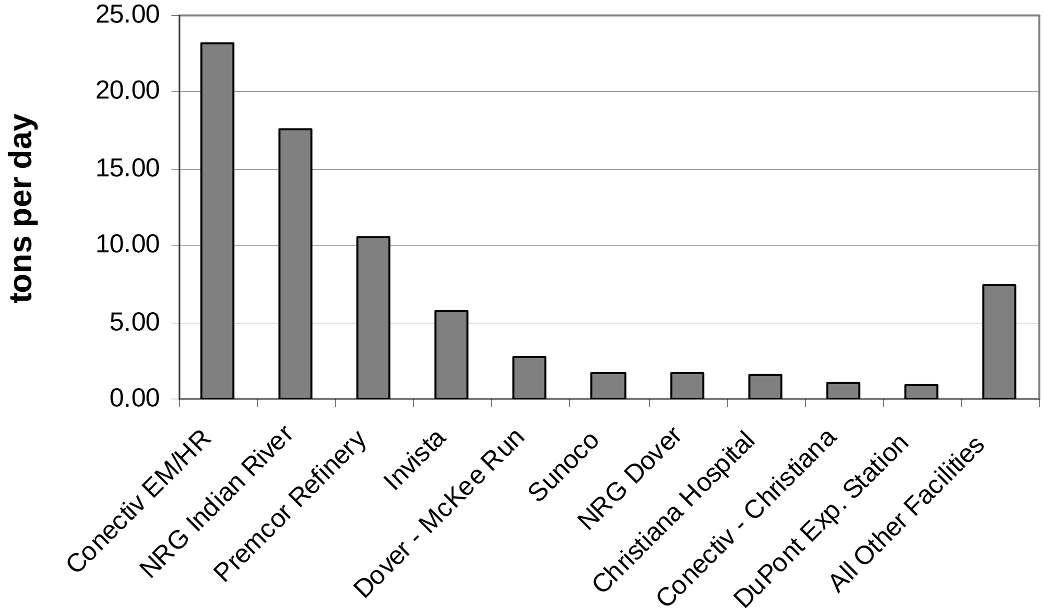
		NO_x	
Facility Name	**Major Activity**	**TPD**	**TPY**
Conectiv Edge Moor/Hay Road	Electricity Generation	23.13	3,704
NRG Indian River Power Plant	Electricity Generation	17.57	4,320
Premcor Refinery & Terminal	Petroleum Refinery	10.59	3,555
Invista	Nylon Production/Cogeneration	5.67	1,563
City of Dover McKee Run	Electricity Generation	2.70	392
Sunoco	Petroleum Refinery	1.76	610
NRG Energy Center Dover	Electricity Generation	1.63	492
Christiana Hospital	Health Care	1.62	36
Conectiv Christiana	Electricity Generation	1.04	26
DuPont Experimental Station	R&D Hazardous Waste Incinerator	0.91	208
All Other Facilities		7.47	1,467
Statewide Total		**74.09**	**16,372**

2.16.3 Sources of CO Emissions

CO is typically formed during combustion processes. Most combustion units produce mostly carbon dioxide (CO_2) since CO emissions represent incomplete combustion and loss of efficiency. Large quantities of CO emissions may result from combustion processes operating at lower than normal temperature, short residence time, and/or under starved-air conditions.

The largest point source of CO emissions for 2002 is the Premcor Refinery. Over 90% of CO emissions from the refinery come from the catalytic cracking unit, the fluidized coking unit, and several gas flares. The refinery limits the emissions from the cracking and coking units by routing exhaust gases from these processes through CO boilers, which convert the CO into CO_2. The second largest CO source is the DuPont Edge Moor titanium dioxide plant. The manufacturing of titanium dioxide through the roasting of titanium rich ore forms large quantities of CO.

Figure 2-2. 2002 NO_X SSWD Emissions by Facility

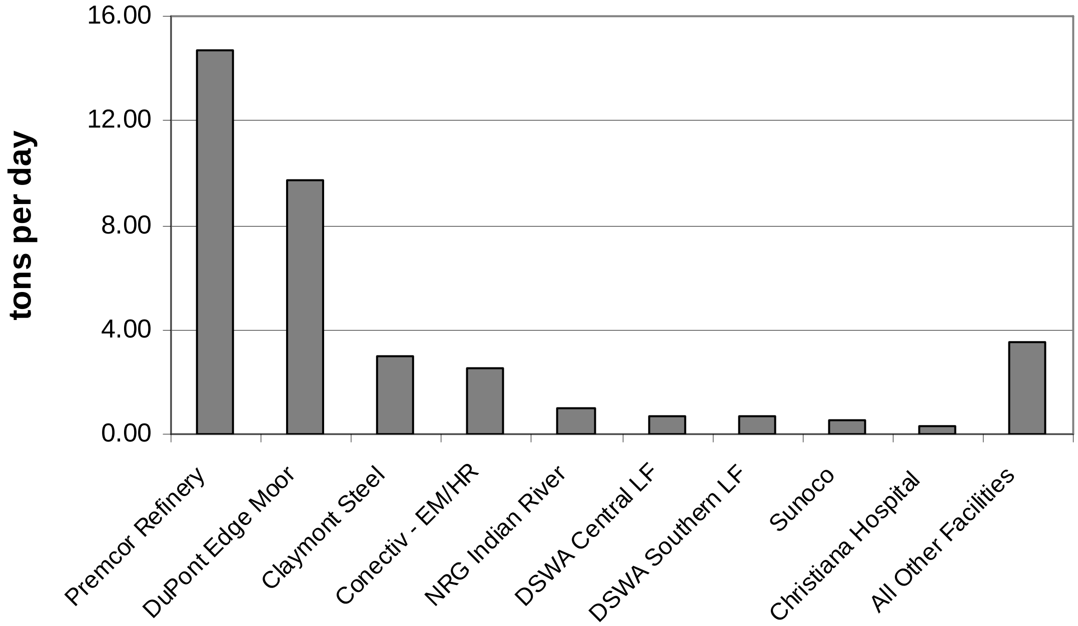


The top nine CO sources, representing 90% of statewide CO SSWD daily emissions for 2002 from point sources, are presented in Table 2-11 and in Figure 2-3.

Table 2-11. 2002 Facility Ranking of CO SSWD Emissions

		CO	
Facility Name	**Major Activity**	**TPD**	**TPY**
Premcor Refinery & Terminal	Petroleum Refinery	14.66	3,858
DuPont Edge Moor	Titanium Dioxide Manufacturing	9.70	2,843
Claymont Steel	Steel Manufacturing	3.00	624
Conectiv Edge Moor/Hay Road	Electricity Generation	2.56	525
NRG Indian River Power Plant	Electricity Generation	1.01	249
DSWA Central Landfill	Municipal Solid Waste Landfill	0.73	265
DSWA Southern Landfill	Municipal Solid Waste Landfill	0.72	263
Sunoco	Petroleum Refinery	0.53	182
Christiana Hospital	Health Care	0.34	4
All Other Facilities		3.53	798
Statewide Total		**36.77**	**9,612**

Figure 2-3. 2002 CO SSWD Emissions by Facility



2.17 Facilities Since Closed

Several facilities included in the 2002 ozone SIP inventory have permanently closed. Table 2-12 presents a list of closed facilities and the month and year operations ceased.

Table 2-12. Facilities That Have Ceased Operations

Facility Name	Date Closed
Metachem Products	May 2002
Lafarge	November 2002
Westvaco	May 2003
Kaneka	July 2003
VPI Film	July 2003
Wilmington Piece Dye	September 2003
General Chemical	June 2004
Conectiv - Madison Street	December 2004
Ametek	October 2005
Tilcon - Horsepond Road	December 2005

2.18 References

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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:

$$Emissions\ (E) \quad = \quad Activity\ Data\ (Q) \quad x \quad Emission\ Factor\ (EF)$$

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

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

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

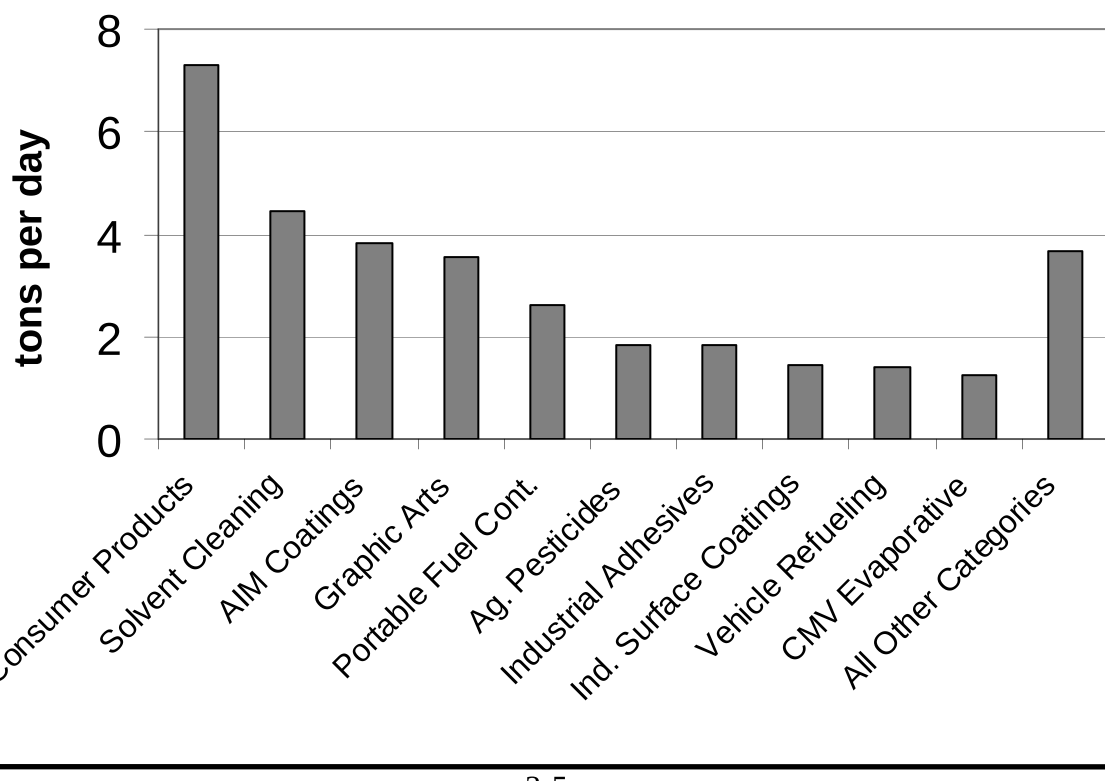

Table 3-2. Summary of 2002 Statewide Emissions from Non-point Sources

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:

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

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:
- 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	VOC 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:

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

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:

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

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	VOC 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:	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

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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

Fuel Type	Emission Factors[a]			Units
	VOC	NO_x	CO	
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

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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:

- 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

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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

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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)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	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

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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:

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

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

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		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

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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:

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

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.

NFDC, 2003. Federal Emergency Management Agency, U.S. Fire Administration, National Fire Data Center, *2002 Residential and Non-Residential Fire Data*, Washington, DC, accessed November 2003, available at http://www.usfa.fema.gov/inside-usfa/nfdc/nfdc-data.shtm.

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:

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

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) VOC	Annual (TPY) NO_x	Annual (TPY) CO	SSWD (TPD) VOC	SSWD (TPD) NO_x	SSWD (TPD) 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:

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

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:

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:

$$E = W \times EF \times \frac{1}{2000}$$

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

SECTION 4

NON-ROAD MOBILE SOURCES

4.1 Introduction

Non-road mobile sources represent a large and diverse set of off-road vehicles and non-stationary equipment. Emission estimates for this source sector account for exhaust emissions (VOCs, NOx, and CO) from engine fuel combustion and evaporative VOC emissions. The evaporative emissions are associated with equipment fuel tanks, fuel lines, and refueling of non-road equipment using portable fuel containers. Finally, the methodology for estimating evaporative emissions from commercial marine vessel (CMV) loading and transport of petroleum products is included within this section due to the large overlap with CMV engine exhaust emission estimation methodologies. However, SCCs associated with loading and transport of petroleum products are grouped with other non-point source SCCs. Therefore, loading and transport emissions are included in the non-point source NIF files and summaries under the Gas Marketing category.

4.1.1 Source Categories

Non-road vehicles and equipment are grouped into four source category types for the purpose of developing emission estimates. These include:

- **Aircraft –** Commercial, military, and private aircraft are considered under this source category.

- **Locomotives –** Commercial line haul and yard locomotives are considered under this source category.

- **Commercial Marine Vessels (CMVs) –** Various types of vessels that navigate the Delaware Bay and River and the Chesapeake and Delaware Canal are included under this source category. Recreational boats are included in the next category.

- **Other Off-road Vehicles and Equipment –** All other off-road emission sources are accounted for through the use of EPA's NONROAD model. The NONROAD model compiles off-road equipment pertinent to Delaware into the following subcategories:

  - Recreational (land-based);
  - Construction and Mining;
  - Industrial;
  - Lawn and Garden;
  - Agricultural;
  - Commercial;
  - Logging;
  - Airport Ground Support;
  - Recreational Marine; and
  - Railway Maintenance.

Individual equipment SCCs covered in the NONROAD model are further broken down by the fuel type, including 2-stroke gasoline, 4-stroke gasoline, diesel, liquefied petroleum gas (LPG), and compressed natural gas (CNG).

4.1.2 Emission Estimation Methodologies

The 1999 Periodic Emission Inventory (PEI) served as the starting point for non-road source category selection and methodology development. No new sources were added to Delaware's off-road mobile source inventory. However, new methods were applied to some existing source categories, such as the CMV category, and emission factors were updated where available. Also the NONROAD model went through several versions during the development of the 2002 inventory with important improvements in the latest version (NONROAD2005).

Similar to the estimation of stationary non-point emissions, off-road equipment emissions were estimated by multiplying an indicator of collective activity within the inventory area for a source category by a corresponding emission factor. The indicators of activity for off-road sources include landing and take-offs (LTOs), vessel port-of-calls, time-in-mode (TIMs, which are pertinent to aircraft and CMVs), gross ton miles (locomotives), equipment populations and economic activity (both pertinent to NONROAD equipment) that can be correlated with the emissions from that source. The corresponding emission factors are amount of pollutant (either grams or pounds) per unit of fuel used (locomotives and military/commercial aircraft), per LTO (air taxi and general aviation) or per unit of power output in brake horsepower or kilowatt-hours (NONROAD equipment and CMVs, respectively).

A major portion of the work involved in creating the 2002 non-road 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. The details of gathering activity data for each source category are presented within this section of the report.

There are no point source data that must be backed out of the non-road mobile source sector. Even though there are airports that report as a point source (e.g., the Dover Air Force Base), their reported emissions do not include ground support equipment or aircraft engine and evaporative emissions. Also, aircraft emissions are estimated only for LTOs that take place at a Delaware airport. Emissions from aircraft that transit Delaware airspace are not included in Delaware's inventory.

Source activity may fluctuate significantly on a seasonal and weekly basis. As an example, most residential lawn and garden equipment usage takes place during the warmer months of the year. However, that activity is also more prevalent on weekends, thus reducing the summer season weekday (SSWD) emissions value. Because off-road 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 and temporal allocation profiles were developed to estimate SSWD emissions.

4.1.3 2002 Emissions Summary

Table 4-1 provides a statewide summary of the 2002 annual (tons per year, TPY) and SSWD (tons per day, TPD) emissions for aircraft, locomotives, commercial marine vessels, and all equipment emissions estimated using EPA's NONROAD model. The non-road sector is a significant contributor to ozone precursors in Delaware. The totals may not match the sum of the individual values due to independent rounding.

Table 4-1. Summary of 2002 Statewide Emissions from Non-road Sources

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
NONROAD Model Equipment	7,531	25.28	5,798	21.40	65,954	258.10
Aircraft	291	0.94	970	3.18	1,570	5.11
Locomotives	57	0.16	1,097	3.02	120	0.33
Commercial Marine Vessels	140	0.39	9,118	25.20	1,275	3.53
NON-ROAD SECTOR TOTAL	**8,019**	**26.77**	**16,982**	**52.79**	**68,918**	**267.06**

Figures 4-1 presents the top seven VOC categories based on SSWD daily emissions. The lawn and garden equipment category accounts for 43% of the statewide SSWD daily VOC emissions from the non-road sector. The lawn and garden category is comprised of a large equipment population made up of 2-stroke and 4-stroke gasoline engines, which produce most of the VOC emissions for this category.

The recreational marine category, also referred to as pleasure craft, accounts for 25% of the statewide SSWD daily VOC emissions from the non-road sector, due to the large number small boats that use 2-stroke gasoline engines. A large amount of the annual activity of lawn and garden equipment and pleasure craft takes place within the peak ozone season, further increasing the SSWD daily values compared to other categories.

Figure 4-1. 2002 Statewide VOC SSWD Emissions by Non-road Source Category

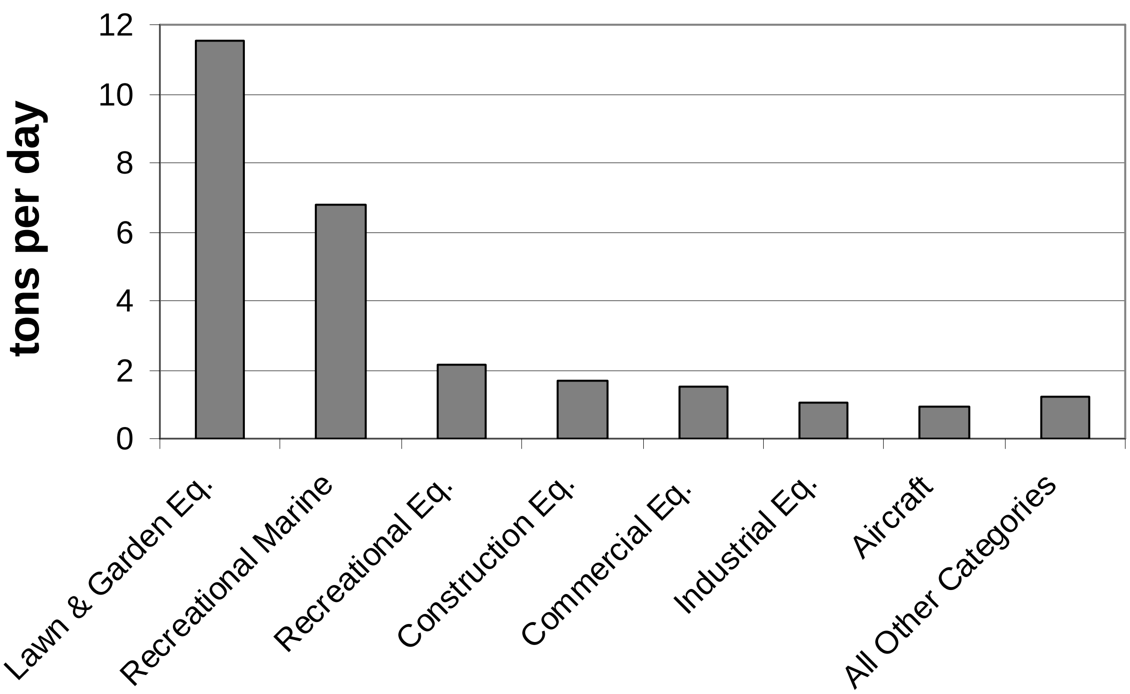
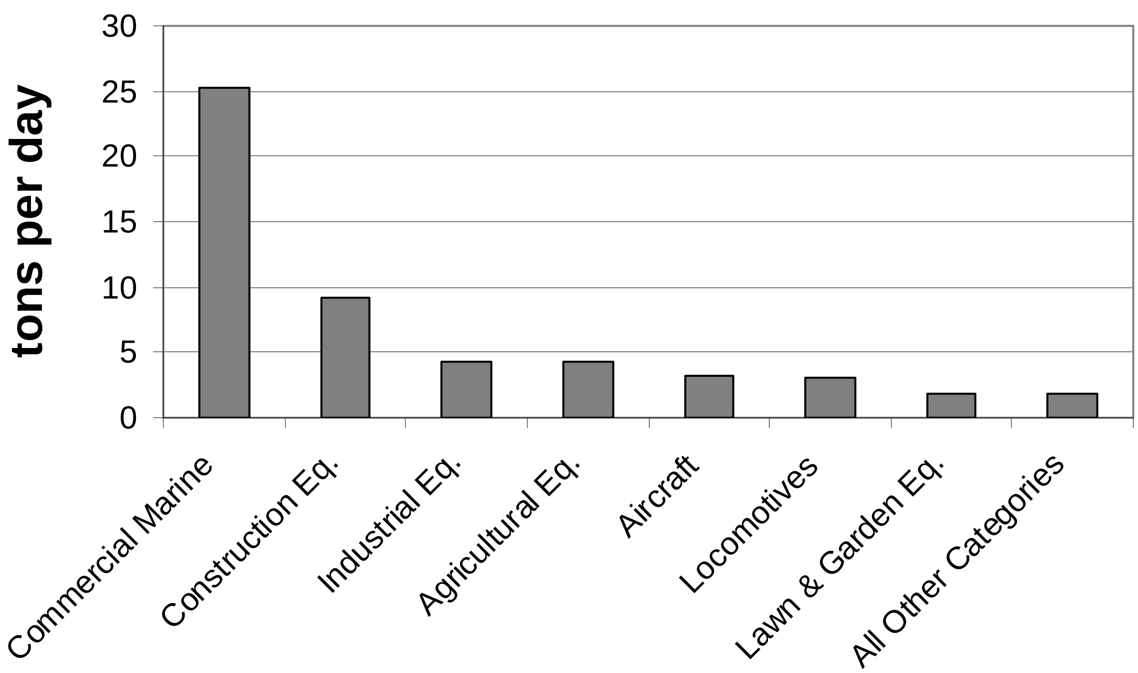


Figure 4-2 presents the top seven NO_x categories based on SSWD daily emissions. The commercial marine vessel (CMV) category accounts for 48% of the statewide SSWD daily NO_x emissions from the non-road sector. The Delaware River and Bay is one of the largest port areas in the United States. Thousands of ships each year ply Delaware waters en route to ports in Wilmington, Philadelphia, Camden, Trenton, and other locations along the highly industrialized Delaware River. The predominant fuels used by CMVs are diesel and residual oil. NOx emission rates for CMV engines combusting these fuels are high compared to rates for the combustion of gasoline and other fuels (liquid propane and natural gas).

The construction equipment category accounts for 17% of the statewide SSWD daily NO_x emissions from the non-road sector, due to the large diesel equipment population. The construction category includes commercial, residential, and road construction equipment.

Figure 4-2. 2002 Statewide NO_X SSWD Emissions by Non-road Source Category



Tables 4-2 through 4-4 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.

Table 4-2. Summary of 2002 Non-road Emissions for Kent County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
NONROAD Model Equipment	1,360	4.30	1,487	5.68	9,974	37.39
Aircraft	235	0.76	945	3.10	774	2.63
Locomotives	11	0.03	206	0.57	22	0.06
Commercial Marine Vessels	30	0.08	2,071	5.67	291	0.80
KENT COUNTY TOTAL	**1,636**	**5.17**	**4,709**	**15.02**	**11,061**	**40.88**

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

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
NONROAD Model Equipment	3,250	11.76	2,480	8.69	37,075	149.01
Aircraft	53	0.16	24	0.08	683	2.05
Locomotives	41	0.11	776	2.13	85	0.23
Commercial Marine Vessels	72	0.20	4,999	13.72	767	2.10
NEW CASTLE COUNTY TOTAL	**3,415**	**12.24**	**8,279**	**24.62**	**38,609**	**153.40**

Table 4-4. Summary of 2002 Non-road Emissions for Sussex County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
NONROAD Model Equipment	2,921	9.22	1,831	7.03	18,906	71.69
Aircraft	4	0.01	1	< 0.01	113	0.43
Locomotives	6	0.02	115	0.32	13	0.03
Commercial Marine Vessels	38	0.11	2,047	5.81	217	0.63
SUSSEX COUNTY TOTAL	**2,968**	**9.36**	**3,994**	**13.15**	**19,248**	**72.79**

4.2 NONROAD Model Equipment

DNREC began the development of non-road source emissions using the draft NONROAD2002a model version (EPA, 2003) and developed annual and SSWD emission estimates based on that version. The documentation in this section is based on the efforts to develop those estimates. However, in early 2006 MANE-VU contracted with E.H. Pechan and Associates to develop new 2002 annual emission estimates based on the use of NONROAD2005, the newly released version of the model (EPA, 2005). These new estimates were used for the regional attainment demonstration modeling. These estimates included the same Delaware-specific inputs that were developed for the running of the NONROAD2002a model version. In order to be consistent with the modeling effort, the annual emissions developed by MANE-VU using NONROAD2005 are the emissions Delaware is submitting in its SIP and included in this report. SSWD values were developed by summing the NONROAD2005 monthly emissions for June, July, and August and applying the weekly allocation profiles used to develop the original SSWD daily values.

Most equipment covered by the NONROAD model is powered by diesel-fueled compression-ignition engines or gasoline-fueled spark-ignition engines. Engines fueled by compressed natural gas (CNG) and liquefied petroleum gas (LPG) engines are also included in the NONROAD model. Table 4-5 lists general SCCs addressed by the NONROAD model. Equipment categories are typically defined at the 7-digit SCC level (with recreational marine and railway maintenance being exceptions) and specific equipment are defined at the 10-digit SCC level.

Table 4-5. SCCs Addressed by the NONROAD Model

Nonroad SCCs	SCC Descriptions	Nonroad SCCs	SCC Descriptions
2260xxxxxx	2-stroke gasoline engines	2268xxxxxx	CNG engines
2260001xxx	- recreational vehicles	2268002xxx	- construction equipment
2260002xxx	- construction equipment	2268003xxx	- industrial equipment
2260003xxx	- industrial equipment	2268005xxx	- agricultural equipment
2260004xxx	- lawn & garden equipment	2268006xxx	- light commercial equipment
2260005xxx	- agricultural equipment	226801xxxx	- oil field equipment
2260006xxx	- light commercial equipment	2270xxxxxx	Diesel engines
2260007xxx	- logging equipment	2270001xxx	- recreational vehicles
2265xxxxxx	4-stroke gasoline engines	2270002xxx	- construction equipment
2265001xxx	- recreational vehicles	2270003xxx	- industrial equipment
2265002xxx	- construction equipment	2270004xxx	- lawn & garden equipment
2265003xxx	- industrial equipment	2270005xxx	- farm equipment
2265004xxx	- lawn & garden equipment	2270006xxx	- light commercial equipment
2265005xxx	- agricultural equipment	2270007xxx	- logging equipment
2265006xxx	- light commercial equipment	2270008xxx	- airport service equipment
2265007xxx	- logging equipment	2270009xxx	- underground mining equipment
2265008xxx	- airport service equipment	227001xxxx	- oil field equipment
226501xxxx	- oil field equipment	2282xxxxxx	Recreational marine equipment
2267xxxxxx	LPG engines	2285xxx015	Railway maintenance equipment
2267001xxx	- recreational vehicles		
2267002xxx	- construction equipment		
2267003xxx	- industrial equipment		
2267004xxx	- lawn & garden equipment		
2267005xxx	- agricultural equipment		
2267006xxx	- light commercial equipment		
2267008xxx	- airport service equipment		

To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. Geographic allocation factors (GAFs) are used to distribute national equipment populations to counties/states. These factors are based on surrogate indicators of equipment populations. For example, harvested cropland is the surrogate indicator used in allocating agricultural equipment. A national average engine activity (i.e., load factor times annual hours of use) is used in NONROAD.

4.2.1 Methodology/Input Data by Equipment Category

To improve the accuracy of the model runs, default inputs were replaced in the NONROAD model option files for select parameters. In the options packet, inputs that can be replaced include: Reid vapor pressure (RVP), temperature, oxygenated fuel weight percent, Stage 2 control factors, and fuel sulfur levels. Local activity data inputs, such as equipment populations or activity (e.g., hours of use or load factors), can also replace default values in the model.

NONROAD model option files were prepared to account for temperatures and fuel characteristics representative of each county for each of the four seasons (winter, spring, summer, and fall). Temperature and fuel input values for each three-month period (December-February, March-May, June-August, and September-November) were averaged to estimate seasonal values. Minimum, maximum, and average temperatures per month were obtained from the National Climatic Data Center (NCDC, 2003). Table 4-6 presents a summary of the temperature and fuel characteristic data used for each season and for each of the three counties.

Table 4-6. NONROAD Model Temperature and Fuel Characteristic Input Values by County and Season

County	Season	Oxygen Weight %	RVP psi	Gasoline Sulfur ppm	Temperature, degrees F		
					Minimum	Maximum	Average
Kent	Summer	2.1	6.76	130	66	85	77
Kent	Autumn	2.06	8.03	138.38	49	65	59
Kent	Winter	1.87	13.41	174	30	46	40
Kent	Spring	2.02	9.29	146.76	44	64	57
New Castle	Summer	2.1	6.76	130	66	85	76
New Castle	Autumn	2.06	8.03	138.38	48	64	56
New Castle	Winter	1.87	13.41	174	29	45	37
New Castle	Spring	2.02	9.29	146.76	44	63	54
Sussex	Summer	1.7	6.43	134	62	86	74
Sussex	Autumn	1.63	7.76	151.33	48	67	57
Sussex	Winter	1.5	13.41	225	28	49	38
Sussex	Spring	1.57	9.09	168.67	43	66	54

For the diesel fuel sulfur level, a value of 2,500 parts per million (ppm) was used instead of the default value of 2,318 ppm currently in the NONROAD model. The 2,318 default value represents a national average including California's lower diesel fuel sulfur level, and is more appropriate for national-level runs. EPA's Office of Transportation Air Quality (OTAQ) recommends 2,500 ppm for non-California state and regional model runs. A Stage 2 control factor of 60 percent was used for all counties. This was estimated based on a control efficiency of 95 percent, a rule effectiveness of 65.3 percent and a rule penetration of 97.2 percent.

DNREC researched the availability of state and county-specific data to improve upon the default equipment populations and GAFs incorporated in the model. The following sections describe the equipment categories for which more representative state and/or county-specific data were used. Agricultural, commercial, construction, and industrial equipment categories relied on default data included in the model for population and activity estimates.

Residential Lawn and Garden Equipment

The NONROAD model uses the 1990 number of single and double-family housing units adjusted using more current population estimates to allocate residential lawn and garden equipment. DNREC obtained data from the 2000 Census on the number of single detached, single attached, and double housing units for both the State of Delaware and for Kent, New Castle, and Sussex Counties. The 2000 Census reports 246,731 single and double-family housing units for the State of Delaware, 34,679 housing units for Kent County, 151,018 housing units for New Castle County, and 61,034 housing units for Sussex County (BOC, 2003). These updated values were incorporated into the NONROAD GAF files for use in allocating 2002 state-level lawn and garden equipment populations to each county. See Table 4-7 for the county-specific values for single and double-family housing units.

Table 4-7. Delaware County Allocation Factor Data for Replacing NONROAD Defaults

NONROAD Category				
Residential Lawn and Garden	**County**	**Number of Single and Double Family Housing Units**		**Fraction**
	Kent	34,679		0.14
	New Castle	151,018		0.61
	Sussex	61,034		0.25
Recreational Equipment	**County**	**Rural Land Area, square km**		**Fraction**
	Kent	206		0.20
	New Castle	251		0.25
	Sussex	551		0.55
Golf Carts	**County**	**Golf Course Area, square km**		**Fraction**
	Kent	2		0.12
	New Castle	9		0.46
	Sussex	8		0.43
Logging	**County**	**Number of Acres Logged**		**Fraction**
	Kent	1,122		0.27
	New Castle	258		0.06
	Sussex	2,727		0.66
Aircraft Ground Support	**County**	**Commercial Aircraft LTOs**		**Fraction**
	Kent	28,975		0.28
	New Castle	63,051		0.62
	Sussex	10,350		0.10

Snow blowers

For residential snow blowers, the NONROAD model uses the number of single and double-family housing units to allocate a state's snow blower population to counties receiving at least 15 inches of snow in 1996. For commercial snow blowers, the model uses the number of employees in landscaping and horticultural services, combined with snowfall, to allocate a state's snow blower population. For counties that did not receive at least 15 inches of snow in the 1996 Winter season (Dec., Jan.-Mar.), the allocation factors are set to zero so that no snow blowers are allocated to those counties. DNREC investigated the amount of snow that counties in Delaware received in 2002 (DSC, 2003). Snowfall amounts for the counties were: 9.5 inches in Kent County (one weather station); an average of 5.5 inches in New Castle County (four weather stations); and, an average of 4 inches in Sussex County (three weather stations). Thus, the snow blower allocation factors for all counties in Delaware were set to zero.

Recreational Equipment (except snowmobiles and golf carts)

DNREC contacted the Delaware Department of Transportation (DelDOT) Division of Motor Vehicles to determine whether registration data were available for off-road motorcycles and all-terrain vehicles (ATVs). Registration is required by the State of Delaware for these off-highway vehicles (OHVs). Snowmobiles are not included in the classification of OHVs. Table 4-8 presents the 2002 number of OHVs, registered for the State of Delaware, including off-road motorcycles and ATVs combined (Shock, 2003). In the NONROAD model, equipment populations of gasoline ATVs and off-road motorcycles total 13,024 for the State of Delaware.

Table 4-8. 2002 Off-Highway Vehicle Registrations

County	DelDOT OHV Registrations	NONROAD2002a Model Equipment Populations
Kent	38	0
New Castle	202	3,256
Sussex	6	9,768
State Total	**246**	**13,024**

Though significantly lower than the NONROAD model estimates, DelDOT indicated the registration data to be representative of OHV use in Delaware. Nonetheless, DNREC did not replace the NONROAD model estimates, obtained from the Motorcycle Industry Council, with populations based on DelDOT information.

Note that Kent County, which is less urbanized than New Castle County, is showing zero OHV populations in the NONROAD model. The NONROAD GAFs are based on 1996 County Business Patterns establishment data for SIC 7030 (Camp and Recreational Vehicle Parks). SIC 7030 is defined as "sporting and recreational camps providing lodging and meals, or lodging only. Included are children's camps, fishing camps, hunting camps, and dude ranches, and establishments providing overnight or short-term sites for recreational vehicles, trailers, campers, or tents." The County Business Patterns data showed no establishments in Kent County in 1996. In 2001, County Business Patterns data showed only one establishment in Kent County.

As an alternative to the NONROAD GAFs, new state-to-county GAFs were developed based on the amount of non-urbanized land area per county, presented in Table 4-7.

Snowmobiles

In the NONROAD model, snowmobile populations are allocated to counties with sufficient snowfall using a minimal average annual snowfall limit of 40 inches in 1996. For counties that did not receive at least forty inches of snow in the 1996 winter season, the allocation factors are set to zero so that no snowmobiles are allocated to those counties. Similar to snow blowers, the NONROAD model snowmobile allocation factors for all counties in Delaware are set to zero as a result of the 1996 data. Given the small amount of snow in Delaware for 2002, DNREC did not make changes to the NONROAD model inputs for this equipment category.

Golf Carts

To develop alternate county fractions for use in allocating state-level golf cart emissions to each county, GIS coverage was used for the land area of golf courses. See Table 4-7 for the county-specific values for golf course area in square kilometers. These data replaced the default surrogate data used in the NONROAD model, which represents the total number of golf courses per county.

Recreational Marine Equipment

DNREC investigated the availability of recreational boat registrations for the State of Delaware to obtain a more representative estimate of the total recreational marine equipment population in use for the State. Using boat registrations as a means to allocate recreational marine activity is likely to over or underestimate activity in specific counties because residents may register their boats in one county, but use their boats in other parts of the State or neighboring counties. The NONROAD model uses water surface area to apportion State recreational marine populations to counties, which is generally a suitable geographic allocation factor. DNREC believes that a disproportionately high fraction of pleasure craft activity is allocated to New Castle County. However, DNREC was unable to obtain data to adjust the allocation fraction for this county.

2002 in-state registrations of boats and personal watercraft for the State of Delaware were available from the Delaware Division of Fish and Wildlife (DNREC, 2003). Table 4-9 presents the 2002 boat registrations for the State of Delaware, as well as the equipment populations from the NONROAD model.

Table 4-9. 2002 In-State Boat Registrations and NONROAD Defaults

Vessel Type	Delaware In-State Registrations	NONROAD2002a Model
Inboard	5,729	14,517
Outboard	32,150	64, 916
In/Out (Inboard w/ stern drive)	6,315	
Jet Drive	4,860	
Other	509	
Personal Watercraft	5,239	8,765
Total	**54,802**	**88,198**

AQMS contacted the Delaware Division of Fish and Wildlife (DE F&W) to obtain clarification on the definitions and boat types included in "jet drive" and "other." The "other" category includes non-power boats and electric trolling motors. The "jet drive" category refers to jet skis, which are already being accounted for in the personal watercraft registration data. As such, DNREC discounted vessel populations for these two categories in developing an estimate of revised Delaware state-level boat populations.

Next, the in-state registration data was augmented with estimates of the number of out-of-state boat ramp permits provided by DE F&W. Delaware F&W estimates that 1,500 boat ramp permits are issued each year. These out-of-state data are not reported by boat type; therefore, DNREC assumed the same distribution of boat types from the in-state data corresponding to vessels with a draft of 16 to 26 feet, since this is the most likely size category of boats coming from out of state (see Table 4-10).

Table 4-10. 2002 Out-of-State Boat Registrations

Vessel Type	In-State Registration Data (Vessels w/draft of 16 to 26 ft)	Ratio	Out-of-State Registration Data, Estimated by Vessel Type
Inboard	1,361	0.052	78
Outboard	19,933	0.758	1,136
In/Out	5,009	0.190	286
Total	**26,303**	**1.000**	**1,500**

DNREC also added the 2002 vessel registration data (497 total vessels) for commercial marine passenger (e.g., party boats) and fishing vessels into the NONROAD model population input files since these vessels are not included in the activity data used in the CMV category. The total vessel populations used in the NONROAD model for 2002 are provided in Table 4-11.

Table 4-11. 2002 Recreational Marine Equipment Populations

Vessel Type	Registration Data
Inboard + In/Out	12,905
Outboard	33,286
Personal Watercraft	5,239
Total	**51,430**

Delaware's registration data do not distinguish between gasoline and diesel-fueled engines for inboard/outboard vessels. DNREC estimated these engine counts using the fraction of gasoline versus diesel engines for total inboard/outboard engines as estimated from the NONROAD model. For commercial passenger and fishing vessels, populations were distributed to the 4-stroke gasoline and diesel inboard SCCs. This resulted in the following SCC level populations for Delaware:

Table 4-12. 2002 Recreational Marine Equipment Populations by SCC

SCC	Vessel Type	2002 Population
2282005015	Personal Watercraft	5,239
2282005010	2-Stroke Outboard	33,249
2282010005	4-Stroke Inboard + In/Out	12,010
2282020005	Diesel Inboard	895
2282020010	Diesel Outboard	37
Total		**51,430**

SCC-level populations were then allocated to horsepower ranges using the horsepower distribution within the NONROAD model. All commercial marine passenger and fishing vessels were assumed to be greater than 25 horsepower.

Aircraft Ground Support Equipment

In the NONROAD model, aircraft ground support equipment is allocated to counties using the number of employees in air transportation, as reported by the Census Bureau's *County Business Patterns*. However, this indicator may include employees that are not directly connected to aircraft operations. To allocate ground support equipment activity, the number of commercial aircraft landing and take-offs (LTOs) is believed to be a more appropriate surrogate, since the number of LTOs is a primary determinant of the level of aircraft ground support equipment activity at a given airport (EPA, 2002). The number of commercial aircraft LTOs for calendar year 2002 is presented in Table 4-19 within the aircraft category description. These data were incorporated into the GAF files for aircraft ground support equipment.

Logging Equipment

Per NONROAD model defaults (based on employment in the logging industry), no emissions would be reported in New Castle and Kent counties for the logging equipment category, which includes chain saws and shredders greater than six horsepower (hp), and fellers/bunchers/ skidders. Chain saws and shredders less than six hp are present in all counties and are accounted for in the lawn and garden equipment category. DNREC believes there is likely to be minimal to no commercial logging activity in New Castle County, but some activity for Kent County. DNREC contacted the Division of Forestry within the Department of Agriculture, and obtained data on the number of acres logged (Short, 2003). These data are shown in Table 4-7 and were used to refine the NONROAD model GAFs for distributing emissions to the three counties.

4.2.2 Non-road Refueling Emissions

The NONROAD model accounts for refueling emissions from non-road equipment for two separate components, vapor displacement and spillage. Non-road equipment may be fueled from a gasoline pump or a portable container. Delaware had a statewide Stage 2 program in place for 2002 (DNREC, 2002). Stage 2 non-road emissions are associated with non-road equipment being filled directly at the gasoline pumps. Portable fuel container (PFC) use results in vapor displacement and spillage emissions from refueling non-road equipment, as well as diurnal and permeation emissions resulting from storage. The PFC refueling emission component was estimated using fuel consumption for equipment filled using PFCs (typically smaller horsepower engines), obtained from the NONROAD model. While non-road related Stage 2 and PFC refueling emissions were included in the non-road source sector, emissions from the filling of PFCs at gasoline stations are accounted for in the gasoline marketing category within the non-point sector.

4.2.3 Emission Factors

The NONROAD model contains emission factor input files representing engine exhaust emissions rates and adjustments that are used to determine evaporative emissions. The pollutants addressed in the exhaust emission factor files include total hydrocarbons (THC), NO_x, and CO.

Emission factors are defined by SCC and power level range. Base, or uncontrolled, emission rates are specified and the effect of Federal non-road standards are reflected in technology type emission factors. All exhaust emission factors are expressed in units of grams per horsepower-hour (g/hp-hr) or grams per mile (g/mile). Evaporative THC emissions are based on fuel consumption. The model includes conversion factors by SCC to estimate VOC from THC.

4.2.4 Temporal Allocation

Table 4-13 summarizes the NONROAD model default seasonal activity allocation fractions for the Mid-Atlantic region by equipment category. Delaware is included in the Mid-Atlantic region.

Table 4-13. Default Seasonal Activity Allocation Fractions for the Mid-Atlantic Region in NONROAD

Equipment Category	Winter	Spring	Summer	Fall
Agricultural	0.060	0.270	0.400	0.270
Construction	0.150	0.234	0.381	0.234
Industrial	0.250	0.250	0.250	0.250
Lawn and Garden (excl. chainsaws)	0.060	0.270	0.400	0.270
Snow blowers/Snowmobiles	1.000	0.000	0.000	0.000
Commercial Marine	0.250	0.250	0.250	0.250
Airport Service	0.250	0.250	0.250	0.250
Logging (incl. chainsaws)	0.250	0.250	0.250	0.250
Light Commercial	0.250	0.250	0.250	0.250
Recreational Marine	0.021	0.204	0.570	0.204
Recreational Equipment	0.120	0.234	0.411	0.234
Railway Maintenance	0.250	0.250	0.250	0.250

Table 4-14 summarizes the model default weekday and weekend day activity allocation fractions by equipment category. SSWD values are based on the seasonal and weekly allocation fractions.

4.2.5 Controls

The NONROAD model is designed to account for the effect of federal emission standards. Table 4-15 provides a summary of the Federal emission standards affecting NONROAD model category engines, as well as the corresponding SCCs and engine size or horsepower.

In November 2002, a final rulemaking for large spark ignition (SI) engines (> 25hp) and recreational engines (both marine and land-based) was published. Since the implementation year for this rule is after 2002, these standards do not apply to this inventory.

In the NONROAD model, controlled emission rates are applied to new engines subject to Federal standards as they are phased-in over time. Rule penetration (RP) varies by SCC depending on the percentage of the population that is included in the horsepower range subject to the standard. Rule effectiveness (RE) is assumed to be 100 percent, since engine manufacturers are required to develop the technologies to meet these standards.

Table 4-14. Default Weekday and Weekend Day Activity Allocation Fractions in NONROAD[a]

Equipment Category	Weekday	Weekend Day
Recreational	0.1111111	0.2222222
Construction	0.1666667	0.0833334
Industrial	0.1666667	0.0833334
Residential Lawn and Garden	0.1111111	0.2222222
Commercial Lawn and Garden	0.1600000	0.1000000
Agricultural	0.1666667	0.0833334
Light Commercial	0.1666667	0.0833334
Logging	0.1666667	0.0833334
Airport Service	0.1428571	0.1428571
Railway Maintenance	0.1800000	0.0500000
Recreational Marine	0.0600000	0.3500000
Transportation A/C Refrigeration	0.1428571	0.1428571
Underground Mining	0.1666667	0.0833334
Oil Field Equipment	0.1428571	0.1428571

[a] The values are the fractions of weekly activity allocated to each weekday and each weekend day. To get the fraction for all weekdays, multiply the weekday fraction by 5. Similarly, to get the weekend fraction, multiply the weekend day fraction by 2.

Table 4-15. Summary of NONROAD Model Category Control Programs

Standard	SCC	Description	Applicable, HP
Phase I/II Small Spark-Ignition Handheld Engines	Specific applications of 2260	Gasoline Class III, IV, and V engines[a]	<25 hp
Phase I/II Small Spark-Ignition Non-handheld Engines	Specific applications of 2265	Gasoline Class I and II engines[a]	<25 hp
Tier 1/Tier 2 Large Spark-Ignition	2260xxxxxx 2265xxxxxx 2267xxxxxx 2268xxxxxx	2-stroke gasoline 4-stroke gasoline Liquefied petroleum gasoline (LPG) Compressed natural gasoline (CNG)	>=25 hp
Recreational Vehicles	2260001010 2265001010	Gasoline Off-highway Motorcycles	All hp
Recreational Vehicles	2260001020 2265001020	Gasoline Snowmobiles	All hp
Recreational Vehicles	2260001030 2265001030	Gasoline ATVs	All hp
Recreational Marine Exhaust Emission Standards	2282005xxx 2282010xxx	Gasoline Pleasure Craft - Outboard, Personal Watercraft, and Inboard	All hp
Evaporative Emission Standards (Proposed)	2282005xxx 2282010xxx	Gasoline Pleasure Craft - Outboard, Personal Watercraft, and Inboard	All hp
Tier 1/2/3 Compression-Ignition	2270xxxxxx	Diesel Equipment	All hp
Tier 1/2 Compression-Ignition	2282020xxx	Diesel Pleasure Craft	<50 hp
Diesel Recreational Marine	2282020xxx	Diesel Pleasure Craft	>50 hp

[a] EPA established technology classes based on use (hand-held versus non-handheld and displacement) that are predominately 2-stroke (Class III, IV, and V), or 4-stroke (Class I and II) engines.

4.2.6 Sample Calculations and Results

The standard NONROAD model emission equation is as follows:

$$I_{exh} = E_{exh} * A * L * P * N$$

where:
- I_{exh} = Exhaust emissions, (ton/year)
- E_{exh} = Exhaust emission factor, (ton/hp-hr)
- A = Equipment activity, (hours/year)
- L = Load factor, (proportion of rated power used on average basis)
- P = Average rated power for modeled engines, (hp)
- N = Equipment population

Table 4-16. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for NONROAD Equipment

		Annual (TPY)			SSWD (TPD)		
Fuel Type	**Equipment Category**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
Gasoline	Recreational	612	23	2,883	2.12	0.07	10.17
	Construction	166	24	2,063	0.62	0.08	7.92
	Industrial	58	54	1,347	0.18	0.14	4.43
	Lawn & Garden	2,805	330	36,235	11.44	1.27	161.83
	Agriculture	18	8	389	0.09	0.04	2.03
	Light Commercial	413	96	9311	1.38	0.25	30.65
	Logging	3	< 1	22	0.01	< 0.01	0.07
	Airport Support	< 1	< 1	5	< 0.01	< 0.01	0.01
	Railway Maintenance	1	< 1	17	< 0.01	< 0.01	0.06
	Recreational Marine	2,726	201	7,433	6.75	0.48	19.19
Diesel	Recreational	1	3	4	< 0.01	0.01	0.01
	Construction	279	2,415	1,351	1.04	9.03	5.05
	Industrial	44	403	188	0.13	1.23	0.57
	Lawn & Garden	16	108	57	0.08	0.53	0.28
	Agriculture	101	828	482	0.51	4.21	2.45
	Light Commercial	29	167	107	0.09	0.48	0.34
	Logging	< 1	6	2	< 0.01	0.02	0.01
	Airport Support	1	8	4	< 0.01	0.02	0.01
	Railway Maintenance	2	8	7	0.01	0.03	0.02
	Recreational Marine	4	108	17	0.01	0.28	0.04
LPG	All Equipment	249	920	3,678	0.80	2.95	11.80
CNG	All Equipment	1	87	352	< 0.01	0.28	1.13
All Fuels	**Total**	**7,531**	**5,798**	**65,954**	**25.28**	**21.40**	**258.10**

4.2.7 References

BOC, 2003: U.S. Department of Commerce, Bureau of the Census, *2000 County and State Housing Units by Unit Type, Census 2000*. At (http://factfinder.census.gov/servlet/DTTable?_ts=84275328235)

DNREC, 2002: Delaware Department of Natural Resources and Environmental Control, *Regulation No. 24, Control Of Volatile Organic Compound Emissions, Section 36 – Stage II Vapor Recovery*. January 11, 2002.

DNREC, 2003: Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, *Delaware Annual Boating Statistics.* At (http://www.dnrec.state.de.us/fw/boatstats.htm)

DSC, 2003: Delaware State Climatologist, University of Delaware, *Monthly Climate Data- Monthly Snowfall*, at (http://www.udel.edu/leathers/monthly.html)

EPA, 2002: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Office of Air and Radiation, *Geographic Allocation of State Nonroad* Engine Population Data to the County Level, EPA-420-P-02-009, July 2002.

EPA, 2003: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, *Draft NONROAD2002a*, [Computer software], June 2003.

EPA, 2005: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, *NONROAD2005*, [Computer software], December 2005.

NCDC, 2003: National Climatic Data Center, Data Set 9956 (DSI-9956), Datsav3 Global Surface Hourly Data, Asheville, NC 28801, January 6, 2003.

Shock, 2003: K. Shock, Delaware Department of Transportation, Division of Motor Vehicles, personal communication, via email, with M. Spivey, E.H. Pechan & Associates, Inc., October 2003.

Short, 2003: Austin Short, Delaware Department of Agriculture, personal communication, via email, with D. Fees, Delaware Department of Natural Resources and Environmental Control, Air Quality Management Section, December 2, 2003.

4.3 Aircraft

The aircraft source category includes emissions from commercial, air taxi, general aviation, and military aircraft. These sub-categories are described as follows:

- Commercial aircraft are used for scheduled service transporting passengers, freight, or both;
- Air taxis are used for scheduled service carrying passengers and/or freight, but are smaller aircraft that operate on a more limited basis than the commercial carriers;
- General aviation includes other non-military aircraft used for recreational flying, business, personal transportation, and various other activities; and
- Military aircraft are used by the U.S. military in a wide range of missions.

Airport-specific emissions for all aircraft sub-categories were allocated to the county in which each airport is located. Where there are multiple airports in a given county, the emissions were summed to provide a county-level emissions estimate. Aircraft emissions are reported under the following SCCs:

Table 4-17. SCCs for Aircraft

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2275001000	Mobile Sources	Aircraft	Military Aircraft	Total
2275020000	Mobile Sources	Aircraft	Commercial Aircraft	Total: All Types
2275050000	Mobile Sources	Aircraft	General Aviation	Total
2275060000	Mobile Sources	Aircraft	Air Taxi	Total

4.3.1 Activity Data

DNREC estimated annual aircraft emissions using a combination of airport-specific activity data and Federal Aviation Administration (FAA)/EPA emission factors. Estimating aircraft emissions focuses on the “mixing zone,” which has a height (mixing height) equal to the thickness of the inversion layer. Air emissions within this zone are trapped by the inversion layer and ultimately affect ground-level pollutant concentrations. When aircraft are above the mixing zone, emissions tend to disperse and have no ground-level effects. The aircraft operations within the mixing zone are defined by the landing and take-off (LTO) cycle. Each LTO cycle consists of five specific operating modes:

- Approach – aircraft operates in this mode when it approaches the airport on its descent from the mixing height to when it lands on the runway.
- Taxi/idle-in – aircraft operates in this mode when it taxis from the runway to the gate and turns its engines off.
- Taxi/idle-out – this period occurs from engine start-up to take-off as the aircraft taxis from the gate back out to the runway.
- Take-off – this mode is characterized primarily by full-throttle operation that typically lasts until the aircraft reaches between 500 and 1000 feet above ground, which is when engine power is reduced.

- Climb-out – this mode begins right after the take-off mode and lasts until the aircraft passes out of the mixing height.

The operation time in each of these modes is dependent on the aircraft category, local meteorological conditions, and operational considerations at a given airport. The time-in-mode (TIM) for the take-off operating mode is the least variable.

The following are the general steps to be used to estimate aircraft emissions:

- Determine the mixing height to be used to define the LTO cycle;
- Define the fleet make-up for each airport;
- Determine airport activity in terms of the number of LTOs by aircraft/engine type;
- Select emission factors for each engine model associated with the aircraft fleet;
- Estimate the TIM for the aircraft fleet at each airport;
- Calculate emissions based on aircraft LTOs, emission factors for each aircraft engine model, and estimated aircraft TIM;
- Aggregate the emissions across aircraft; and
- Convert hydrocarbon (HC) emissions to VOC emissions.

Commercial Aircraft

DNREC first contacted the Delaware Aeronautics Administration (DAA), to obtain LTOs for Delaware airports (VanDenHeuvel, 2004). Because the data from DAA were not reported by aircraft or engine type, DNREC made a written request of additional data needed to the individual airports. DNREC contacted New Castle County Airport, Sussex County Airport, and Dover Air Force Base to request the number of U.S. commercial aircraft LTOs by aircraft/engine model for calendar year 2002, as well as TIM data specific to each airport. Table 4-18 presents the commercial aircraft LTO data obtained by aircraft and engine type

Table 4-18. 2002 Commercial Aircraft LTO Data

Make of Aircraft	Engine Type	No. of Engines	LTOs
New Castle County Airport			
DC-8-50F (DC8-50F)	JT3D3-3B (JT3D-3B)	4	8
DC-9-15F (DC9-15F)	JT8D-7B	2	10
DC-9-30 (DC9-30)	JT8D-7B	2	3
B-727-200 (B727-200)	JT8D-15	3	3
B-737-300 (B737-300)	CF56-3 (CFM56-3)	2	2
B-757-200 (B757-200)	RB211-535C	2	2
FALCON 20C (Falcon 20)	CF700-2D2 (CF700-2D)	2	13
FALCON 900B (Falcon 100)	TFE731-3	3	5
Dover AFB			
Gulf Stream 5	RR BR710-48 (BR700-710A1-10 GulfV)	2	580
H/B-747 (B747-400)	GE or PW (PW4056)	4	1,449
H/MD-11(MD-11)	GE or PW (PW4460)	4	290

DNREC used these airport-specific LTO data to estimate commercial aircraft emissions using FAA's Emissions and Dispersion Modeling System (EDMS), Version 4.12 (FAA, 2003). The model requires detailed inputs on aircraft operation by aircraft and engine type. DNREC matched the aircraft LTO data to the existing aircraft/engine types in EDMS, and used the default EDMS TIM data. A mixing height of 2,300 feet was used for all airports in Delaware based on an isopleth chart of annual average morning mixing heights for the continental U.S. as provided in EPA's *Procedures* Manual (EPA, 1992). Table 4-18 presents the aircraft/engine assignments made for EDMS.

EDMS generates emissions for HC, NO_x, and CO, in tons per year. The model also generates emissions for ground support equipment (GSE). However, the GSE estimates generated from the NONROAD model were used for the 2002 inventory, so these were subtracted from the EDMS results.

Air Taxi and General Aviation

DNREC contacted the following airports to request the number of 2002 LTO for the air taxi and general aviation sub-categories, as well as TIM data:

Kent County:
- Chandelle Estates
- Chorman
- Delaware Airpark
- Dover AFB
- Henderson
- Jenkins
- Smyrna

New Castle County:
- New Castle County
- Summit

Sussex County:
- Laurel
- Sussex County Airport

The activity data collected for these airports/aircraft types, presented in Table 4-19, represents total LTOs. In a few cases, data by aircraft type were provided (e.g., Sussex County Airport), but the data were too general to match to existing aircraft types in EDMS. As such, EPA fleet average emission factors were applied to the LTO data to estimate annual general aviation and air taxi emissions (EPA, 1992).

Military Aircraft

DNREC estimated military aircraft emissions using the same methods as the commercial aircraft sub-category (i.e., FAA's EDMS). Dover Air Force Base (AFB) and New Castle County Airport are the only airports in Delaware known to have military operations. The Delaware Army National Guard (DE ARNG) and the Delaware Air National Guard (DE ANG) operate units at the New Castle County Airport. DNREC contacted these airports to obtain airport-specific LTO and fleet mix data for calendar year 2002. DNREC obtained fleet mix data for military operations at Dover AFB, and estimated fleet mix data for military operations at New Castle County airport based on their 1999 fleet mix, since they provided only the total military LTOs (DNREC, 2002).

Table 4-19. 2002 General Aviation and Air Taxi LTO Data

Airport	County	Category	LTOs
Smyrna	Kent	General Aviation	1,263
Jenkins	Kent	General Aviation	1,250
Henderson	Kent	General Aviation	900
Chandelle Estates	Kent	General Aviation	3,400
Delaware Airpark	Kent	General Aviation	18,000
Dover AFB	Kent	General Aviation	1,967
Chorman	Kent	General Aviation	840
New Castle County	New Castle	General Aviation	56,458
New Castle County	New Castle	Air Taxi	1,941
Summit	New Castle	General Aviation	41,644
Sussex County	Sussex	General Aviation	14,960
Laurel	Sussex	General Aviation	3,875

Dover AFB and DE ANG operate low-level training flights termed “touch and gos” (TGs). TGs are flights conducted mostly below the mixing height, with different engine power settings and emissions rates than LTOs. When entering airport fleet mix data into EDMS, DNREC accounted for the percentage of annual LTO categorized as TG operations for Dover AFB. “Touch and go” operations were not obtained for the DE ANG. Refer to Table 4-20 for a summary of annual LTO and TG operations data for military aircraft.

Table 4-20. 2002 Military Aircraft LTO Data

Make of Aircraft	Engine Type	No. of Engines	LTOs	TGs
Dover AFB				
C-5 Galaxy	GE TF-39 (TF39-GE-1)	4	6,346	14,806
C-130	T56-15	4	261	608
C-17 (C-17A)	F117-PW100	4	435	1,014
C-141	GTCP 165-1 (used TF33-P-7)	4	261	608
KC-10 (KC-10A)	F103-101 (F103-GE-100_101)	3	261	608
KC-135 (KC-135R)	F108-100 (F108-CF-100)	4	174	406
A-10 (A-10A Thunderbolt)	T34-GE-100 (TF34-GE-100-100A)	2	174	406
F-16	F100-PW-220	1	87	203
New Castle County Airport[a]				
C-130	T56-A-16	4	2,066	NA
BEECH C-12 (C-12A/B/C)	PT6A-42	2	131	NA
C-9 (C-9A or C-9B)	JT8D-9	2	1,158	NA
C-130	T56-A-15	5	127	NA
VC-137 (B-707-E)	CFM56-2B-1	4	114	NA
Grumman Gulfstream (Gulfstream I)	Dart RDa7 (RDa7)	2	1,012	NA

[a]Aircraft LTO distribution for 2002 estimated by applying 1999 fraction of total LTOs by aircraft type to 2002 reported LTOs.

4.3.2 Emission Factors

Emission factors for all aircraft categories were obtained from either EPA's *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory* (EPA, 2002), or EDMS. Table 4-21 lists the fleet average emission factors by aircraft SCC. Conversion factors obtained from EPA documentation were applied to the HC emission estimates to obtain VOC emissions. Table 4-22 lists the VOC/HC conversion factors by aircraft category.

Table 4-21. Fleet Average Emission Factors by Aircraft SCCs

		Emission Factors lbs/LTO		
SCC	Aircraft Category	VOC	NO_x	CO
2275050000	General Aviation	0.3825	0.065	12.014
2275060000	Air Taxi	1.2234	0.158	28.13

Table 4-22. Aircraft VOC to HC Conversion Factors

Aircraft Category	VOC/HC Conversion Factors
Commercial	1.0947
General Aviation	0.9708
Air Taxi	0.9914
Military	1.1046

4.3.3 Temporal Allocation

DNREC obtained monthly operations data from the Dover AFB (military and commercial), Summit Airport, and Sussex County Airport. These monthly data were used to develop airport-specific monthly allocation profiles. The monthly profile from the Dover AFB (representing both military and commercial LTOs) was considered representative of the seasonality of activity from the commercial and military sectors. Therefore, the monthly profile was applied to the military, commercial, and air taxi annual LTOs reported by the New Castle County Airport. The monthly profile from the Summit Airport for general aviation was considered representative of the seasonality of activity from airports with more than 20,000 LTOs annually. This profile was applied to the general aviation annual LTOs reported by the New Castle County Airport. Finally, the monthly profile from the Sussex County Airport was used to represent seasonality associated with smaller airports (less than 20,000 LTOs annually.) This monthly profile was applied to all general aviation annual LTOs reported by Kent and Sussex County airports.

To estimate commercial and air taxi aircraft typical summer weekday emissions, DNREC assumed that activity occurs primarily during the weekdays (e.g., 90 percent of total weekly activity), based on the assumption that the majority of commercial flights are scheduled during weekdays. For general aviation and military aircraft, weekday emissions were estimated using an operating schedule of seven days per week.

4.3.4 Controls

EDMS represents current actual emission rates and as such additional controls were not applied to emissions calculated using EDMS. Fleet average emission factors represent older emission rate data, and are likely uncontrolled. However, information on emission reductions related to the aircraft engine standards established by the International Civil Aviation Organization (ICAO) were determined not to be available, and the reductions are believed to be minimal.

4.3.5 Sample Calculations and Results

Commercial and Military Aircraft

The equation below is the calculation of taxi and queue mode time that is an airport-specific input in EDMS.

Taxi and Queue Mode Time = (Airport Average Taxi-In Time + Airport Average Taxi-Out Time) - EDMS Aircraft-Specific Landing Roll Time

The following is the equation used in EDMS to calculate annual emissions by aircraft type for one LTO cycle (FAA, 2002):

$$E_{ij} = \Sigma\ [(TIM_{jk}) * (FF_{jk}/1000) * (EI_{ijk}) * (NE_j)]$$

where:

E_{ij} = Total emission of pollutant *i*, in pounds, produced by aircraft type *j* for one LTO cycle.
TIM_{jk} = Time in mode for mode *k*, in minutes, for aircraft type *j*
FF_{jk} = Fuel flow for mode *k*, in pounds per minute, for each engine used on the aircraft type *j*
EI_{ijk} = Emission index for pollutant *i*, in pounds of pollutant per one thousand pounds of fuel, in mode *k* for aircraft type *j*
NE_j = Number of engines used on aircraft type *j*

Finally, annual emissions per airport are calculated with the following equation:

$$\text{Annual Emissions for Airport A (tons/yr)} = \Sigma\ [(E_{ij} * LTO_j)]/2000 \text{ lbs/ton}$$

where:

$E_{i,j}$ = annual emissions in pounds of pollutant *i*, produced by aircraft type *j* per LTO cycle.
$LTOs_j$ = annual number of LTOs for aircraft type j

Air Taxi and General Aviation Aircraft

The following equation is the estimate of air taxi and general aviation aircraft emissions using LTO data and fleet average emission factors.

$$E_i = LTOs \times EF_i \times 1/2000$$

where:

E_i = annual emissions in tons of pollutant *i*
LTOs = annual number of LTOs
EF_i = default aviation fleet mix emission factor in pounds of pollutant for pollutant *i*

Table 4-23. 2002 Statewide Annual and SSWD VOC, NO_X, and CO Emissions for Aircraft

SCC	Aircraft Category	Annual (TPY)			SSWD (TPD)		
		VOC	NO_X	CO	VOC	NO_X	CO
2275001000	Military	256	880	612	0.82	2.82	1.96
2275020000	Commercial	6	85	62	0.03	0.34	0.25
2275050000	General Aviation	28	5	868	0.09	0.02	2.78
2275060000	Air Taxi	1	< 1	27	< 0.01	< 0.01	0.11
22750xxxxx	**Total: Aircraft**	**291**	**970**	**1570**	**0.94**	**3.18**	**5.11**

4.3.6 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, 1992: U.S. Environmental Protection Agency, Office of Air and Radiation, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d (Revised), 1992.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory, Volume I: Methodology*, prepared by Eastern Research Group, Morrisville, NC for the U.S. Environmental Protection Agency, November 2002.

FAA, 2003: Federal Highway Administration, “Emissions and Dispersion Modeling System (EDMS) Version 4.12,” October 2002.

VanDenHeuvel, 2004: H. VanDenHeuvel, Delaware Department of Transportation, personal communication, via email, with M. Spivey, E.H. Pechan & Associates, Inc., January 31, 2004.

4.4 Locomotives

Railroad locomotives are a combustion source of emissions with most significant emissions occurring where there is a concentration of railroad activity (such as a large switch yard). The primary fuel consumed by railroad locomotives is distillate oil (diesel fuel). Locomotives can perform two different types of operations: line haul and yard (or switch). Line haul locomotives generally travel between distant locations, such as from one city to another. Yard locomotives are primarily responsible for moving railcars within a particular railway yard. Locomotive emissions are reported under the following SCCs:

Table 4-24. SCCs for Locomotives

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2285002006	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class I Operations
2285002007	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class II/Class III Operations
2285002010	Mobile Sources	Railroad Equipment	Diesel	Yard Locomotives

4.4.1 Activity Data

For line haul locomotives, DNREC calculated Class I operation emissions separately from Class II/III operations. Line haul locomotive emissions for passenger trains and commuter lines were estimated to be zero since rail service in Delaware (Amtrak and SEPTA) is electric powered. Fuel consumption was used to estimate locomotive engine emissions. Fuel consumption rates are usually known only for the entire interstate operating region, therefore, it is necessary to allocate the total amount of fuel consumed "system-wide" to Delaware.

Line Haul Locomotives – Class I Operations

Norfolk Southern and CSX Transportation operate Class I locomotives within Delaware. DNREC contacted these companies to obtain estimates of fuel consumption or data to calculate fuel consumption (e.g., gross ton-miles (GTM) and gallons of fuel consumed per GTM).

Norfolk Southern and CSX provided to DNREC GTM data at the county level for each county in Delaware in which they operated. Norfolk Southern provided a fuel consumption index (GMT/fuel consumed) for the system that includes operations in Delaware. CSX provided system-wide GMT and fuel consumption, from which a system-wide fuel consumption index (FCI) was calculated. CSX only operates in New Castle County. County-level GMT was divided by the fuel consumption index to estimate county-level fuel consumption. The system-wide fuel consumption indices, county-specific GMT, and calculated county-level uel consumption are provided in Table 4-25.

Line Haul Locomotives – Class II/III Operations

The Brandywine Valley Railroad, Maryland & Delaware Railroad, and the Delaware Coast Line Railroad operate Class II/III locomotives within Delaware. These companies were contacted to obtain estimates of fuel consumption. All three railroads provided 2002 statewide fuel consumption data. Since the Brandywine Valley Railroad only operates in New Castle County, and the Delaware Coast Line Railroad only operates in Sussex County, the fuel data are county specific. The Maryland & Delaware Railroad operates in New Castle and Sussex Counties. Track miles within each county were used to allocate statewide fuel consumption to each county. Table 4-26 presents a summary of the activity data calculated by Class II/III railroad and county for 2002.

Table 4-25. 2002 Locomotive Fuel Consumption Data for Class I Line Haul Operations

Class I Railroad	County	Gross Ton Miles (GMT)	System-wide GMT/Gallon Diesel	Fuel Consumed, gallons/year
Norfolk Southern	Kent	231,873,699	790.03	293,500
Norfolk Southern	New Castle	322,158,680	790.03	407,780
Norfolk Southern	Sussex	141,653,747	790.03	179,302
CSX Transportation	New Castle	736,781,000	908.87	810,654

Table 4-26. 2002 Locomotive Fuel Consumption Data for Class II/III Line Haul Operations

Class II/III Railroad	County	Fuel Consumed, gallons/year
Brandywine Valley	New Castle	15,600
Maryland & Delaware	New Castle	1,719
Maryland & Delaware	Sussex	2,306
Delaware Coast Line	Sussex	9,730

Yard Locomotives

Norfolk Southern and CSX Transportation have yard operations within Delaware. These companies provided the number of locomotives by switchyard location. CSX only operates a switchyard in New Castle County. For each company, the number of locomotives was summed by county. Table 4-27 provides a summary of switchyard operations and fuel consumption by county. An average switchyard engine fuel consumption estimate of 82,490 gallons per year was applied (EPA, 1992). The EPA estimate assumes switchyard locomotive operations running 24 hours per day, 365 days per year.

Table 4-27. 2002 Switchyard Activity and Estimated Fuel Consumption

Class I Switchyard	County	No. of Yard Locomotives	Fuel Consumed, gallons/year[a]
Norfolk Southern	Kent	4	329,960
Norfolk Southern	New Castle	9	742,410
Norfolk Southern	Sussex	2	164,980
CSX Transportation	New Castle	5	412,450

[a]Estimated assuming 82,490 gallons fuel consumed per yard locomotive.

4.4.2 Emission Factors

Emission factors for line haul and yard locomotives were obtained from Table C-1 of Appendix C in *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory* (EPA, 2002). Emission factors are expressed in grams per gallon. See Table 4-28 for the emission factors used.

Table 4-28. Emission Factors for Locomotives

Pollutant	Line Haul Emission Factor, grams/gallon	Switchyard Emission Factor, grams/gallon
VOC	10.05	21.105
NO_x	270	362
CO	26.6	38.1

4.4.3 Temporal Allocation

Emissions from this source category are not expected to vary substantially from season to season. Uniform monthly temporal allocation was assumed. To estimate typical summer weekday emissions, DNREC assumed that locomotive operate evenly 7 days a week.

4.4.4 Controls

In the Regulatory Support Document (RSD) for locomotive emission standards, national emissions account for future, phased-in controls that will reduce NO_x, particulate and hydrocarbon emissions (EPA, 1997). Emission reductions, which include RE and RP, are estimated based on the percent change in emissions from the base year to a given projection year. The 2002 Class I line haul and yard locomotive emissions for NO_x were reduced by the percentages shown in Table 4-29. For the Class II/III locomotives, emissions were estimated as uncontrolled since the RSD standards do not take effect until 2003.

Table 4-29. Percent Reduction Applied to Locomotive NO_x Emissions

Source Category	Percent Reduction
Class I Line Haul Locomotive	12
Yard Locomotive	2

4.4.5 Sample Calculations and Results

Line Haul Locomotive

To determine the amount of pollutant ***p*** at the county level:

$$E_{px} = FC \times EF_p \times 1/2000$$

where: E_p = amount of pollutant ***p*** emitted for the county in pounds
FC = fuel consumption for the county in gallons

EF_p = emission factor for pollutant ***p*** in pounds per gallon

Yard Locomotive

To determine the amount of pollutant ***p*** at the county-level:

$$E_p = Yd * FC_{Yd} * EF_{\boldsymbol{p}}$$

where: E_p = amount of pollutant ***p*** emitted for the county in pounds
Yd = number of yard locomotives in the county
FC_{Yd} = fuel consumption per yard locomotive in gallons per year
EF_p = emission factor for pollutant ***p*** in pounds per gallon

Table 4-30. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Locomotives

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_X	CO	VOC	NO_X	CO
2285002006	Class I Line Haul	19	443	50	0.05	1.22	0.14
2285002007	Class II/III Line Haul	< 1	9	1	< 0.01	0.02	< 0.01
2285002010	Yard Locomotives	38	645	69	0.11	1.77	0.19
22850020xx	**Total: Locomotives**	**57**	**1,097**	**120**	**0.16**	**3.02**	**0.33**

4.4.6 References

EPA, 1992: U.S. Environmental Protection Agency, Office of Air and Radiation, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d (Revised), 1992.

EPA, 1997: U.S. Environmental Protection Agency, Office of Mobile Sources, *Locomotive Emission Standards: Regulatory Support Document*, December 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory, Volume I: Methodology*, prepared by Eastern Research Group, Morrisville, NC for U.S. EPA, November 2002.

4.5 Commercial Marine Vessels (Exhaust Emissions)

The CMV sector includes many types of vessels, such as large deep draft vessels, barge towboats, harbor tugs, dredging vessels, ferries, excursion vessels, and commercial fishing vessels. In addition to the numerous vessel types, each vessel type engages in different activities such as hotelling, maneuvering within the port, and cruising.

In its 1999 final rule for commercial marine diesel engines, EPA defined three categories of marine diesel engines based on engine displacement, power and revolutions per minute (rpm) (EPA, 1999a). Table 4-31 presents the definitions for each category. The EPA developed a baseline emissions inventory for each category. In 2003, a separate rule was finalized for Category 3 engines. EPA prepared a more detailed emissions inventory for Category 3 engines in the regulatory support document for that rulemaking (EPA, 2003).

Table 4-31. U.S. EPA Marine Engine Category Definitions

Category	Displacement per cylinder	Power range (kW)	RPM range
1	disp. < 5 liters and power ≥ 37 kW	37 - 2,300	1,800 - 3,000
2	5 ≤ displacement < 30 liters	1,500 - 8,000	750 - 1,500
3	displacement ≥ 30 liters	2,500 - 80,000	60 - 900

The EPA classifies CMV emissions by fuel type (residual and diesel) and by either vessel type (ocean-going, harbor, fishing, and military) or mode of operation (port and underway). DNREC used the port and underway SCCs to characterize the CMV emissions as listed below.

Table 4-32. SCCs for Commercial Marine Vessels

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

CMVs often burn multiple types of fuel and may burn different fuels for different operating modes or locations (i.e., near ports). The SCC classification is based on the most common type of fuel utilized by the vessel category. Ocean-going vessels (OGV) predominately burn intermediate fuel oil (IFO). DNREC placed emissions from OGV burning IFO in the residual fuel SCC. This is consistent with how petroleum product sales data are reported by the Energy Information Administration and EPA's classification of fuels (EPA 1999b).

There are four activity modes for CMV; cruise, reduced speed zone (RSZ), maneuver, and hotel. Underway emissions are estimated as the combined activity of cruise and RSZ modes. Port emissions are estimated as the combined activity of maneuvering and hotelling modes. Emissions from ferries and dredging are considered port emissions since these vessels operate primarily within the port area.

DNREC calculated emissions for ocean-going vessels, towboats, tug-assist vessels, ferries and vessels associated with dredging operations. Sample calculations are included throughout this section due to the complexity of this category. Details of the estimation methodology can be found in the spreadsheets and databases that accompany this report.

4.5.1 Activity Data

CMV engine emissions are assumed to be a function of the following:

- Mode of operation,
- Vessel type (bulk carrier, tanker, towboat, etc.);
- Vessel dead weight tonnage (DWT);
- Type of engine (2-stroke, 4-stroke, or steam); and
- Length of waterway segment.

Therefore, DNREC accounted for these variations when estimating CMV activity. The four modes of operation that are performed by vessels are defined below:

Cruise - This mode is assumed to begin 25 miles out from the port breakwater until the vessel reaches the breakwater (EPA, 1999c). The breakwater is located at the mouth of the Delaware Bay. Although Delaware's jurisdictional waters extend only three miles beyond the coastline, emissions were calculated based on the 25 miles beyond breakwater to account for vessels cruising just off the coast and for emissions beyond three miles that may impact Delaware's air quality.

Reduced Speed Zone (RSZ) - This mode begins at the breakwater and continues until the vessel is one to two nautical miles from the berth or anchorage. The vessel is assumed to have a speed of ten knots during this mode (EPA, 1999c). This mode is also referred to as transit and escort for towboats and tug-assist vessels.

Maneuvering - This mode is defined as the time the vessel slows to below four knots until the dock lines are secure. This mode is also referred to as assist mode for tug-assist vessels.

Hotelling - This mode is defined as the time the vessel is at dock. During this mode, the vessel operates auxiliary engines for electrical power.

The waterway segment distances used to estimate activity and to allocate the activity to the county level are given in Table 4-33 (DNREC, 2002; USACE, 2001). The distance South is given to the breakwater. The distance north is given to the Delaware-Pennsylvania border. The distance for the C&D Canal East is given from the Delaware-Maryland border to the entrance of the Delaware River (Reedy Point). The location of the Premcor Refinery is shown as south relative to the C&D canal, when it is actually just north of the canal. The distances were obtained from two different sources, hence the discrepancy, but future inventories will reflect the accurate relative location.

The engine activity for each mode is calculated using the following equation:

$$Activity_{mode} = Power \times LoadFactor \times Time_{mode} \times Calls$$

where:

$Activity_{mode}$	=	activity by mode (kilowatt-hours)
Power	=	rated engine power by vessel and engine type (kilowatts)
Load Factor	=	load factor of the engine by vessel type and mode
Time	=	time in mode per call by vessel type (hours)
Calls	=	number of calls by vessel and engine type

This calculation must be performed for both propulsion and auxiliary engines and for each mode. Both propulsion engines and auxiliary engines are operating during cruise, RSZ and maneuvering modes. Only auxiliary engines operate during hotelling. Once the activity is calculated, it is allocated to the county level using county allocation factors.

This approach to calculating activity of CMVs was used for all vessel types except vessels involved in dredging activity. For dredging, the activity data used for emissions calculations was the volume of material dredged. Details on the sources and development of activity data are given in the following subsections.

Table 4-33. Waterway Segment Distances for the Delaware River Area

Waterway Segment	Distance (mi.)
Point	**South**
DE/PA Border	83.1
Port of Wilmington	76.5
Delaware Terminal	75.0
Oceanport	69.0
C&D Canal	62.5
Premcor Refinery	62.1
Latitude 39°30'	57.6
New Castle Co/Kent Co	48.6
Kent Co/Sussex Co	15.8
Point	**North**
Port of Wilmington	6.6
C&D Canal	20.6
Point	**East**
C&D Canal	12.9

Ocean-Going Vessels

DNREC obtained vessel call data for ocean-going vessels (OGVs) during calendar year 2002 from the Marine Exchange of the Delaware River (ME, 2004). Data were obtained for vessels that called on ports in Delaware, New Jersey and Pennsylvania. The data for the entire port area is required since the majority of the vessels pass through Delaware waterways en route to other ports. The vessel call data included the vessel name, ship type (i.e., container, bulk carrier, tanker), DWT, pier, and the date of the call.

Vessels may shift between piers during the same call on the Delaware River Area. DNREC adjusted the vessel call data to remove shifts between piers, where possible, to avoid double counting using a methodology recommended by the staff of the Marine Exchange of the Delaware River. Data on the engine power and engine type (2-stroke, 4-stroke, and steam) used on OGVs were not available through the Marine Exchange. Therefore, DNREC assigned engine power and engine type based on average engine data obtained from other sources.

Auxiliary engine power is typically reported as total installed power, not as power for each engine. For the Houston-Galveston emissions inventory, a study on OGV auxiliary engine power and load factors for hotelling was conducted (HARC, 2000). The average engine power and load factor was given by vessel type. No size was reported for refrigerated container vessels (reefers) in this report. Auxiliary engines for reefers are generally large; therefore, DNREC assumed these engines were 6,000 kW operating at a load factor of 50% (EPA, 2001). Table 4-34 summarizes the average auxiliary engine power and load factors used to estimate emissions. The load factors are assumed to be the same for all activity modes.

Table 4-34. Average OGV Auxiliary Engine Power and Load Factors

Codes	Vessel Type	Engine Type	Engine Power (kW)	Load Factor
BU	Bulk	4-stroke	1,132	0.33
CC	Container	4-stroke	2,918	0.33
GC	General Cargo	4-stroke	913	0.33
CH	Chemical Carrier	4-stroke	2,356	0.33
RR	Roll on-Roll off (RORO)	4-stroke	2,518	0.33
RF	Refrigerated Cargo (Reefer)	4-stroke	6,000	0.50
TA	Tanker	4-stroke	2,214	0.50
VE	Car Carrier	4-stroke	2,181	0.33
PA	Passenger	4-stroke	6,000	0.50
MS	Miscellaneous	4-stroke	1,000	0.33

For propulsion engines, the average engine power and the engine type were obtained from the EPA report *Commercial Marine Activity for Deep Sea Ports in the United States* (*Deep Sea Ports*) (EPA, 1999c). This report presents data for vessels that called on the Delaware River Area ports during calendar year 1996. Note that the Delaware River Area includes ports in Delaware, New Jersey and Pennsylvania, which are located on the Delaware River. The number of calls by vessel type, and engine type is presented for specific DWT ranges. The average engine power is also given.

For each vessel type and DWT range, DNREC calculated the ratio between the vessel calls for each engine type to the total number of calls in 1996. An example (using general cargo vessel calls) of how the engine type ratios were calculated is given below to illustrate this process. Table 4-35 provides a list of calculated ratios for general cargo vessels.

$$\begin{aligned} Ratio\ of\ Engine\,Types &= \frac{Number\ of\ Calls_{\ (Vessel\,Type,\,DWT\ Range,\,Engine\,Type)}}{Total\ Number\ of\ Calls_{\ (Vessel\,Type,DWT\ Range)}} \\ &= \frac{132\,Calls_{\ (GC,<15{,}000DWT,\,2\text{-}stroke)}}{299_{(GC,<15{,}000DWT}\ )} \\ &= 0.4415 \end{aligned}$$

Next, DNREC counted the number of vessel calls on the Delaware River Area during 2002 for each vessel type and DWT range. DNREC then multiplied the 2002 vessel calls by the ratio of calls for each engine type developed for 1996.

Table 4-35. Example of 1996 Engine Ratio Types for General Cargo Vessels

Vessel Code	DWT Range	Engine Type	Average Propulsion Engine Power (hp)	Delaware River Area Vessel Calls in 1996	Delaware River Area 1996 Ratio of Engine Types
GC	<15,000	2-stroke	5,784	132	0.4415
		4-stroke	3,944	166	0.5552
		Steam turbine	ND	1	0.0033
GC	15,000 - 30,000	2-stroke	10,456	90	0.8491
		4-stroke	7,536	16	0.1509
GC	30,000 - 45,000	2-stroke	12,876	8	1.0000
GC	> 45,000	2-stroke	12,170	1	1.0000

$$Calls_{(VesselType,DWTRange,EngineType)} = 2002\ Calls_{(VesselType,DWTRange)} \times Ratio\ of\ Engine\ Types$$

$$= 201\ Calls_{(GC,<15,000\ DWT)} \times 0.4415_{(GC,<15,000\ DWT,\ 2\text{-}stroke)}$$

$$= 89\ Calls_{(GC,<15,000\ DWT,\ 2\text{-}stroke)}$$

This procedure provided the estimated number of 2002 vessel calls on the Delaware River Area for each vessel type and DWT range by engine type. As an example, the results for general cargo vessels calls on the Delaware River Area are given below in Table 4-36.

Table 4-36. 2002 General Cargo Delaware River Area Vessels Calls

Vessel Code	DWT Range	Vessel Calls in 2002 by Vessel Type	Engine Type	1996 Ratio of Engine Types	Vessel Calls in 2002 by Vessel and Engine Type
GC	<15,000	201	2-stroke	0.4415	89
			4-stroke	0.5552	112
			Steam turbine	0.0033	< 1
GC	15,000 - 30,000	114	2-stroke	0.8491	97
			4-stroke	0.1509	17
GC	30,000 - 45,000	58	2-stroke	1.0000	58
GC	> 45,000	81	2-stroke	1.0000	81

The average engine power estimated for vessel calls on the Delaware River Area in 1996 was then assigned to the appropriate vessel/engine category for the vessel calls during 2002. The process was repeated for all vessel types. Table 4-37 presents the assigned propulsion engine power and the number of calls by vessel type, DWT Range and engine type for calls on the Delaware River Area in 2002.

In order to calculate underway emissions for Delaware, the number of calls (by vessel type and DWT range) had to be allocated to each port. For the State of Delaware, these ports are Port of Wilmington, Delaware Terminal, Premcor, and Oceanport. For the States of Pennsylvania and

New Jersey, DNREC assumed all vessels traveled from the breakwater to beyond the Delaware state line (PA/DE to the Sea). Vessels calling on New Jersey and Pennsylvania ports must be included in underway emissions calculations for the Delaware since the vessels travel on the Delaware portion of the river. These vessel calls were handled separately from the Delaware calls; therefore the port allocation ratio for these calls is 1.0.

Table 4-37. Average Propulsion Engine Power and the 2002 Number of Calls for OGVs Calling on the Delaware River Area (DE, NJ and PA)

Code	DWT Range	Engine Type	Power (hp)	Calls	Code	DWT Range	Engine Type	Power (hp)	Calls
BU	<25,000	2-stroke	9,665	66	RR	<15,000	2-stroke	8,280	22
BU	<25,000	4-stroke	7,504	11	RR	<15,000	4-stroke	8,553	24
BU	25,000 - 35,000	2-stroke	9,696	71	RR	15,000 - 30,000	2-stroke	12,852	33
BU	35,000 - 45,000	2-stroke	10,320	78	RR	>30,000	2-stroke	16,328	11
BU	> 45,000	2-stroke	16,328	104	TA	<30,000	2-stroke	10,008	172
CC	<25,000	2-stroke	17,757	173	TA	<30,000	4-stroke	7,077	41
CC	<25,000	4-stroke	10,898	91	TA	<30,000	Steam	14,646	17
CC	25,000 - 35,000	2-stroke	16,327	248	TA	30,000 - 60,000	2-stroke	12,616	127
CH	<25,000	2-stroke	9,665	3	TA	30,000 - 60,000	4-stroke	15,360	8
CH	<25,000	4-stroke	7,504	1	TA	30,000 - 60,000	Steam	15,498	88
CH	25,000 - 35,000	2-stroke	9,696	2	TA	60,000 - 90,000	2-stroke	16,026	59
CH	35,000 - 45,000	2-stroke	10,320	2	TA	60,000 - 90,000	4-stroke	14,305	8
GC	<15,000	2-stroke	5,784	89	TA	90,000 - 120,000	2-stroke	15,451	162
GC	<15,000	4-stroke	3,944	112	TA	90,000 - 120,000	Steam	23,923	3
GC	15,000 - 30,000	2-stroke	10,456	97	TA	120,000 - 150,000	2-stroke	23,046	88
GC	15,000 - 30,000	4-stroke	7,536	17	TA	> 150,000	2-stroke	25,559	60
GC	30,000 - 45,000	2-stroke	12,876	58	TA	> 150,000	Steam	36,324	19
GC	> 45,000	2-stroke	12,170	81	VE	<12,500	2-stroke	11,877	31
PA	5,000 - 10,000	4-stroke	20,776	8	VE	<12,500	4-stroke	13,150	6
RF	<5,000	2-stroke	9,553	20	VE	12,500 - 15,000	2-stroke	12,859	46
RF	<5,000	4-stroke	7,048	11	VE	12,500 - 15,000	4-stroke	14,770	8
RF	5,000 - 10,000	2-stroke	9,706	73	VE	15,000 - 17,500	2-stroke	13,911	52
RF	5,000 - 10,000	4-stroke	6,837	14	VE	> 17,500	2-stroke	15,224	70
RF	10,000 - 15,000	2-stroke	12,500	110	MS	< 1,000	2-stroke	2,400	6
RF	10,000 - 15,000	4-stroke	15,672	2	MS	< 1,000	4-stroke	1,293	3
RF	15,000-25,000	2-stroke	18,467	228					

For Delaware port vessel calls, DNREC calculated the ratio between the number of calls to each Delaware port by vessel type and DWT range to the total number of calls to Delaware ports by vessel type and DWT range. An example of how the engine type ratios for all general cargo vessels were calculated is given below to illustrate this process.

$$Ratio\ of\ Ports = \frac{Number\ of\ Calls_{\ (Vessel\ Type,\ DWT\ Range,\ Port)}}{Total\ Number\ of\ Calls_{\ (Vessel\ Type, DWT\ Range)}}$$

$$= \frac{3\ Calls_{\ (GC, 15\text{-}30\ DWT, Oceanport)}}{5\ Calls_{\ (GC, 15\text{-}30\ DWT}\ )} = 0.60$$

Table 4-38 provides a list of the calculated ratios for general cargo vessels.

Table 4-38. Engine Type Ratios for All General Cargo Vessels Calling on Delaware Ports

Codes	DWT Range	Total Calls	Port	Calls at Ports	Port Ratio
GC	< 15,000	9	WILM (PORT) DE	9	1.00
GC	15,000-30,000	5	OCEANPORT DE	3	0.60
			WILM (PORT) DE	2	0.40
GC	30,000-45,000	1	WILM (PORT) DE	1	1.00
GC	> 45,000	2	WILM (PORT) DE	2	1.00

DNREC then multiplied the 2002 vessel calls (by vessel type, DWT range, and engine type) by the ratio of calls for each port. Rounding is required since a vessel call must be an integer value.

$$\begin{aligned} Calls_{(VesselType,DWTRange,EngineType,Port)} &= 2002\ Calls_{(VesselType,DWTRange,EngineType)} \times Ratio\ of\ Ports \\ &= 4\ Calls_{(GC,15\text{-}30\ DWT,2stroke)} \times 0.60_{(GC,15\text{-}30\ DWT,Oceanport)} \\ &= 2\ Calls_{(GC,15\text{-}30\ DWT,\ 2\text{-}stroke,Oceanport,\ )} \end{aligned}$$

This procedure provided the estimated number of 2002 vessel calls for each vessel type, DWT range, and engine type by port. The results for general cargo vessels are given below in Table 4-39. The call data by vessel type, DWT range, engine type, and port are located in the OGV database files that accompany this report.

Table 4-39. General Cargo Calls by Engine Type & Port

Codes	DWT Range	Engine Type	Power (hp)	Calls by Engine	Port Ratio	Port	Calls by Engine & Port
GC	<15,000	2-stroke	5,784	4	1.00	Wilmington	4
GC	<15,000	4-stroke	3,944	4	1.00	Wilmington	4
GC	15,000 - 30,000	2-stroke	10,456	4	0.60	Oceanport	2
					0.40	Wilmington	2
GC	15,000 - 30,000	4-stroke	7,536	1	0.60	Oceanport	1
					0.40	Wilmington	0
GC	30,000 - 45,000	2-stroke	12,876	1	1.00	Wilmington	1
GC	> 45,000	2-stroke	12,170	2	1.00	Wilmington	2

Propulsion engine load factors specific to Delaware River ports for the various modes of operation, presented in Table 4-40, were obtained from EPA's *Deep Sea Ports* (EPA, 1999c).

For each vessel type, the average time spent in cruise, maneuver, and hotel modes was obtained from *Deep Sea Ports* (EPA, 1999c). For the RSZ mode, DNREC calculated the time-in-mode based on the distance to each port and an average OGV vessel speed of 10 knots. Table 4-41 presents the time-in-mode by vessel type and port. An example is given below for the Port of Wilmington. Note that one vessel call requires 2 trips, one inbound trip and one outbound trip.

Table 4-40. Propulsion Engine Load Factors for Ocean-Going Vessels

Codes	Vessel Type	Engine Load Factors by Mode		
		Cruise	Maneuver	RSZ
BU	Bulk	0.80	0.20	0.40
CC	Container	0.80	0.15	0.30
GC	General Cargo	0.80	0.20	0.35
CH	Chemical Carrier	0.80	0.20	0.40
RR	RORO	0.80	0.15	0.30
RF	Reefer	0.80	0.15	0.30
TA	Tanker	0.80	0.20	0.40
VE	Car Carrier	0.80	0.15	0.30
PA	Passenger	0.80	0.10	0.20
MS	Miscellaneous	0.80	0.15	0.30

$$\begin{aligned} Time\ in\ RSZ &= \frac{Distance\ from\ Breakwater\ to\ Port}{Vessel\ Speed} \times 2trips \\ &= \frac{66.5\ nautical\ miles}{10\ knots} \times 2trips \\ &= 13.3\ hours \end{aligned}$$

Table 4-41. Average Time-in-Mode by Vessel Type and Port

Codes	Ship Type	Cruise (hr/call)	Maneuver (hr/call)	Hotel (hr/call)	Port	RSZ (hr/call)
BU	Bulk	3.4	1.7	95.8	DE/PA to Sea	14.4
CC	Container	2.7	1.1	33.5	Wilmington	13.3
GC	General Cargo	3.6	1.6	91.3	DE Terminal	13.0
CH	Chemical Carrier	3.4	1.7	95.8	Oceanport	12.0
RR	RORO	3.3	1.2	60.7	Premcor	10.8
RF	Reefer	2.7	1.5	63.0		
TA	Tanker	3.4	2.4	85.1		
VE	Car Carrier	3.2	1.2	22.7		
PA	Passenger	2.4	1.1	20.5		
MS	Miscellaneous	3.6	1.3	44.0		

While the engine activity equation is the same for propulsion engines and auxiliary engines, the activity for the two engines must be kept separate since they have different emissions factors. An example is given below for RSZ mode of general cargo vessels with DWT of 15,000-30,000 and 2-stroke engines that call to Oceanport.

For the propulsion engine:

$$\begin{aligned} Activity_{mode} &= Power \times LoadFactor \times Time_{mode} \times Calls \\ &= 10{,}456\ hp \times \frac{0.7457\ kW}{hp} \times 0.35 \times 12\ hours \times 2\ calls \\ &= 65{,}495\ kW\text{ - }hours \end{aligned}$$

For the auxiliary engine:

$$Activity_{mode} = Power \times LoadFactor \times Time_{mode} \times Calls$$
$$= 913\,kW \times 0.33 \times 12\ hours \times 2\ calls$$
$$= 7{,}231\ kW\text{ - }hours$$

Chesapeake & Delaware (C&D) Canal Vessels and Towboats

DNREC obtained data on vessels passing through the C&D Canal during calendar year 2002 from *Waterborne Commerce of the United States* (USACE, 2004a). Self-propelled vessels were categorized as towboat, dry cargo vessel, or tanker. Non-self-propelled vessels, typically referred to as barges, are not included in the vessel trip counts. Table 4-42 presents the number of trips through the C&D Canal.

Table 4-42. Number of Trips through the C&D Canal in 2002

Vessel Type	Number of Trips
Towboat	4,235
Dry Cargo Vessel	555
Tanker	40

The only activity in the C&D canal is transit (RSZ mode). The distance between the Maryland-Delaware border and the Delaware River is 11.2 nautical miles, based on information provided in the 1999 CMV emissions inventory for the State of Delaware (DNREC, 2002). The average vessel speed through the canal was assumed to be 10 knots (EPA 1999a). Therefore, the average transit time through the C&D Canal is:

$$Time_{C\&D\ transit} = \frac{distance}{speed} = \frac{11.2\ nautical\ miles}{10\ knots} = 1.12\ hours\ per\ trip$$

For dry cargo vessels and tankers, propulsion and auxiliary engine power were based on the information presented above for OGVs. DNREC estimated the average propulsion engine power by weighting the engine power with the number of 1996 vessel calls per engine type. For towboat engine data, DNREC relied on survey information collected for the Port of New York, New Jersey and Long Island (NYNJ, 2003). DNREC assumed the load factors were similar to those reported for towboats in the Port of New York, New Jersey and Long Island survey. Table 4-43 presents the average engine size and load factors for the various types of vessels using the C&D Canal.

Table 4-43. Average Propulsion and Auxiliary Engine Power and Load Factors for C&D Canal Vessels

	Average Engine Size		RSZ Load Factor	
Vessel Type	Propulsion (kW)	Auxiliary (kW)	Propulsion	Auxiliary
Dry cargo	4,686	913	0.6875	0.65
Tanker	11,060	2,214	0.6875	0.65
Towboat	3,183	913	0.6875	0.65

Delaware River Towboats

The number of towboat trips along the Delaware River area was obtained from *Waterborne Commerce* (USACE, 2004a). Each trip was assumed to be a unit tow. The Delaware River data includes trips for both the POW and the C&D Canal. DNREC subtracted the number of towboat trips for the POW and the C&D Canal from the number of trips on the Delaware River. The towboats coming from and going to the Port of Wilmington and the C&D Canal travel both south and north on the Delaware River. Therefore, DNREC split these number of towboat trips evenly. The number of trips is given in Table 4-44.

Table 4-44. Towboat Trips and Time-in-Mode for the Delaware River

Parameter	Units	DE River	POW South	POW North	C&D South	C&D North
Trips[a]		16,414	552	552	2,118	2,118
Distance	miles	83.1	76.5	6.6	62.5	20.6
Speed	mph	11.5	11.5	11.5	11.5	11.5
RSZ	hr/trip	7.2	6.6	0.6	5.4	1.8
Maneuver	hr/trip	0	1.0	1.0	1.0	1.0
Total RSZ Time	**hours**	**118,529**	**3,670**	**317**	**11,500**	**3,791**
Total Man. Time	**hours**	**0**	**552**	**552**	**2,118**	**2,118**

[a]Assumes 50% of the vessels travel North and 50% travel South for POW and C&D

Mileage for each trip was obtained from Table 4-33. The average vessel speed was assumed to be 10 knots (EPA, 1999c). The time in transit per trip was estimated from the average vessel speed and the distance to each port. The maneuvering time for towboats entering or leaving the Port of Wilmington and the C&D Canal was assumed to be one hour per EPA's *Deep Sea Ports* (EPA, 1999c). Propulsion and auxiliary engine power and load factors were obtained from Table 4-43 for towboats.

Tug-Assist Vessels

DNREC calculated propulsion and auxiliary engine activity for tug-assist vessels. Activity was calculated for two modes: 1) transit mode, which refers to taking the pilot to the vessel and escorting the vessel to the port; and 2) assist mode, which refers to maneuvering the vessel into the berth and securing the dock lines. DNREC did not estimate emissions from hotelling of tug-assist vessels due to lack of activity data.

Tug-assist vessels are not accounted for in the towboat/tugboat activity reported in *Waterborne Commerce.* More than one tug is generally required to assist an OGV during a call. DNREC obtained the average number of assist tugs required per call for each vessel type from the survey information collected for the Port of New York, New Jersey and Long Island (NYNJ, 2003). Table 4-45 presents the number of assist tug vessels required for each call by vessel type.

The number of OGV vessel calls in 2002 by vessel type and port was obtained from the 2002 OGV activity. DNREC multiplied the number calls by the number of tugs required to assist each vessel type. An example using general cargo vessels assisted to Oceanport is given below. DNREC obtained average engine power and load factors from the survey information collected for the Port of New York, New Jersey and Long Island (NYNJ, 2003). Table 4-46 presents the average tug-assist vessel engine data.

$$TugCalls_{(VesselType,Port)} = 2002\ OGV\ Calls_{(VesselType,Port)} \times Tugs_{(VesselType)}$$
$$= 3\ Calls_{(GC,Oceanport)} \times 3_{(GC)}$$
$$= 9\ Tug\ Calls_{(GC,Oceanport)}$$

Table 4-45. Average Number of Assist Tugs Required Per Vessel Call

Codes	Number of Assist Tugs	Codes	Number of Assist Tugs
RF	4	BU	3
CC	4	RR	3
CH	3	PA	2
GC	3	MS	2
TA	3	VE	1.5

For transit mode, DNREC applied the RSZ time developed for each port in the 2002 OGV activity data and presented in Table 4-41. The time to assist the vessels with berthing is assumed to be 20% more time than the time spent maneuvering by the OGV. DNREC multiplied the maneuvering time given in Table 4-41 by 120% to obtain the time spent in assist mode. Table 4-47 presents the average time spent assisting OGV vessels.

Table 4-46. Engine Propulsion and Auxiliary Engine Power and Load Factors for Tug-Assist Vessels

Engine	Power (kW)	Load Factor	
		Escort	Assist
Propulsion	2,908	0.40	0.68
Auxiliary	90	0.50	0.50

Table 4-47. Average Time in Assist Mode for Tugs

Codes	Assist Time (hr)	Codes	Assist Time (hr)
BU	2.04	RF	1.80
CC	1.32	RR	1.44
CH	2.04	TA	2.88
GC	1.92	VE	1.44
PA	1.32	MS	1.56

Dredging

Maintenance dredging is performed routinely on the Delaware River to keep the channels to their required depths. Dredging involves multiple vessels, including dredges, assist tugs, and generator barges that provide additional power. Estimating emissions from dredging vessel engine activity is time-consuming. Therefore, DNREC developed emissions based on the volume of material dredged during calendar year 2002 rather than engine activity in kilowatt-hours.

DNREC obtained the dredging activity data from both the USACE and from within DNREC. The amount of material dredged by the USACE was obtained directly from the USACE Pennsylvania District Office (USACE, 2004b). DNREC obtained the amount of material dredged by contractors from the USACE report on dredging contracts awarded for the year 2002 (USACE, 2004c). DNREC also contacted the Delaware Division of Soil and Water Conservation to obtain the amount of material dredged by the Division (DSWC, 2004). Table 4-48 presents the estimated amount of material dredged and the type of dredge used.

Table 4-48. Material Dredged in the Delaware River Area during 2002

Project Location	Type of Equipment	Total Material Dredged (cubic yards)
PA to the Sea	Hydraulic Dredge	3,100,000
Mispillion River	Hydraulic Dredge	22,500
Murderkill River	Hydraulic Dredge	25,000
Wilmington Harbor	Hydraulic Dredge	465,600
Cedar Creek/Slaughter Beach	Hydraulic Dredge	8,606

DNREC assumed all the dredging activity is maintenance dredging. New cut dredging results in higher emissions, therefore this assumption may result in lower emission estimates than are actually occurring in the area.

Ferries

The Cape May-Lewes Ferry and the Three Forts Ferry were identified as ferry services in the Delaware. DNREC obtained the number of trips for the year 2002 from the ferry schedules (DRBA, 2004a; CMLF, 2004). Times for maneuvering and idling at dock were obtained from EPA's Deep Sea Ports (EPA, 1999c). For summer workweek activity, DNREC obtained the average number of weekday trips during the months of June, July and August from the Delaware River and Bay Authority staff and the Delaware Division of Parks and Recreation (DRBA, 2004b; DDPR, 2004). Table 4-49 presents time-in-mode data and distances for the ferries.

Table 4-49. Number of Trips, Time-in-Mode, and Distance for Delaware Ferries

Parameter	Cape May-Lewes	Three Forts
Number of trips (yearly)	2,465	1,330
Number of trips (summer)[a]	1,200	880
Trip distance (miles)	17[b]	2
Speed (knots)	16	10
Average Time (hr/trip)		
Cruise	1.3	0.5
Maneuvering	0.167	0.1666
Idle	0.333	0.333

[a]Summer defined as 13 weeks for CML Ferry and 11 weeks for the Three Forts Ferry.
[b]Trip distance is the distance traveled in Delaware

DNREC obtained the propulsion and auxiliary engine power from the websites for the Delaware Division of Parks and Recreation and Delaware River and Bay Authority (DDPR, 2004; DRBA, 2004a). Load factors were obtained from EPA's *Deep Sea Ports* (EPA, 1999c). Table 4-50 presents engine data used to estimate ferry activity.

Table 4-50. Engine Power and Load Factors for Ferries

Ferry	Engine	Engine Power (hp)	Load Factor		
			Cruise	Maneuver	Idling
Cape May-Lewes	Propulsion	4000	0.75	0.20	0
	Auxiliary	300	0.65	0.65	0.65
Three Forts	Propulsion	550	0.75	0.20	0
	Auxiliary	195	0.65	0.65	0.65

4.5.2 Spatial Allocation

DNREC developed county allocation factors for CMV activity data based on the location of the activity on the various waterways and length of the waterway segment. In developing county allocation factors, DNREC assumed that from latitude 39°30' to 25 miles beyond the mouth of the Delaware Bay, the activity are split evenly between Delaware and New Jersey since the ship channel roughly corresponds to the boundary between the two states. Above latitude 39°30', all emissions are allocated to Delaware since the entire breadth of the river is under Delaware's jurisdiction. Allocations were developed for each activity mode, since the activity takes place in different areas depending on the mode. Table 4-51 presents the distances used in developing county allocation factors for vessels traveling through Delaware to ports north of the state line.

Table 4-51. County Allocation Factors for PA/DE to the Sea

PA/DE to the Sea	Distance (miles)	Distance Ratio	DE-NJ Activity Ratio	Total RSZ Alloc. Factor
PA/DE line to Latitude 39°30'	25.5	0.3069	1.0	0.3069
Latitude 39°30' to NCC/KC Line	9.0	0.1083	0.5	0.0542
New Castle County	34.5			0.3610
Kent County	32.8	0.3947	0.5	0.1974
Sussex County	15.8	0.1901	0.5	0.0951
Total Distance	**83.1**			

Ocean-Going Vessels

Cruise mode for OGVs occurs 25 miles out from the breakwater to the breakwater. The activity data was first split evenly between Delaware and New Jersey. The Delaware portion was then allocated to Sussex County since all cruise activity takes place off the Sussex County coast.

For OGV maneuvering and hotelling modes, the activity is allocated to the county in which the port is located. All the Delaware ports are located in New Castle County. Therefore, all maneuvering and hotelling activity was allocated to occur in New Castle County.

For the RSZ mode, county allocation factors were developed for the four ports in Delaware (Port of Wilmington, Delaware Terminal, Oceanport, and Premcor) and from the Pennsylvania-Delaware border to the breakwater (PA/DE to the Sea). An example is given below for developing the county allocations factors for PA/DE to the Sea.

The total distance between the Pennsylvania-Delaware border and the breakwater is 83.1 miles. The distance between each county and the distance from the county line to latitude 39°30' was obtained from the Delaware 1999 emissions inventory (DNREC, 2002). The distance ratio is the distance for each segment divided by the total distance. This ratio was multiplied by the ratio of the activity split between Delaware and New Jersey. For PA/DE to the Sea, the county allocation factor for Kent County is calculated as:

$$KentCounty = (32.8 / 83.1) \times 0.5 = .1974$$

The activity data for each port was multiplied by the county allocation factors (CAF) to estimate the activity in each county. Continuing the example for general cargo vessels with 2-stroke engines in RSZ mode that call on Oceanport, the total activity is 65,495 kW-hours. The activity in New Castle County is calculated as:

$$\begin{aligned} Activity_{(mode,county,port,vessel,engine)} &= Activity_{(mode,port,vessel,engine)} \times CAF_{(port,RSZ)} \\ &= 65{,}495\ kW\text{ - }hours_{(NewCastle,GC,2-st)} \times 0.2307_{(Oceanport,RSZ)} \\ &= 15{,}110\ kW\text{ - }hours_{(RSZ,New\ Castle,Oceanport,GC,2\text{-}st)} \end{aligned}$$

Table 4-52 presents the county allocation factors for the waterways and ports that were developed using this methodology. The C&D North/South and POW North/South factors were only used for towboats.

C&D Canal, Delaware River, and POW Towboats

All activity for the C&D Canal was allocated to New Castle County, the location of the Canal. Transit and maneuvering mode activity data were estimated for towboats on the Delaware River. As stated previously, towboats on the Delaware River were assumed to travel the full distance from the Delaware-Pennsylvania border to the Sea. However, for the Port of Wilmington and the C&D Canal, half the trips were assumed to head north and half the trips were assumed to head south on the Delaware River. Transit mode activity was allocated using the same methodology used for OGV RSZ activity. Distance and activity ratios were developed for each waterway. The activity was then multiplied by the CAFs provided in Table 4-52.

Tug-Assist Vessels

Transit and maneuvering mode activity data were estimated for tug-assist vessels on the Delaware River. Assist (maneuvering) activity is assumed to take place in port, therefore this activity was allocated to New Castle County. Transit mode activity was allocated using the same methodology developed for OGV RSZ activity. Distance and activity ratios were developed for each waterway. The activity was then multiplied by the CAFs provided in Table 4-52.

Table 4-52. County Allocation Factors for the Waterways and Ports Used for the Reduced Speed Zone, Transit, and Escort Modes

County	Port/Waterway	County Allocation Factor
New Castle County	PA to Sea	0.3610
Kent County	PA to Sea	0.1974
Sussex County	PA to Sea	0.0951
New Castle County	Delaware Terminal	0.3059
Kent County	Delaware Terminal	0.2144
Sussex County	Delaware Terminal	0.1033
New Castle County	Premcor	0.1451
Kent County	Premcor	0.2640
Sussex County	Premcor	0.1272
New Castle County	Oceanport	0.2307
Kent County	Oceanport	0.2376
Sussex County	Oceanport	0.1145
New Castle County	POW South	0.3059
Kent County	POW South	0.2144
Sussex County	POW South	0.1033
New Castle County	POW North	1.0000
New Castle County	C&D South	0.1504
Kent County	C&D South	0.2624
Sussex County	C&D South	0.1264
New Castle County	C&D North	1.0000
New Castle County	C&D East	1.0000

Dredging and Ferries

CAFs were developed specifically for allocating dredging in the Delaware River. The entire project length was reported by the USACE Pennsylvania District Office as 120 miles, which includes 36.9 miles above the PA/DE border. The CAFs also account for the activity split between Delaware and New Jersey below the latitude of $39^{o}30'$. The activity was then multiplied by the CAFs to produce county-level activity. For the other dredging areas, the activity was allocated based on the location of the dredging. The Mispillion River is located on the border of Kent and Sussex Counties, and thus emissions were split between the two counties. Table 4-53 presents the county allocation factors for dredging.

Table 4-53. County Allocation Factors for Dredging

Project Location	County	County Allocation Ratio
PA to the Sea	New Castle	0.2500
	Kent	0.1367
	Sussex	0.0658
Mispillion River	Kent	0.5000
	Sussex	0.5000
Murderkill River	Kent	1.0
Wilmington Harbor	New Castle	1.0
Cedar Creek/Slaughter Beach	Sussex	1.0

The Cape-May Lewes Ferry activity data was split evenly between Delaware and New Jersey. While the Three Forts Ferry travels to Fort Mott on the New Jersey side of the Delaware River, at that latitude, Delaware's jurisdictional waters extend the breadth of the river. Therefore, all activity for the Three Forts Ferry was allocated to Delaware. Based on the ferry location, DNREC allocated all Delaware-assigned activity for the Cape May-Lewes Ferry to Sussex County and all activity for the Three Forts Ferry to New Castle County.

4.5.3 Emission Factors

The EPA published revised emission factors as a result of the emissions inventories developed for the CMV sector Regulatory Impact Analysis reports (EPA, 1999a; EPA, 2003). Emission factors are based on EPA engine category definitions. Using EPA methodologies, DNREC placed each propulsion and auxiliary engine in an EPA Marine Engine Category based on the vessel type (EPA 2001; EPA, 2002). Table 4-54 presents DNREC's assumptions regarding EPA CMV engine categories.

Table 4-54. EPA Marine Engine Category by Vessel Type

Vessel Type	Propulsion	Auxiliary	Vessel Type	Propulsion	Auxiliary
Bulk	Cat 3	Cat 2	Car Carrier	Cat 3	Cat 2
Container	Cat 3	Cat 2	Passenger	Cat 3	Cat 3
General Cargo	Cat 3	Cat 2	Miscellaneous	Cat 3	Cat 2
Chemical Carrier	Cat 3	Cat 2	Towboat	Cat 2	Cat 1
RORO	Cat 3	Cat 2	Tug Assist	Cat 2	Cat 1
Reefer	Cat 3	Cat 3	Ferry	Cat 2	Cat 1
Tanker	Cat 3	Cat 2			

DNREC obtained Category 3 engines emission factors for NO_x, HC (assumed equivalent to VOC), and CO from EPA (EPA, 2002). Category 1 and 2 engine emission factors for NO_x, HC, and CO were obtained from (EPA, 1999a). Tables 4-55 and 4-56 present the emission factors.

Table 4-55. Emission Factors for Category 3 Engines

Mode	Engine	VOC g/kW-hr	NO_x g/kW-hr	CO g/kW-hr
Cruise	2-stroke	0.530	23.60	1.10
	4-stroke	0.530	16.60	0.70
	Steam	0.067	2.80	0.30
RSZ	2-stroke	0.530	23.60	1.10
	4-stroke	0.530	16.60	0.70
	Steam	0.067	2.80	0.30
Maneuver	2-stroke	2.803	32.06	8.14
	4-stroke	2.910	22.64	5.94
	Steam	0.067	2.80	0.30
Hotel	2-stroke	0.134	13.36	2.48
	4-stroke	0.134	13.36	2.48
	Steam	0.067	2.80	0.30

Annual emissions were calculated by vessel type, engine type and mode of operation using the county-level activity data in kilowatt-hours. Emissions were calculated by multiplying the activity in kilowatt-hours by the emissions factor in grams per kilowatt-hour and a conversion factor for grams to tons. Continuing with the example for general cargo vessels in RSZ mode, the total activity for vessels calling at all Delaware ports must be summed.

Table 4-56. Emission Factors for Category 1 and 2 Engines

Engine Category	Power [kW]	VOC [g/kW-hr]	NO_x [g/kW-hr]	CO [g/kW-hr]
Category 2	all	0.134	13.36	2.48
Category 1	75-130	0.27	10	1.7
	130-225	0.27	10	1.5
	225-450	0.27	10	1.5
	450-560	0.27	10	1.5
	560-1000	0.27	10	1.5
	1000+	0.27	13	2.5

$$TotalActivity_{(mode,vessel,engine,county)} = \sum_{ports} Activity_{(mode,port,vessel,engine,county)}$$

$$= 15{,}110\ kWhr_{\ (Oceanport)} + 86{,}291\ kWhr_{\ (Wilmington)}$$

$$= 101{,}401\ kW\text{-}hr_{\ (RSZ,GC,2\text{-}st,NewCastle)}$$

Annual emissions for NOx are estimated as:

$$Emissions_{(mode,vessel,engine,county)} = EF_{(Mode,Engine)} \times TotalActivity_{(mode,vessel,engine,county)} \times \frac{1}{CF}$$

$$= \frac{23.60_{(RSZ,Cat3,2\text{-}st)} \times 101{,}401\ kW\text{-}hours_{(RSZ,\ GC,2\text{-}st,New\ Castle,)}}{907{,}184.7\ g/ton}$$

$$= 2.64\ tons\ NO_X\ _{(RSZ,GC,Cat3,2\text{-}st,NewCastle)}$$

where:

EF = emission factor by engine type (grams per kilowatt-hour)
Activity = rated power of propulsion engine by vessel type (kilowatt-hour),
CF = conversion factor (grams per ton).

Dredging

For dredging, emissions were estimated using ratios developed from the emissions estimates for maintenance dredging of the Delaware River Channel. The report "Delaware River Main Channel Deepening Project, Preliminary Emissions Reduction Strategy Report" presents air emissions that would result from the proposed deepening of the Delaware River Channel (USACE, 2003). The report also estimates emissions of criteria pollutants from annual maintenance of the existing Delaware River Channel and berths. The report presents emissions by amount of material dredged for maintenance dredging activity. The estimates include emissions for the dredge, support equipment, mobilization/demobilization towing and setup/teardown. Table 4-57 presents the emission factors for several methods of dredging.

DNREC multiplied the emission factors by the volume of material dredged from the Delaware River area in 2002 to estimate emissions. Emissions from dredging of the Delaware River from

PA to the Sea in New Castle County are used as an example. The volume of material dredged is obtained from Table 4-48 (3,100,000 cubic yards) and the county allocation factor from Table 4-53 (0.2500). First, the activity data is allocated to the county level as follows:

Table 4-57. Emission Factors for Dredging Operations

Type of Equipment	Emission Factors (tons per million cubic yards)		
	VOC	NO_X	CO
Clamshell Dredge/Drillboat	2.1600	171.7946	20.7482
Hopper Dredge	1.9218	208.0370	21.0683
Hydraulic Dredge	0.6277	57.5744	6.4059

$$Volume_{NewCastle}\left(yd^3\right) = Volume_{PAtoSea} \times CAF$$

$$= 3{,}100{,}000\left(yd^3\right) \times 0.2500$$

$$= 775{,}000\left(yd^3\right)$$

Using the emission factors given in Table 4-57:

$$Annual\ Emissions = Volume\left(yd^3\right) \times ER$$

$$= \frac{775{,}000\left(yd^3\right)}{10^6} \times 57.5744\left(\frac{Ton\ NOx}{million\ yd^3}\right)$$

$$= 44.6\ tons\ NO_X$$

4.5.4 Temporal Allocation

All CMV emissions were calculated as annual emissions, except for ferries. For ferries, DNREC estimated the summer work weekday emissions based on the number of ferry trips for a summer work weekday. For all other vessel types, SSWD daily emissions were calculated by multiplying the annual emissions by a temporal allocation factor (TAF).

DNREC reviewed the distribution of vessel calls during summer months for OGV. The number of vessel calls to Delaware ports in the summer months was approximately 24% of the calls. Since the temporal variation in the OGV activity on a monthly or weekly basis was fairly consistent, a uniform temporal profile was used to estimate SSWD emissions. The same assumption was used for towboats and tug-assist vessels as well. No temporal data were obtained for dredging; therefore, DNREC assumed there was no temporal variation in that activity either. For OGVs, towboats, tug-assist vessels, and dredge operation vessels, activity and emissions were allocated evenly using a TAF of 0.00274.

4.5.5 Controls

New EPA emissions standards for Category 1, 2, and 3 commercial marine engines did not take effect until 2004. In addition, Delaware does not currently regulate air pollution from commercial marine engines. Therefore, the 2002 emissions inventory does not include controls for commercial marine engines.

The international NO_x emissions standards proposed by the International Maritime Organization in Annex VI to the International Convention on the Prevention of Pollution from Ships (MARPOL 73/78) affect only Category 3 engines. The standard had not been ratified as of 2002. However, in 1999, many engines manufactured met the emissions standards due to the possibility of retroactive implementation.

DNREC incorporated the expected emissions reductions due to the use of new Category 3 engines installed on vessels calling at Delaware ports and transiting Delaware waters in 2002. The emission reductions and the expected rule penetration were obtained from the EPA Regulatory Support Document for Category 3 engines (EPA, 2003). DNREC estimated the reduction in NO_x for 2002 based on a linear interpolation between the uncontrolled and the control efficiency in year 2010. Table 4-58 presents the expected reductions due to MARPOL Annex VI.

DNREC applied NO_x emission controls to OGVs calling on the Delaware River Area with Category 3, 2-stroke, 4-stroke and auxiliary engines. No controls were applied to steam engines.

Table 4-58. Estimated Reductions in NO_x Emissions for OGV Engines due to MARPOL Annex VI in Year 2002

Engine Type	MARPOL Control Efficiency	2010 Control Efficiency	2002 Rule Penetration	2002 Overall Control Efficiency
Slow Speed	27.8%	13.1%	9%	2.5%
Medium Speed	22.6%	10.6%	9%	2.0%
Auxiliary	12.0%	5.4%	9%	1.1%

$$Controlled\ Emissions_{(mode,vessel,engine,county)} = Emissions_{(mode,vessel,engine,county)} \times (1 - CE_{(engine)} \times RP_{(engine,year)})$$

$$= 2.64\ tons\ NO_{X\ (RSZ,GC,Cat3,2\text{-}st,NewCastle)} \times (1 - 27.8\%_{(Cat3,2\text{-}st)} \times 9\%_{(Cat3,2\text{-}st,2002)})$$

$$= 2.57\ tons\ NO_{X\ (RSZ,Cat3,2\text{-}st,NewCastle)}$$

4.5.6 Results

Table 4-59. 2002 Statewide Annual and SSWD VOC, NO_X, and CO Emissions for Commercial Marine Vessel Engine Exhaust

SCC	Port/ Underway	Fuel Type	Vessel and Mode	Annual (TPY)			SSWD (TPD)		
				VOC	NO_X	CO	VOC	NO_X	CO
2280002100	Port	Diesel	Tugboat - Maneuver	1	106	20	< 0.01	0.29	0.05
			Towboat-Maneuver	2	175	33	< 0.01	0.48	0.09
			Ferries	3	119	23	0.01	0.55	0.10
			Dredging	1	111	12	< 0.01	0.30	0.03
			Total	**7**	**511**	**87**	**0.02**	**1.62**	**0.28**
2280002200	Underway	Diesel	Tugboat-Escort	15	1,460	270	0.04	4.00	0.74
			Towboat-Transit	29	2,838	526	0.08	7.78	1.44
			Total	**45**	**4,298**	**796**	**0.12**	**11.78**	**2.18**
2280003100	Port	Residual	OGV-Hotel and Maneuver	13	802	154	0.04	2.20	0.42
2280003200	Underway	Residual	OGV-Transit	76	3,506	238	0.21	9.60	0.65
228000xxxx	**Total: Commercial Marine Vessels**			**140**	**9,118**	**1,275**	**0.39**	**25.20**	**3.53**

4.5.7 References

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4.6 Commercial Marine Vessel Loading, Ballasting, and Transit

CMV operations carrying petroleum liquids cause emissions of VOC during loading of product onto barges, during ballasting operations, and during vessel transit within the port area. Emissions from these operations are estimated using the procedure described in *EIIP Volume III,* Chapter 12 (EPA, 2001).

Loading losses occur as a result of organic vapors in "empty" cargo tanks being displaced to the atmosphere by the liquid being loaded into the tanks. Loading losses are usually the largest source of evaporative emissions from petroleum vessels. This activity usually only occurs at refineries or at the terminal at the end of the pipeline where the product is loaded for distribution. However, petroleum liquids shipped in super tankers may unload to barges in a harbor to allow the tanker to enter shallower ports. This operation is referred to as "lightering."

Ballasting losses are associated with the unloading of petroleum liquids at marine terminals and refinery loading docks. Emissions from ballasting occur as vapor-laden air in the empty cargo tank is displaced to the atmosphere by ballast water being pumped into the tank. U.S. Coast Guard regulation (33 CFR, Part 157) requires that all vessels greater than 150 gross registered tons must have segregated ballast tanks, which eliminates emissions from ballasting in Delaware waters (DNREC, 2002). Therefore, these emissions are assumed to be zero for the 2002 inventory.

Transit losses are similar in many ways to breathing losses associated with petroleum storage. Transit loss is the expulsion of vapor from a vessel compartment through vapor contraction and expansion, which are the result of changes in temperature and barometric pressure. Transit emissions are based on the amount of time that the vessel is in an area. Some ships are equipped with controls for these losses. Emissions are reported under the following SCCs:

Table 4-60. SCCs for Commercial Marine Vessel Loading, Ballasting, and Transit

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2505020030	Storage and Transport	Petroleum Product Transport	Marine Vessel	Crude Oil
2505020060	Storage and Transport	Petroleum Product Transport	Marine Vessel	Residual Oil
2505020090	Storage and Transport	Petroleum Product Transport	Marine Vessel	Distillate Oil
2505020120	Storage and Transport	Petroleum Product Transport	Marine Vessel	Gasoline
2505020150	Storage and Transport	Petroleum Product Transport	Marine Vessel	Jet Naphtha

There are more types of petroleum commodities that are reported than listed in the SCCs given above. Fuels and other petroleum liquids transported by CMVs are classified into five major product types of significantly different densities, vapor pressures, and physical compositions. DNREC assigned the various petroleum commodities to an SCC based on the methodology presented in Table 12.4-2 of *EIIP Volume III* (EPA, 2001). Table 4-61 presents the methodology for assigning petroleum commodities to an SCC.

Table 4-61. Petroleum Commodity SCC Classification

Petroleum Commodity	SCC Product Classification
Crude petroleum	Crude oil
Residual fuel oil	Residual oil
Asphalt, tar, and pitch	Residual oil
Petroleum coke	Residual oil
Kerosene	Distillate oil
Distillate fuel oil	Distillate oil
Lube oil and greases	Distillate oil
Petroleum jelly and waxes	Distillate oil
Gasoline	Gasoline
Liquid natural gas	Gasoline
Naphtha and solvents	Jet naphtha
Petroleum products n.e.c.	Jet naphtha

The Federal Standards for Marine Tank Vessel Loading Operations and National Emission Standards for Hazardous Air Pollutants for Marine Tank Vessel Loading Operations were promulgated in 1995. The compliance date for Maximum Achievable Control Technology (MACT) standards was September 19, 1999. It requires large marine loading terminals (i.e., terminals that load either 200 million barrels per year of crude oil, or 10 million barrels per year of gasoline) to reduce emissions of VOC by at least 95 percent. It also requires all other major sources to reduce air toxic emissions by 97 percent. The sources are subject to recordkeeping and reporting requirements as well.

In the State of Delaware, the rule affects marine vessel loading operations at Maritrans, the principal lightering firm in the Delaware River Area, and the Premcor Refinery. The loading activity data reported under the point source inventory for Maritrans and Premcor was not counted as part of the loading activity under this category. However, emissions from evaporative losses during transit were calculated for Premcor and Maritrans.

4.6.1 Activity Data

DNREC based evaporative VOC emissions from marine vessels on the amount and type of petroleum products transported to, from, or through the inventory area via waterways. The waterways under consideration include Delaware's portion of the Delaware River and Bay (DE River), the Chesapeake and Delaware Canal (C&D Canal), and the Port of Wilmington (POW). DNREC obtained the amount and type of petroleum liquids transported through Delaware waterways and shipped from the Port of Wilmington in 2002 from the USACE publication *Waterborne Commerce* for calendar year 2002 (USACE, 2004).

Waterborne Commerce contains information on the foreign and domestic traffic classification (import, domestic, etc.). The types of losses (emission points) expected from a specific operation are determined based on the traffic classification. The emission points for the various traffic classifications are obtained from Table 12.4-1 in *EIIP Volume III* (EPA, 2001).

Loading activity was obtained from *Waterborne Commerce* for the POW. The loading activity data are summarized in Table 4-62. Assumptions for which traffic classification are considered part of loading activity are given below:

Traffic Classification	Assumption
Foreign exports	loaded onto vessels
Domestic coastwise shipments	loaded onto vessels
Domestic internal shipments	loaded onto barges
Domestic internal intra-port	loaded onto barges

Table 4-62. 2002 Loading Activity at the Port of Wilmington

Waterway	Fuel	Rig	Throughput (1,000 tons)
POW	Gasoline	Vessel	0
POW	Residual	Vessel	280
POW	Distillate	Vessel	18
POW	Naphtha	Vessel	35
POW	Gasoline	Barge	0
POW	Residual	Barge	296
POW	Distillate	Barge	61
POW	Naphtha	Barge	0

Transit activity was obtained from *Waterborne Commerce* for the Delaware River and Bay, the C&D Canal, and the POW. DNREC obtained the amount of crude oil received by Premcor from the point source inventory for 2002. Assumptions for which traffic classifications in Waterborne Commerce are considered part of transit activity are given below.

Traffic Classification	Assumption
Foreign imports/exports	transit on vessels
Domestic coastwise receipts/shipments	transit on vessels
Domestic internal receipts/shipments	transit on barges
Domestic internal intra-port	transit on barges

The amount of petroleum product reported by *Waterborne Commerce* as transported on the Delaware River includes the quantity transported to/from the POW and Premcor, and through the C&D Canal. To prevent double counting, DNREC subtracted these quantities from the quantity transported on the Delaware River. Transit emissions for the POW, C&D Canal and Premcor were calculated separately since the transit times are less than the transit time from the breakwater to the Delaware-Pennsylvania border. The transit activity associated with lightering operations conducted by Maritrans was not subtracted from the quantity of crude oil transported on the Delaware River since petroleum product handled by Maritrans is assumed to continue up the Delaware River after lightering. Thus, the amount reported within *Waterborne Commerce* as “Internal/Intraport/Upbound” was considered the lightered amount. The adjusted transit activity data is summarized in Table 4-63.

The loading and transit activity is reported in units of 1,000 tons. The emissions factors require units of 1,000 gallons. DNREC converted between the mass of petroleum product and the volume of petroleum product using an average product density. The densities were obtained from Appendix A of AP-42 (EPA, 1995). Table 4-64 presents the average density for each petroleum product category.

Table 4-63. Adjusted 2002 Transit Activity Data for the Port of Wilmington, C&D Canal, Premcor and the Delaware River

Fuel	Waterway	Rig	Throughput (1,000 Tons)	Throughput (1,000 Gallons)
Crude	DE River	Vessel	52,883	14,938,766
Crude	Premcor	Vessel	9,437	2,665,754
Crude	POW	Vessel	222	62,713
Distillate	C&D	Barge	328	93,050
Distillate	POW	Barge	204	57,872
Distillate	DE River	Barge	1,773	502,979
Distillate	C&D	Vessel	256	72,624
Distillate	POW	Vessel	20	5,674
Distillate	DE River	Vessel	3,044	863,546
Gasoline	C&D	Barge	1,127	365,316
Gasoline	POW	Barge	5	1,621
Gasoline	DE River	Barge	1,343	435,332
Gasoline	C&D	Vessel	855	277,147
Gasoline	DE River	Vessel	2,265	734,198
Naphtha	C&D	Barge	18	5,625
Naphtha	DE River	Barge	85	26,563
Naphtha	C&D	Vessel	44	13,750
Naphtha	POW	Vessel	52	16,250
Naphtha	DE River	Vessel	1,032	322,500
Residual	C&D	Barge	1,285	326,142
Residual	POW	Barge	510	129,442
Residual	DE River	Barge	1,489	377,919
Residual	C&D	Vessel	1,087	275,888
Residual	POW	Vessel	615	156,091
Residual	DE River	Vessel	6,018	1,527,411

Table 4-64. Average Densities of Petroleum Products

Product	Density (lb/gallon)
Gasoline	6.17
Crude Oil	7.08
Naphtha	6.4
Distillate	7.05
Residual	7.88

To calculate transit emissions, the time vessels and barges travel on Delaware waterways was estimated. Waterway segment distances from Table 4-33 were used to estimate transit times. The vessels coming from the Port of Wilmington (POW) and the C&D Canal travel both south and north on the Delaware River. DNREC split the activity data evenly and assumed half the volume of the petroleum products traveled north on the Delaware River and half traveled south. Transit time for vessels includes travel on Delaware waterways and travel between the Delaware Bay breakwater and 25 miles out to sea (cruise mode). Maneuvering and hotelling times were not considered for transit emissions.

DNREC assumed vessels and barges traveled 10 knots (11.51 mph) in reduced speed zone mode and vessels traveled 11.74 knots (13.51 mph) in cruise mode based on the cruise time for tankers on the Delaware River as identified in *Deep Sea Ports* (EPA, 1999). Table 4-65 presents the transit times for vessels and barges on Delaware waterways. As an example, the transit time for vessels and barges traveling through Delaware at RSZ mode was calculated as:

$$Time_{transit} = \frac{Distance\ Traveled\ on\ Waterway}{Vessel\ Speed}$$
$$= \frac{83.1\ miles}{11.51\ mph} \times \frac{1\ week}{168\ hours}$$
$$= 0.0430\ weeks$$

Table 4-65. Transit Times on Delaware Waterways (weeks/trip)

CMV Type and Mode	DE River	POW South	POW North	C&D East	C&D North	C&D South	Premcor
Barges and vessels in RSZ mode	0.0430	0.0396	0.0034	0.0067	0.0107	0.0323	0.0320
Vessels in cruise mode	0.0072	0.0072	NA	NA	NA	0.0072	0.0072

The county allocation factors for each waterway segment presented in Table 4-52 were used to allocate statewide emissions from the transit of petroleum products to each county. All loading activity occurs at the POW, therefore all the activity was allocated to New Castle County. All vessel transit in cruising mode occurs beyond the breakwater, therefore half of all activity was allocated to Sussex County (the other half was attributed to New Jersey.)

4.6.2 Emission Factors

The only pollutant resulting from this activity is VOC. VOC emissions are a function of the physical and chemical characteristics of both previous and new cargos. DNREC obtained VOC emission factors for crude oil, naphtha, distillate and residual fuel from Table 12.4-5 in EPA's *EIIP Volume III* Chapter 12 (EPA, 2001). VOC emission factors for gasoline loading were obtained from Table 5.2-2 in AP-42. These emission factors, which represent total organics, are summarized in Table 4-66. All products other than crude oil can be assumed to have VOC factors equal to total organic factors. Typical crude oil VOC factors are 15 percent lower than total organic factors due to the presence of methane and ethane in crude. DNREC reduced the crude oil emission factors presented in Table 4-66 by 15 percent.

Table 4-66. VOC Emission Factors for Marine Vessel Loading and Transit

Source Type	Units	Crude Oil[a]	Gasoline	Jet Naphtha	Distillate	Residual
Ship Loading	lbs/ 10^3 gal	0.61	1.8	0.5	0.005	0.00004
Barge Loading	lbs/ 10^3 gal	1.0	3.4	1.2	0.012	0.00009
Transit	lbs/week/10^3 gal	1.3	2.7	0.7	0.005	0.00003

[a]Crude oil emission factors represent total organics, not VOC.

DNREC calculated the VOC emissions from loading of barges and vessels at the POW using the county level activity data. As an example, 17,305 thousand gallons of distillate (converted from 61 thousand tons) was loaded onto barges in New Castle County during calendar year 2002. VOC emissions are calculated using the following equation:

$$E_{VOC} = VolumeLoaded_{\text{barge},distillate} \times EF_{VOC,\text{barge},distillate}$$
$$= 17{,}305(1{,}000\,gal) \times 0.012 \frac{\text{lbs}}{(1{,}000\,gal)} \times \frac{1\,ton}{2{,}000\,lbs}$$
$$= .0104\,tons$$

DNREC calculated the VOC emissions from transit of barges and vessels on the various waterways using the activity data from Table 4-63 and the allocated transit times from Table 4-65. An example of the emissions calculation is given below.

From Table 4-63, there is 62,542 thousand tons of crude oil transported on the Delaware River. This was converted to a volume basis using the densities given in Table 4-64 to 17,667,233 thousand gallons. Premcor reported 2,665,754 thousand gallons of crude oil handled in 2002 and the POW received 62,713 thousand gallons. Thus, the amount of crude oil passing through Delaware is:

$$Volume_{transit} = 17{,}667{,}233(10^3\,gal) - 2{,}665{,}754(10^3\,gal) - 62{,}713(10^3\,gal) = 14{,}938{,}766\,(10^3\,gal)$$

From Table 4-65, the RSZ transit time for vessels is 0.0430 weeks per trip. This value was multiplied by the county allocation factors given in Table 4-52 to arrive at county-level RSZ transit times on the Delaware River. In addition, the cruise time for vessels approaching the Delaware Bay is 0.0072 weeks per trip, which was allocated to Sussex County. The allocated county-level transit times are provided in Table 4-67.

Table 4-67. County Allocation of Transit Time on the Delaware River

Operating Mode	Transit Time (weeks/trip)	County	County Allocation Ratio	Allocated Transit Time (weeks/trip)
RSZ	0.0430	New Castle County	0.3610	0.0155
		Kent County	0.1974	0.0085
		Sussex County	0.0951	0.0041
Cruise	0.0072	Sussex County	0.5000	0.0036

DNREC then calculated the emissions from transit of vessels carrying crude oil on the Delaware River in a given county using the emission factors in Table 4-66. For Kent County, the VOC emissions are calculated as:

$$E_{VOC} = \frac{Volume_{transit} \times time_{transit,Kent} \times EF_{VOC,transit,crude} \times (100\% - CF_{crude})}{2{,}000\,lbs/ton}$$

$$= \frac{14{,}938{,}766(10^3\,gal - trip) \times 0.0085 \frac{weeks}{trip} \times 1.3 \frac{lbs}{(10^3\,gal - weeks)} \times (100\% - 15\%)}{2{,}000\,lbs/ton}$$

$$= 63.5\,tons\ VOC$$

where: EF = emission factor in lbs per 1,000 gallon-weeks
CF = correction factor for TOC to VOC for crude oil

Note that the correction factor is only needed for crude oil.

4.6.3 Temporal Allocation

All CMV loading and transit emissions are calculated as annual emissions. There is no temporal variation in the activity associated with loading and transport of petroleum products on the Delaware River. Therefore, uniform monthly and weekly allocations were assumed for estimating the SSWD values.

4.6.4 Controls

As previously stated, U.S. Coast Guard regulation (33 CFR, Part 157) requires that all vessels greater than 150 gross registered tons must have segregated ballast tanks. This essentially eliminates emissions from ballasting in Delaware waters (DNREC, 2002). The MACT standard applies to terminals that load either 200 million barrels per year of crude oil, or 10 million barrels per year of gasoline. These sources include Maritrans and the Premcor Refinery, which report as point sources. No other controls are assumed for vessel transit.

4.6.5 Results

Table 4-68. 2002 Statewide Annual and SSWD VOC Emissions for Loading and Transport of Petroleum Products

SCC	Petroleum Product Category Description	VOC	
		TPY	TPD
2505020030	Crude Oil	365	1.00
2505020060	Residual Oil	< 1	< 0.01
2505020090	Distillate Oil	< 1	< 0.01
2505020120	Gasoline	75	0.21
2505020150	Jet Naphtha	8	0.02
2505020xxx	**Total: CMV Loading & Transport**	**448**	**1.23**

4.6.6 References

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SECTION 5

ON-ROAD MOBILE SOURCES

The 2002 on-road mobile source inventory is an estimate of vehicle emissions based on actual vehicle miles traveled (VMT) on Delaware roadways in 2002 combined with emission factors developed through the use of EPA's MOBILE6.2 model. Vehicles include passenger cars, light-duty trucks, including sport utility vehicles, heavy-duty trucks, buses, and motorcycles. Emissions were calculated for vehicles fueled by gasoline or diesel. Controls as of 2002 were incorporated into the MOBILE6.2 model inputs, and thus emission factors account for controls. Engine exhaust emissions for VOC, NO_x, and CO, as well as for other criteria pollutants and air toxics, were calculated. In addition, VOC evaporative emissions were separately calculated. Annual and summer season weekday daily emissions were calculated by roadway class, vehicle type, and county.

The applicable Standard Classification Codes (SCCs) comprising vehicle type, roadway class, and emission process (exhaust or evaporative) are shown in Table 5-1. As an example, the SCC applicable to exhaust emissions from a passenger car fueled by gasoline on an urban interstate would be 220100123X, with the "2201001" indicating that the vehicle is a light-duty gasoline vehicle, the "23" indicating the activity is occurring on an urban interstate, and the "X" indicating that the emissions are exhaust emissions.

Table 5-1. SCCs Included in On-road Mobile Inventory

SCC Digits	Applicable Portion of SCC Code	Portion that SCC Describes	Description
1 - 7	2201001	Vehicle type	Light-duty gasoline vehicles (passenger cars)
1 - 7	2201020	Vehicle type	Light-duty gasoline trucks 1 (0-6,000 lb gross vehicle weight rating [GVWR])
1 - 7	2201040	Vehicle type	Light-duty gasoline trucks 2 (6,001-8,500 lb GVWR)
1 - 7	2201070	Vehicle type	Heavy-duty gasoline vehicles (> 8,500 lb GVWR)
1 - 7	2201080	Vehicle type	Motorcycles (gasoline)
1 - 7	2230001	Vehicle type	Light-duty diesel vehicles (passenger cars)
1 - 7	2230060	Vehicle type	Light-duty diesel trucks (0-8,500 lb GVWR)
1 - 7	2230071	Vehicle type	Class 2b heavy-duty diesel vehicles (8,501-10,000 lb GVWR)
1 - 7	2230072	Vehicle type	Class 3, 4, and 5 heavy-duty diesel vehicles (10,001-19,500 lb GVWR)
1 - 7	2230073	Vehicle type	Class 6 and 7 heavy-duty diesel vehicles (19,501-33,000 lb GVWR)
1 - 7	2230074	Vehicle type	Class 8 heavy-duty diesel vehicles (> 33,000 lb GVWR)
1 - 7	2230075	Vehicle type	Diesel buses
8 - 9	11	Roadway type	Rural interstates
8 - 9	13	Roadway type	Rural other principal arterials
8 - 9	15	Roadway type	Rural minor arterials

Continued next page

Table 5-1. continued

SCC Digits	Applicable Portion of SCC Code	Portion that SCC Describes	Description
8 - 9	17	Roadway type	Rural major collectors
8 - 9	19	Roadway type	Rural minor collectors
8 - 9	21	Roadway type	Rural locals
8 - 9	23	Roadway type	Urban interstates
8 - 9	25	Roadway type	Urban other freeways and expressways
8 - 9	27	Roadway type	Urban other principal arterials
8 - 9	29	Roadway type	Urban minor arterials
8 - 9	31	Roadway type	Urban collectors
8 - 9	33	Roadway type	Urban locals
10	X	Emission process	Exhaust
10	V	Emission process	Evaporative

5.1 Activity Data

The activity data used for developing the on-road emission inventory is VMT. The Delaware Department of Transportation (DelDOT) provided 2002 link-level VMT data for each county in Delaware. The link-level VMT data file includes a link identifier, a roadway type classification code, link distance, average daily speed on the link, link volume, and daily VMT on the link. The VMT data were not provided by vehicle class. VMT by vehicle type was developed using Delaware registration data and EPA mileage accumulation rates (refer to Section 5.2.7 for more details on this method.) In developing VMT by vehicle type, the VMT from each link was split into 28 records, according to the fraction of VMT for each vehicle type. VMT by vehicle type, county, roadway class, and speed were used to match each link-level VMT record to the corresponding emission factors developed through MOBILE6.2.

5.1.1 Estimating County-level VMT Using HPMS Data

DelDOT is required to submit calendar year VMT data annually to the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS). The VMT is estimated based on data from 40 permanent traffic count stations throughout the state. DelDOT's traffic count program provides daily and seasonal variation data. Additional temporary stations provide shorter-term counts that are expanded with factors derived from appropriate permanent count stations. Counting and expansion activities are consistent with FHWA guidelines. The traffic data submitted to HPMS are considered the most accurate VMT totals for each county. The permanent count station data are provided in the supporting documentation contained on the CD accompanying this report.

5.1.2 Estimating Link-level VMT Using Travel Demand Models

To accurately represent VMT across all roadway links within the statewide transportation network, DelDOT used two network-based travel demand models (TDMs) to estimate VMT by functional classification (i.e., roadway type.) DelDOT has developed and maintained regional

TDMs that, when combined, amount to a statewide model. The New Castle County (NCC) model covers approximately the northern one-third of the state. The downstate model is comprised of Kent and Sussex Counties (KSC). Both models are similar in content and procedure, with some variation in basic makeup.

Rather than relying solely on the HPMS data, the network models were selected to develop VMT estimates by functional classification to account for variations in travel according to purpose; to account for various movements such as internal, internal-external, and external travel; and to account for travel by auto and truck. The models are calibrated to the same traffic count base used to develop the HPMS VMT estimates. In addition, the models were validated and calibrated with 2002 population and other household data. Finally, total network model VMT was factored to be consistent with county-based HPMS VMT.

5.2 Emission Factor Development

The EPA MOBILE6.2 model was used to develop 2002 county-level emission factors by roadway class, speed, and vehicle type for each county in Delaware (EPA, 2003). The emission factors were developed on a monthly basis, using monthly temperature and fuel property data. Emissions were then calculated by applying the appropriate emission factors to link-level VMT data. Link-level data were then aggregated to the county level for each vehicle type and roadway class.

In order to use MOBILE6.2 to calculate on-road emission factors, a number of local input parameters were prepared. Some of these are required parameters, while others are optional. The Delaware-specific inputs that were used in the on-road modeling included: monthly temperature data by county, fuel data parameters by county and month, vehicle age distributions by county and vehicle type, vehicle speed distributions, inspection and maintenance (I/M) and anti-tampering program (ATP) parameters, and vehicle mix by vehicle type. Each of these input data sets are discussed separately below.

5.2.1 Temperature Data

Each scenario within the MOBILE6.2 input files was set up to be representative of conditions occurring within a specific month or season in 2002. Data on the average daily minimum and maximum temperatures for each month were obtained from the National Climatic Data Center (NCDC, 2003). One temperature data station was selected for each county in Delaware. For each of these temperature stations, this temperature database contained hourly temperatures for each day of the year in 2002. From these data, the maximum and minimum temperature for each day of the year at each station were first determined. Then, the average of the maximum daily temperature values was determined for each month by summing the maximum daily temperatures for each day in the month and then dividing by the number of days in the month. The same procedure was applied to determine the average minimum daily temperature for each month. The temperatures modeled for the summer season were the weighted average of the June, July, and August average daily maximum and minimum temperatures. The temperature data stations and the resulting average minimum and maximum daily temperatures by month and season are shown in Table 5-2.

Table 5-2. Average 2002 Maximum and Minimum Daily Temperatures (°F) by Month, Season and County

County	Kent	Kent	New Castle	New Castle	Sussex	Sussex
Station	Dover AFB	Dover AFB	Wilmington	Wilmington	Salisbury Airport	Salisbury Airport
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
January	30.7	45.9	30.5	45.5	29.7	49.2
February	31.3	50.4	29.9	48.9	26.3	52.1
March	36.2	55.3	35.1	53.2	35.4	56.7
April	46.1	65.7	45.9	65.6	44.7	67.8
May	51.1	71.0	51.2	71.1	48.0	74.0
June	62.8	80.5	62.8	80.8	58.5	83.5
July	67.3	86.6	68.2	86.9	63.5	88.2
August	68.5	86.7	68.3	86.7	64.4	87.3
September	60.4	77.2	59.5	78.9	58.1	79.7
October	49.6	63.1	48.4	62.7	49.5	66.4
November	38.0	53.5	35.7	51.7	35.7	55.8
December	27.4	42.9	27.6	41.2	26.8	45.9
Summer	66.2	84.6	66.5	84.8	62.2	86.4

Source: National Climatic Data Center, 2003.

5.2.2 Fuel Data

The entire State receives Federal reformulated gasoline. However, the fuel parameters vary seasonally as well as by county, based on information from EPA's Reformulated Gasoline Fuel Survey. This survey reports in-use gasoline parameters during winter (January) and summer (July). Delaware is well-represented in this survey, as the Philadelphia, PA-Wilmington, DE-Trenton, NJ area is one of the surveyed areas, as is Sussex County, Delaware. Thus, it was felt that the parameters obtained from this study could be directly applied for use in the Delaware inventory. It should be noted that the survey data were actually obtained in 2000, but DNREC does not expect there will be any significant differences between 2000 and 2002 fuel parameters.

The summer fuel data were applied to the ozone season months of May through September. Fuel parameters for the remaining months were calculated from the January and July fuel parameter values using the interpolation method developed by EPA's Office of Transportation and Air Quality for use in preparing a national fuel parameter database to populate its National Mobile Inventory Model (ERG, 2003). First, a monthly interpolation factor was calculated from the January and July survey Reid Vapor Pressure (RVP) values as well as the American Society for Testing and Materials (ASTM) monthly schedule of geographical volatility class assigned to each State. The volatility class ranges from class A to class E. An RVP limit was assigned to each of these volatility classes, based on the MOBILE4 User's Guide list of the RVP limits that correspond to each ASTM class (EPA, 1989). These RVP limits are as follows:

- ASTM class A = 9.0 pounds per square inch (psi)
- ASTM class B = 10.0 psi
- ASTM class C = 11.5 psi
- ASTM class D = 13.5 psi
- ASTM class E = 15.0 psi

The monthly interpolation factor was then calculated using the equation below:

$$MIF = (IA - SA) / (WA - SA)$$

where: MIF = Monthly Interpolation Factor (unitless)
IA = Intermediate month's (not January or July) ASTM RVP limit, as listed above by class based on the monthly ASTM class (psi)
WA = Winter (January) ASTM RVP limit (psi)
SA = Summer (July) ASTM RVP limit (psi)

After the monthly interpolation factor was calculated for each month and county, all of the necessary fuel parameters were then interpolated using this monthly interpolation factor along with the county-specific January and July values for that parameter using the following equation:

$$MFP = SFP + MIF * (WFP - SFP)$$

where: MFP = Monthly Fuel Parameter (e.g., RVP, sulfur content, etc.)
SFP = Summer (July) fuel parameter
MIF = Monthly Interpolation Factor (as calculated in previous equation)
WFP = Winter (January) fuel parameter

The resulting fuel parameters for Delaware are shown by month in Table 5-3. The MOBILE6.2 input files were set up to represent the fuel parameters occurring each month in each county in Delaware.

Table 5-3. 2002 Monthly Gasoline Fuel Parameters

County	Months	Reid Vapor Pressure (psi)	Sulfur Content (ppm)
Kent/New Castle	Jan - Feb, Dec	13.41	174
Kent/New Castle	Mar - Apr, Oct - Nov	10.56	155
Kent/New Castle	May - Sep	6.76	130
Sussex	Jan - Feb, Dec	13.41	225
Sussex	Mar - Apr, Oct - Nov	10.42	186
Sussex	May - Sep	6.43	134

Source: EPA Reformulated Gasoline Survey, 2000.

5.2.3 Vehicle Age Distributions

Vehicle registration data were obtained from the Delaware Division of Motor Vehicles (DMV) for each of the three counties in Delaware. The data are a snapshot of DMV's registration database as of July 1, 2002. The data show the number of vehicles registered by model year for the 16 MOBILE6.2 vehicle classes for which registration distributions can be provided. The raw registration data provide information on the combined light-duty truck (LDT) 1 and 2 classes and the combined LDT 3 and 4 classes. These registrations were then split out into the four separate LDT classes using EPA's national average vehicle counts by model year for these four truck classes. EPA's distributions between the LDT1 and LDT2 classes by model year were applied to the combined LDT 1 and 2 registration data to separate the registration data into the LDT1 and LDT2 vehicle classes. The combined LDT3 and LDT4 registration data were similarly split.

5.2.4 Vehicle Speeds

The link-level VMT files included an average daily speed associated with each road link. For the MOBILE6.2 modeling, the speed data were converted to MOBILE6.2 speed distribution files for each county and roadway class. Each of these speed distribution files provides the fraction of VMT that occurs in each of 14 speed bins, with the bins representing 5 mile per hour (mph) increments. To accomplish this, each record in the link-level VMT database was identified according to which of the 14 speed bins that link's speed fell into. The VMT data for each county and roadway class were then totaled by speed bin, and the fractional amount of each county/roadway type's VMT falling into each bin was calculated. These data were then converted to the appropriate format required by the MOBILE6.2 "SPEED VMT" command. Although the "SPEED VMT" distributions must be entered for each hour, hourly VMT and speed data were not available for Delaware. Therefore, the same daily data were entered into each of the 24 hourly records in the SPEED VMT distributions.

Table 5-4 summarizes the resulting speed distribution files used in the MOBILE6.2 modeling by HPMS roadway class. This table includes a column labeled "MOBILE Road Type." The assignment of each of the HPMS roadway classes to one of these MOBILE model road types (freeway, arterial, or local) was based on the default assignment used by EPA in the NEI. The MOBILE6.2 road type listed in this table that corresponds to a given speed distribution was assigned 100 percent of the VMT in a given scenario. For example, in the Kent County MOBILE6.2 input file, all of the VMT in scenarios representing rural interstates would be modeled with 100 percent of the VMT assigned to the MOBILE6 interstate road type, with the VMT distribution by speed provided in the file KC_R2SV.SPD. For the MOBILE6.2 local road type, the model assumes an average speed of 12.9 mph, and no speed-based emission adjustments are made within MOBILE6.2 for local roads. Therefore, no speed distributions are assigned to the scenarios modeling urban local roadways. The speed distribution files can be found in the supporting documentation contained on the accompanying CD.

5.2.5 Inspection and Maintenance (I/M) and Anti-tampering Programs

Delaware's vehicle I/M and ATP programs were modeled using the I/M program and ATP inputs provided by AQMS. However, the I/M programs for Kent and New Castle Counties indicated that a biennial onboard diagnostic testing program began in 2002 for 1996 and later model year vehicles. Since this is a biennial program, only about half of these vehicles will receive credit for being tested in 2002. Thus, an additional test was added for these vehicles. The 2500/idle test was applied to these model year vehicles through 2001. Adding this additional test enabled these vehicles to get the necessary credit for having been tested previously. The Kent County I/M program parameters are shown in Table 5-5 and the New Castle County I/M program parameters are shown in Table 5-6. The Sussex County I/M program includes only an idle test. This program is described in Table 5-7. Both Kent and New Castle Counties have the same ATP. This program is shown in Table 5-8. The input indicating the last model year affected by this program was adjusted to account for a five-year grace period applied to new vehicles. Sussex County did not have an ATP in 2002. Starting in 2003, Delaware began requiring on-board diagnostic (OBD II) testing of 1997 and newer diesel-fueled light-duty vehicles and trucks. This would not affect emissions in 2002, though, since this testing did not begin until 2003.

Table 5-4. Summary of Modeling Parameters by Roadway Class

County	Road Type Portion of SCC	HPMS Roadway Class	MOBILE6 Road Type	Speed Distribution File Name
Kent	110	Rural Interstate	Freeway	KC_R2SV.SPD
	130	Rural Other Principal Arterial	Arterial	KC_R3SV.SPD
	150	Rural Minor Arterial	Arterial	KC_R4SV.SPD
	170	Rural Major Collector	Arterial	KC_R5SV.SPD
	190	Rural Minor Collector	Arterial	KC_R6SV.SPD
	210	Rural Local	Arterial	KC_R7SV.SPD
	250	Urban Other Freeway & Expressway	Freeway	KC_U2SV.SPD
	270	Urban Other Principal Arterial	Arterial	KC_U3SV.SPD
	290	Urban Minor Arterial	Arterial	KC_U4SV.SPD
	310	Urban Collector	Arterial	KC_U5SV.SPD
	330	Urban Local	Local	Not Applicable
New Castle	130	Rural Other Principal Arterial	Arterial	NC_R3SV.SPD
	150	Rural Minor Arterial	Arterial	NC_R4SV.SPD
	170	Rural Major Collector	Arterial	NC_R5SV.SPD
	190	Rural Minor Collector	Arterial	NC_R6SV.SPD
	210	Rural Local	Arterial	NC_R7SV.SPD
	230	Urban Interstate	Freeway	NC_U1SV.SPD
	250	Urban Other Freeway & Expressway	Freeway	NC_U2SV.SPD
	270	Urban Other Principal Arterial	Arterial	NC_U3SV.SPD
	290	Urban Minor Arterial	Arterial	NC_U4SV.SPD
	310	Urban Collector	Arterial	NC_U5SV.SPD
	330	Urban Local	Local	Not Applicable
Sussex	130	Rural Other Principal Arterial	Arterial	SC_R3SV.SPD
	150	Rural Minor Arterial	Arterial	SC_R4SV.SPD
	170	Rural Major Collector	Arterial	SC_R5SV.SPD
	190	Rural Minor Collector	Arterial	SC_R6SV.SPD
	210	Rural Local	Arterial	SC_R7SV.SPD
	270	Urban Other Principal Arterial	Arterial	SC_U3SV.SPD
	290	Urban Minor Arterial	Arterial	SC_U4SV.SPD
	310	Urban Collector	Arterial	SC_U5SV.SPD
	330	Urban Local	Local	Not Applicable

Table 5-5. Kent County I/M Program Parameters

Test Type	2500/IDLE	FP & GC	OBD I/M	2500/IDLE
I/M Program Years	1991-2050	1995-2050	2002-2050	1991-2001
Test Frequency	Biennial	Biennial	Biennial	Biennial
Program Type	T/O	T/O	T/O	T/O
Model Years	1968-1995	1975-1995	1996-2050	1996-2050
Stringency Rate (%)	20	20	20	20
Compliance Rate (%)	96	96	96	96
Waiver Rate (%)	3	0	3	3
Grace Period (years)			5	5
Vehicles Tested				
LDGV	Yes	Yes	Yes	Yes
LDGT1	Yes	Yes	Yes	Yes
LDGT2	Yes	Yes	Yes	Yes
LDGT3	Yes	Yes	Yes	Yes
LDGT4	Yes	Yes	Yes	Yes
HDGV2B	No	No	No	No
HDGV3	No	No	No	No
HDGV4	No	No	No	No
HDGV5	No	No	No	No
HDGV6	No	No	No	No
HDGV7	No	No	No	No
HDGV8A	No	No	No	No
HDGV8B	No	No	No	No
GAS BUS	No	No	No	No

Table 5-6. New Castle County I/M Program Parameters

Test Type	2500/IDLE	FP & GC	OBD I/M	2500/IDLE
I/M Program Years	1983-2050	1995-2050	2002-2050	1983-2001
Test Frequency	Biennial	Biennial	Biennial	Biennial
Program Type	T/O	T/O	T/O	T/O
Model Years	1981-1995	1975-1995	1996-2050	1996-2050
Stringency Rate (%)	20	20	20	20
Compliance Rate (%)	96	96	96	96
Waiver Rate (%)	3	0	3	3
Grace Period (years)			5	5
Vehicles Tested				
LDGV	Yes	Yes	Yes	Yes
LDGT1	Yes	Yes	Yes	Yes
LDGT2	Yes	Yes	Yes	Yes
LDGT3	Yes	Yes	Yes	Yes
LDGT4	Yes	Yes	Yes	Yes
HDGV2B	No	No	No	No
HDGV3	No	No	No	No
HDGV4	No	No	No	No

Continued next page

Table 5-6. continued

HDGV5	No	No	No	No
HDGV6	No	No	No	No
HDGV7	No	No	No	No
HDGV8A	No	No	No	No
HDGV8B	No	No	No	No
GAS BUS	No	No	No	No

Table 5-7. Sussex County I/M Program Parameters

Test Type	IDLE
I/M Program Years	1991-2050
Test Frequency	Biennial
Program Type	T/O
Model Years	1968-2002
Stringency Rate (%)	20
Compliance Rate (%)	96
Waiver Rate (%)	3
Grace Period (years)	5
Vehicles Tested	
LDGV	Yes
LDGT1	Yes
LDGT2	Yes
LDGT3	Yes
LDGT4	Yes
HDGV2B	No
HDGV3	No
HDGV4	No
HDGV5	No
HDGV6	No
HDGV7	No
HDGV8A	No
HDGV8B	No
GAS BUS	No

Table 5-8. 2002 Anti-Tampering Program Parameters - Kent and New Castle

Program Start Year	1995
First Model Year	1975
Last Model Year	1997
Program Type	Test Only
Inspection Frequency	Biennial
Compliance Rate (%)	96
Vehicle Types	
LDGV	Yes

Continued next page

Table 5-8. continued

LDGT1	Yes
LDGT2	Yes
LDGT3	Yes
LDGT4	Yes
HDGV2B	No
HDGV3	No
HDGV4	No
HDGV5	No
HDGV6	No
HDGV7	No
HDGV8A	No
HDGV8B	No
GAS BUS	No
Inspections Performed	
Air pump system disablement	No
Catalyst removal	Yes
Fuel inlet restrictor disablement	Yes
Tailpipe lead deposit test	No
EGR disablement	No
Evaporative system disablement	No
PCV system disablement	No
Missing gas cap	Yes

5.2.6 Northeast Ozone Transport Region Low Emission Vehicle Program

Delaware belongs to the Northeast Ozone Transport Region (OTR). The States in this region have adopted a low-emission vehicle (LEV) program that began with the 1999 model year. The National LEV program, which began with the 2001 model year, is the default modeled in MOBILE6.2. Therefore, to correctly model the Northeast Ozone Transport Region LEV program in place in Delaware, the “94+ LDG IMP” command was used in the MOBILE6.2 input files. The phase-in schedule of the Northeast Ozone Transport Region LEV program is shown in Table 5-9. This phase-in schedule was applied to the MOBILE6.2 LDGV, LDGT1, and LDGT2 vehicle categories.

Table 5-9. LEV Implementation Schedule in the Northeast OTR

Model Year	Federal Tier I Standards	Transitional LEV Standards	LEV Standards	Tier 2 Standards
1999	30%	40%	30%	
2000		40%	60%	
2001 - 2003			100%	
2004 and later				100%

5.2.7 VMT Mix by Vehicle Type

VMT mix data are not collected in Delaware, so an alternate procedure was developed using the local registration data in calculating the VMT mixes rather than using the default MOBILE6.2 VMT distribution by vehicle type. This methodology uses national default MOBILE6.2 mileage accumulation and diesel sales fraction data in combination with the Delaware county-specific registration data to develop estimates of VMT by vehicle type. The number of vehicles registered in Delaware by model year, vehicle type, and county was multiplied first by the MOBILE6.2 default gasoline or diesel sales fraction corresponding to that vehicle type and model year, and then by the average number of miles accumulated annually by vehicles of the same age and vehicle type in the MOBILE6.2 default mileage accumulation database. This provided an estimate of VMT by vehicle age and vehicle type for each county. These VMT estimates were then summed over all years by vehicle type. The total VMT for each vehicle type was divided by the total calculated VMT to give VMT fractions by vehicle type. Table 5-10 reports the resulting VMT mixes by vehicle type for each county.

Table 5-10. County-Specific VMT Mixes by Vehicle Type

Vehicle Type	Vehicle Description	VMT Fraction by Vehicle Type		
		Kent County	New Castle County	Sussex County
LDV	Light Duty Vehicles (Passenger Cars)	0.4566	0.5265	0.4441
LDT1	Light-Duty Trucks 1 (0-6,000 lbs GVWR, 0-3,750 lbs LVW)	0.0651	0.0642	0.0709
LDT2	Light-Duty Trucks 2 (0-6,000 lbs GVWR, 3,751-5,750 lbs LVW)	0.2165	0.2136	0.2357
LDT3	Light-Duty Trucks 3 (6,001-8,500 lbs GVWR, 0-5,750 lbs ALVW)	0.0853	0.0702	0.0957
LDT4	Light-Duty Trucks 4 (6,000-8,500 lbs GVWR, >5,750 lbs ALVW)	0.0397	0.0327	0.0445
HDV2B	Class 2b Heavy-Duty Vehicles (8,501-10,000 lbs GVWR)	0.0371	0.0282	0.0338
HDV3	Class 3 Heavy-Duty Vehicles (10,001-14,000 lbs GVWR)	0.0099	0.0064	0.0099
HDV4	Class 4 Heavy-Duty Vehicles (14,001-16,000 lbs GVWR)	0.0053	0.0060	0.0052
HDV5	Class 5 Heavy-Duty Vehicles (16,001-19,500 lbs GVWR)	0.0016	0.0014	0.0020
HDV6	Class 6 Heavy-Duty Vehicles (19,501-26,000 lbs GVWR)	0.0042	0.0096	0.0035
HDV7	Class 7 Heavy-Duty Vehicles (26,001-33,000 lbs GVWR)	0.0066	0.0049	0.0061
HDV8A	Class 8a Heavy-Duty Vehicles (33,001-60,000 lbs GVWR)	0.0303	0.0113	0.0198
HDV8B	Class 8b Heavy-Duty Vehicles (>60,000 lbs GVWR)	0.0215	0.0155	0.0178
HDBS	School Buses	0.0031	0.0016	0.0022
HDBT	Transit and Urban Buses	0.0113	0.0033	0.0038
MC	Motorcycles	0.0059	0.0046	0.0050
Total		**1.0000**	**1.0000**	**1.0000**

5.3 Preparation of MOBILE6.2 Input Files

The input data described above were combined into MOBILE6.2 input files for each county. The input files were set up to model the 12 monthly scenarios plus a summer weekday scenario for each roadway class present in each county. The input files can be found in the supporting documentation contained on the accompanying CD.

5.4 Controls

All on-road control measures known to be in place in Delaware in 2002 were included in the MOBILE6.2 emission factor modeling. Local control programs include Delaware's I/M program and ATP, the Federal reformulated gasoline program, and the Northeast Ozone Transport Region LEV program. The MOBILE6.2 modeling also includes all national control programs, such as the Tier 1 emission standards. Therefore, no additional control factors were applied to the on-road emissions.

5.5 Temporal Allocation of VMT Data

The emission factors generated are month-specific because the input temperature and fuel data represent monthly conditions. The average daily VMT data were first multiplied by 365 to obtain annual VMT at the link level. The annual VMT data were then allocated by month using data provided by DelDOT from 2002 permanent counter stations. These data, provided separately for each of the three counties, include monthly adjustment factors applicable on a variety of roads across each county. These data were used to determine a single set of monthly temporal allocation factors to be applied to each roadway class in each county. The annual VMT were multiplied by each of the corresponding monthly temporal factors for the appropriate roadway type to obtain monthly VMT. The monthly VMT temporal adjustment factors are shown in Tables 5-11 through 5-13.

Table 5-11. Kent County Temporal Adjustment Factors by Roadway Class

Road Type SCC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SSWD
110	0.0597	0.0658	0.0707	0.0773	0.0714	0.1043	0.1167	0.1165	0.0918	0.0784	0.0757	0.0717	0.00380
130	0.0597	0.0658	0.0707	0.0773	0.0714	0.1043	0.1167	0.1165	0.0918	0.0784	0.0757	0.0717	0.00380
150	0.0768	0.0836	0.0837	0.0860	0.0860	0.0856	0.0846	0.0860	0.0852	0.0805	0.0798	0.0822	0.00289
170	0.0752	0.0796	0.0813	0.0839	0.0877	0.0914	0.0896	0.0845	0.0846	0.0839	0.0804	0.0779	0.00299
190	0.0752	0.0796	0.0813	0.0839	0.0877	0.0914	0.0896	0.0845	0.0846	0.0839	0.0804	0.0779	0.00299
210	0.0752	0.0796	0.0813	0.0839	0.0877	0.0914	0.0896	0.0845	0.0846	0.0839	0.0804	0.0779	0.00299
230	0.0597	0.0658	0.0707	0.0773	0.0714	0.1043	0.1167	0.1165	0.0918	0.0784	0.0757	0.0717	0.00401
250	0.0597	0.0658	0.0707	0.0773	0.0714	0.1043	0.1167	0.1165	0.0918	0.0784	0.0757	0.0717	0.00401
270	0.0597	0.0658	0.0707	0.0773	0.0714	0.1043	0.1167	0.1165	0.0918	0.0784	0.0757	0.0717	0.00401
290	0.0768	0.0836	0.0837	0.0860	0.0860	0.0856	0.0846	0.0860	0.0852	0.0805	0.0798	0.0822	0.00304
310	0.0752	0.0796	0.0813	0.0839	0.0877	0.0914	0.0896	0.0845	0.0846	0.0839	0.0804	0.0779	0.00316
330	0.0752	0.0796	0.0813	0.0839	0.0877	0.0914	0.0896	0.0845	0.0846	0.0839	0.0804	0.0779	0.00316

Table 5-12. New Castle County Temporal Adjustment Factors by Roadway Class

Road Type SCC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SSWD
110	0.0712	0.0769	0.0820	0.0843	0.0866	0.0892	0.0920	0.0957	0.0826	0.0800	0.0814	0.0781	0.00312
130	0.0715	0.0761	0.0796	0.0862	0.0920	0.0933	0.0908	0.0861	0.0842	0.0826	0.0801	0.0775	0.00304
150	0.0670	0.0734	0.0769	0.0813	0.0879	0.0947	0.0986	0.1001	0.0888	0.0815	0.0768	0.0730	0.00330
170	0.0645	0.0708	0.0750	0.0871	0.0983	0.1012	0.1080	0.0930	0.0917	0.0772	0.0709	0.0623	0.00340
190	0.0645	0.0708	0.0750	0.0871	0.0983	0.1012	0.1080	0.0930	0.0917	0.0772	0.0709	0.0623	0.00340
210	0.0662	0.0749	0.0787	0.0833	0.0877	0.0879	0.0862	0.0896	0.0930	0.0906	0.0821	0.0798	0.00297
230	0.0712	0.0769	0.0820	0.0843	0.0866	0.0892	0.0920	0.0957	0.0826	0.0800	0.0814	0.0781	0.00329
250	0.0712	0.0769	0.0820	0.0843	0.0866	0.0892	0.0920	0.0957	0.0826	0.0800	0.0814	0.0781	0.00329

Continue next page

Table 5-12. continued

Road Type SCC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SSWD
270	0.0715	0.0761	0.0796	0.0862	0.0920	0.0933	0.0908	0.0861	0.0842	0.0826	0.0801	0.0775	0.00321
290	0.0670	0.0734	0.0769	0.0813	0.0879	0.0947	0.0986	0.1001	0.0888	0.0815	0.0768	0.0730	0.00349
310	0.0645	0.0708	0.0750	0.0871	0.0983	0.1012	0.1080	0.0930	0.0917	0.0772	0.0709	0.0623	0.00359
330	0.0662	0.0749	0.0787	0.0833	0.0877	0.0879	0.0862	0.0896	0.0930	0.0906	0.0821	0.0798	0.00313

Table 5-13. Sussex County Temporal Adjustment Factors by Roadway Class

Road Type SCC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SSWD
110	0.0647	0.0706	0.0736	0.0787	0.0881	0.0998	0.1109	0.1112	0.0880	0.0768	0.0706	0.0670	0.00362
130	0.0647	0.0706	0.0736	0.0787	0.0881	0.0998	0.1109	0.1112	0.0880	0.0768	0.0706	0.0670	0.00362
150	0.0647	0.0707	0.0740	0.0787	0.0866	0.0997	0.1116	0.1095	0.0858	0.0777	0.0725	0.0685	0.00361
170	0.0640	0.0688	0.0718	0.0785	0.0912	0.1003	0.1105	0.1075	0.0872	0.0785	0.0728	0.0689	0.00358
190	0.0640	0.0688	0.0718	0.0785	0.0912	0.1003	0.1105	0.1075	0.0872	0.0785	0.0728	0.0689	0.00358
210	0.0640	0.0688	0.0718	0.0785	0.0912	0.1003	0.1105	0.1075	0.0872	0.0785	0.0728	0.0689	0.00358
230	0.0647	0.0706	0.0736	0.0787	0.0881	0.0998	0.1109	0.1112	0.0880	0.0768	0.0706	0.0670	0.00383
250	0.0647	0.0706	0.0736	0.0787	0.0881	0.0998	0.1109	0.1112	0.0880	0.0768	0.0706	0.0670	0.00383
270	0.0647	0.0706	0.0736	0.0787	0.0881	0.0998	0.1109	0.1112	0.0880	0.0768	0.0706	0.0670	0.00383
290	0.0647	0.0707	0.0740	0.0787	0.0866	0.0997	0.1116	0.1095	0.0858	0.0777	0.0725	0.0685	0.00381
310	0.0640	0.0688	0.0718	0.0785	0.0912	0.1003	0.1105	0.1075	0.0872	0.0785	0.0728	0.0689	0.00378
330	0.0640	0.0688	0.0718	0.0785	0.0912	0.1003	0.1105	0.1075	0.0872	0.0785	0.0728	0.0689	0.00378

Typical summer weekday temporal adjustment factors were developed by county and roadway class. First, the three monthly adjustment factors for summer (June, July, and August) were summed. These total seasonal activity factors were then divided by the number of days in the peak ozone season (92) to obtain an average daily seasonal VMT factor. Next, these average daily seasonal factors were multiplied by typical weekday VMT adjustment factors. These typical weekday factors were calculated using the methodology and data provided by EPA's Emissions Modeling Clearinghouse (EPA, 2002). The data files in this clearinghouse included day of week temporal factors for on-road vehicles that differed depending upon whether the VMT occurred on rural or urban roads. The weekly profile file was downloaded from the CHIEF website (EPA, 2000). Based on the data in this file, a typical weekday factor of 1.092 for VMT on urban roads and 1.036 for VMT on rural roads was calculated. The resultant typical summer season weekday VMT temporal adjustment factors are shown in Tables 5-11 through 5-13.

5.6 Sample Calculations and Results

Emissions were calculated in the following manner:

$$EM_{exh} = (EF_{exh} * VMT * TF_m) / (453.59g/lb * 2000\ lb/ton)$$

where: EM_{exh} = Exhaust emissions on link *l* for month *m*, vehicle type *v* (tons per year)
EF_{exh} = MOBILE6.2 exhaust emission factor for month *m*, vehicle type *v*, roadway class *f* and speed *s* (grams per mile)
VMT = Annual VMT on link *l* of roadway class *f* for vehicle type *v* (miles)
TF_m = VMT temporal adjustment factor for month *m*

Link-level monthly emissions were summed over 12 months to obtain annual emissions. These link-level emissions were also summed by SCC and the emission file was then converted to NIF. After emissions were calculated at this level of detail, the emissions for each county were summed at the county/SCC level. For VOC, emission factors were calculated for the evaporative emission components in addition to the exhaust emission components. VOC emission factors for all of the evaporative components (hot soak, diurnal, resting loss, running loss, and crankcase) were added together before calculating the total evaporative emissions.

Evaporative emissions that occur when gasoline vehicles are refueled at service stations are considered to be stationary non-point sources and, therefore, are included in Section 3. However, the emission factors from on-road vehicle refueling were calculated with MOBILE6.2, using the same relevant inputs to the model that are discussed in this section.

An example emission calculation is shown below for NO_x emissions from LDGVs in July on link #13511471. This link is on an urban interstate in New Castle County. The corresponding MOBILE6.2 NO_x emission factor is 1.073 grams per mile. The annual VMT for LDGVs on this link is 33.012 million miles. The July VMT temporal adjustment factor for urban interstates in New Castle County is 0.092.

$$EM_{LDGV,\ July,\ 13511471} = (1.073\ g/mi * 33.012E6\ miles * 0.092) / (453.59\ g/lb * 2000\ lb/ton) = 3.59\ tons\ NO_x$$

Table 5-14. 2002 Annual and SSWD VOC, NO_x, and CO Emissions and VMT for On-road Mobile Sources by County

County	Annual (TPY)			Annual VMT	SSWD (TPD)			Daily VMT
	VOC	NO_x	CO	10^6 miles	VOC	NO_x	CO	10^3 miles
Kent	1,737	4,182	25,991	1,406	5.45	13.97	66.61	4,888
New Castle	5,762	11,799	93,358	5,338	16.98	36.56	217.37	17,473
Sussex	3,065	5,360	41,412	2,091	9.95	18.50	112.89	7,548
Total	**10,564**	**21,341**	**160,761**	**8,835**	**32.37**	**69.03**	**396.87**	**29,909**

Table 5-15. 2002 Statewide Annual VOC, NO_x, and CO Emissions and VMT for On-road Mobile Sources by Vehicle Type

Vehicle Type	Annual (TPY)			VMT
	VOC	NO_x	CO	10^6 miles
Light-duty Gasoline Vehicles	5,539	5,789	80,118	4,371
Light-duty Gasoline Trucks	4,195	5,028	74,022	3,522
Heavy-duty Gasoline Vehicles	319	1,423	4,119	264
Motorcycles	116	71	576	44
Light-duty Diesel Vehicles	5	9	11	6
Light-duty Diesel Trucks	11	23	20	16
Heavy-duty Diesel Vehicles	379	8,996	1,896	613
Total	**10,564**	**21,341**	**160,761**	**8,835**

Table 5-16. 2002 Annual and SSWD VOC Evaporative and Exhaust Emissions by County

County	Annual (TPY)			SSWD (TPD)		
	Evaporative	Exhaust	Total	Evaporative	Exhaust	Total
Kent	569	1,169	1,738	2.11	3.34	5.45
New Castle	1,861	3,900	5,761	6.62	10.36	16.98
Sussex	1,029	2,036	3,065	3.80	6.15	9.95
Total	**3,459**	**7,105**	**10,564**	**12.53**	**19.85**	**32.37**

5.7 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, 1989: U.S. Environmental Protection Agency, "User's Guide to MOBILE4 (Mobile Source Emission Factor Model)," EPA-AA-TEB-89-01, Office of Mobile Sources, Ann Arbor, MI, February 1989.

EPA, 2000: U.S. Environmental Protection Agency, Emissions Modeling Clearinghouse, Weekly Profile File, http://www.epa.gov/ttn/chief/emch/temporal/, December 14, 2000.

EPA, 2002: U.S. Environmental Protection Agency, "Temporal Allocation of Annual Emissions Using EMCH Temporal Profiles," memorandum from Gregory Stella, Emission Factor and Inventory Group, April 29, 2002.

EPA, 2003: U.S. Environmental Protection Agency, "User's Guide to MOBILE6.1 and MOBILE6.2 – Mobile Source Emission Factor Model," EPA-420-4-03-010, Office of Transportation and Air Quality, Ann Arbor, MI, August 2003.

ERG, 2003: Eastern Research Group, Inc., "Draft National Mobile Inventory Model (NMIM) Base and Future Year County Database Documentation and Quality Assurance Procedures," prepared for U.S. Environmental Protection Agency, Office of Transportation and Air Quality by Eastern Research Group, Inc., Chantilly, VA, May 30, 2003.

NCDC, 2003: National Climatic Data Center, Data Set 9956 (DSI-9956), Datsav3 Global Surface Hourly Data, Asheville, NC 28801, January 6, 2003.

SECTION 6

NATURAL SOURCES

Emissions of ozone precursors from natural sources are included in the 2002 inventory to gain a more complete picture of emissions contributing to the formation of ground-level ozone. For Delaware, natural sources include biogenic source emissions (VOCs, NO_x, and CO) and NO_x emissions due to lightning. The wildfire category was included in the non-point section because most wildfires in Delaware are a result of human activities (i.e., untended fire, discarded cigarette butt, arson). Emissions for natural sources are reported under the following SCCs:

Table 6-1. SCCs for Natural Sources

SCC	Description 1	Description 3	Description 6	Description 8
2701000000	Natural Sources	Biogenic	Vegetation/Soils	Total
2740001000	Natural Sources	Miscellaneous	Lightning	Total

6.1 Biogenic Emissions

Biogenic source emissions result from biological activity and represent a significant portion of the natural source emissions. The biological activity of plants, especially trees, creates a significant amount of VOCs in Delaware. Microbial activity within soils is responsible for emissions of nitrogen-containing compounds, including nitrogen oxides (NO_x).

The U.S. Environmental Protection Agency developed 2002 monthly county-level biogenic emissions for the entire country (EPA, 2004) using the Biogenic Emissions Inventory System (BEIS) model, version 3.12 (EPA, 2003). EPA allowed states to accept the EPA estimates for purposes of satisfying the requirements of the Consolidated Emissions Reporting Rule (CERR). Delaware opted to accept EPA's estimate of biogenic emissions for Delaware for inclusion in the NEI. Delaware is also adopting these emissions for submission in this 2002 ozone SIP inventory. EPA's report on the estimation of biogenic emissions for 2002 is included in the supporting documentation accompanying this report.

EPA used land use data from the Biogenic Emissions Land Use Database (BELD3) as the primary activity data. Primary sources of data for BELD include the USDA Forest Service, USGS satellite data, and the Census of Agriculture from the U.S. Department of Commerce Bureau of Census. Land use is divided into four main categories: forest, urban forest, agriculture and other. Other categories consist of grassland, scrubland, rangeland, barren land, water and urban other (treated as barren).

EPA relied on 2001 meteorological data since 2002 data were not available at the time biogenic emissions were estimated.

The rate of biogenic emissions is highly dependent on the amount of biological activity, which is at its maximum in the summer and at its minimum in the winter. EPA did not calculate daily emissions for the peak ozone season. However, since EPA created monthly emission tables, AQMS calculated SSWD daily values by summing emissions for June, July and august and dividing by the number of days within the peak ozone season (92).

6.2 Lightning

Lightning is a source of nitric oxide (NO). Lightning forms NO through a high temperature reaction from the energy released during a lightning flash. Lightning can release about 10^5 Joules per meter (J/m), and produce temperatures of about 30,000 degrees Kelvin (°K). NO is in thermodynamic equilibrium with nitrogen and oxygen at temperatures above 2300°K, and as the heated air rapidly cools below 2000°K, NO becomes a steady-state species.

Activity for this category can be collected from commercial lightning detection networks, such as the National Lightning Detection Network operated by Vaisala (formerly Global Atmospherics Inc. of Tucson, AZ.) Global Atmospherics had the only national database for lightning strikes available for 2002. Since archived data is only available for a fee, AQMS has relied on an average annual lightning strike rate of one cloud-to-ground strike per km^2 per year provided by Bill Geitz of Global Atmospherics, with a network detection efficiency of 86% (Geitz, 1997). Mr. Geitz also stated that most of the strikes occur during the peak ozone season, and that using a value of 75% of the annual number of strikes would be a realistic estimate for calculating peak ozone season daily emissions. This information was used to develop 2002 emission estimates for NO_x from lightning.

When estimating NO_x emissions, the *EIIP*, *Volume V* (EPA, 1997) preferred method estimates NO production by assuming the frequency and type of lightning strikes, and the amount of energy released. The method derives emission estimates for cloud-to-ground (CG) flashes and intra-cloud (IC) flashes. The method relies on the following four assumptions:

1) Global production of NO by lightning is six Tg N/yr;

2) Global flash rate is 100 flashes/sec;

3) IC flashes occur approximately four times more frequently than CG flashes, a number which varies with latitude; and

4) CG flashes are approximately ten times more energetic than IC flashes.

The following emission factors have been developed based upon the above assumptions:

- CG flashes: $2.9 * 10^{26}$ molecules NO per flash; and
- IC flashes: $2.9 * 10^{25}$ molecules NO per flash.

In order to calculate emission estimates for this source, the emission factors are applied to activity for the inventory area taking into account any corrections to the activity measurements. The correction factor compensates for lightning flash detection network efficiency, including a lack of detection of IC flashes by the network.

The preferred method for estimating emissions from lightning requires the collection of activity level data on CG lightning flashes and determination of the study area's latitude. Activity for IC flashes is calculated from the CG activity. It is assumed that IC flashes occur about four times more frequently than CG flashes, and this ratio varies with latitude.

The equation to calculate emissions from lightning is as follows:

$$L_{NO} = AREA \times \left\{ \left(N_{CG} \times \left(1/E_{CG} \right) \times EF_{CG} \right) + \left[N_{CG} \times \left(1/E_{CG} \right) \times EF_{IC} \times \left(\frac{10}{1 + \left(\frac{\theta}{30} \right)^2} - 1 \right) \right] \right\}$$

where:

L_{NO} = NO emissions for lightning flashes in study area, molecules NO
$AREA$ = Square kilometers of study area (county, including waters of DE Bay)
N_{CG} = Number of CG flashes recorded by detection network (strikes/km^2 per year)
E_{CG} = Efficiency of the detection network
EF_{CG} = Emission factor of NO for each CG lightning flash (in molecules NO/flash)
θ = Latitude of the study area in degrees
EF_{IC} = Emission factor of NO for each IC lightning flash

6.3 Results

Table 6-2. 2002 Statewide Annual and SSWD VOC, NO_x, and CO Emissions for Natural Sources

SCC	Category Description	Annual (TPY)			SSWD (TPD)		
		VOC	NO_x	CO	VOC	NO_x	CO
2701000000	Biogenic	26,580	612	2,794	173.94	2.63	16.08
2740001000	Lightning	---	151	---	---	1.23	---
27xxxxxxxx	**Total : Natural Sources**	**26,580**	**764**	**2,794**	**173.94**	**3.86**	**16.08**

6.4 References

EPA, 1997. *Emission Inventory Improvement Program, Volume V: Biogenic Sources – Preferred and Alternative Methods*, EPA-454/R-97-004e, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., July 1997.

EPA, 2003. *Biogenic Emissions Inventory System (BEIS), Version 3.12*, a stand-alone module to the Sparse Matrix Operational Kernel Emissions (SMOKE) system, CHIEF website, November 17, 2003.

EPA, 2004. EPA-developed Biogenic Emissions for the 2002 NEI, U.S. EPA, Office of Air Quality Planning and Standards, Emission Factor and Inventory Group, Research Triangle Park, North Carolina, March 2004.

Geitz, 1997. Bill Geitz, Global Atmospherics, Inc., personal communication with John Sipple, Environmental Scientist of DNREC, Air Quality Management Section, May 2, 1997.

SECTION 7

QUALITY CONTROL/QUALITY ASSURANCE

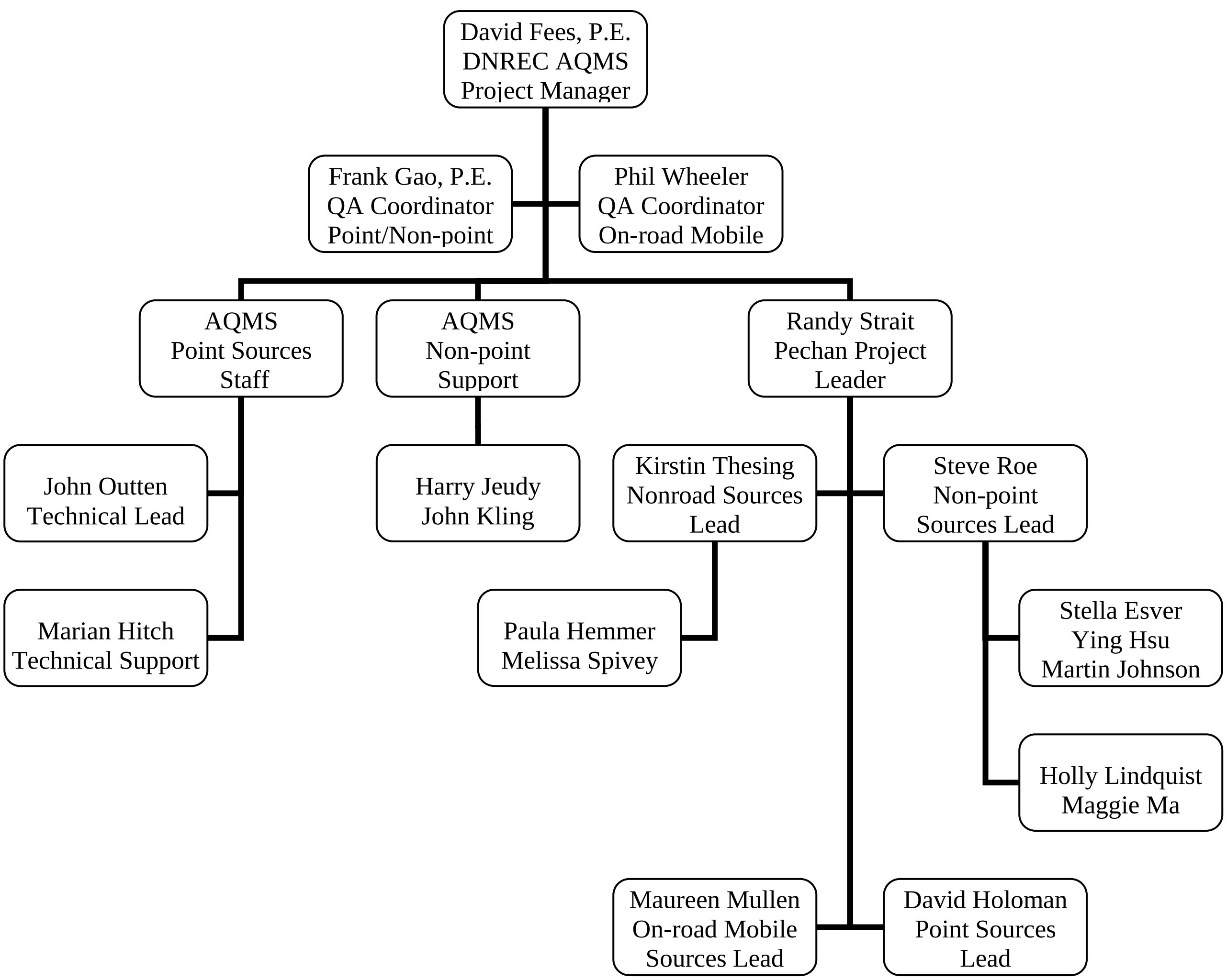
Quality control (QC) is a system of activities employed by the inventory development team to ensure the quality of the inventory in the course of its preparation. QC procedures include the use of approved emission estimation methodologies, technical reviews and data validations. Quality assurance (QA) is a system of review and audit that is conducted by personnel other than the inventory development team. The QA review assesses the effectiveness of the QC efforts and the completeness and accuracy of the inventory.

Quality control and quality assurance were conducted throughout the inventory development process and at multiple levels. This section of the report presents the QA/QC procedures established in the inventory preparation plans and how these procedures were executed.

7.1 Project Organizational Chart

The following chart provides the organizational structure established to develop the 2002 inventory. Responsibilities of key personnel are described in Section 1 of this report.

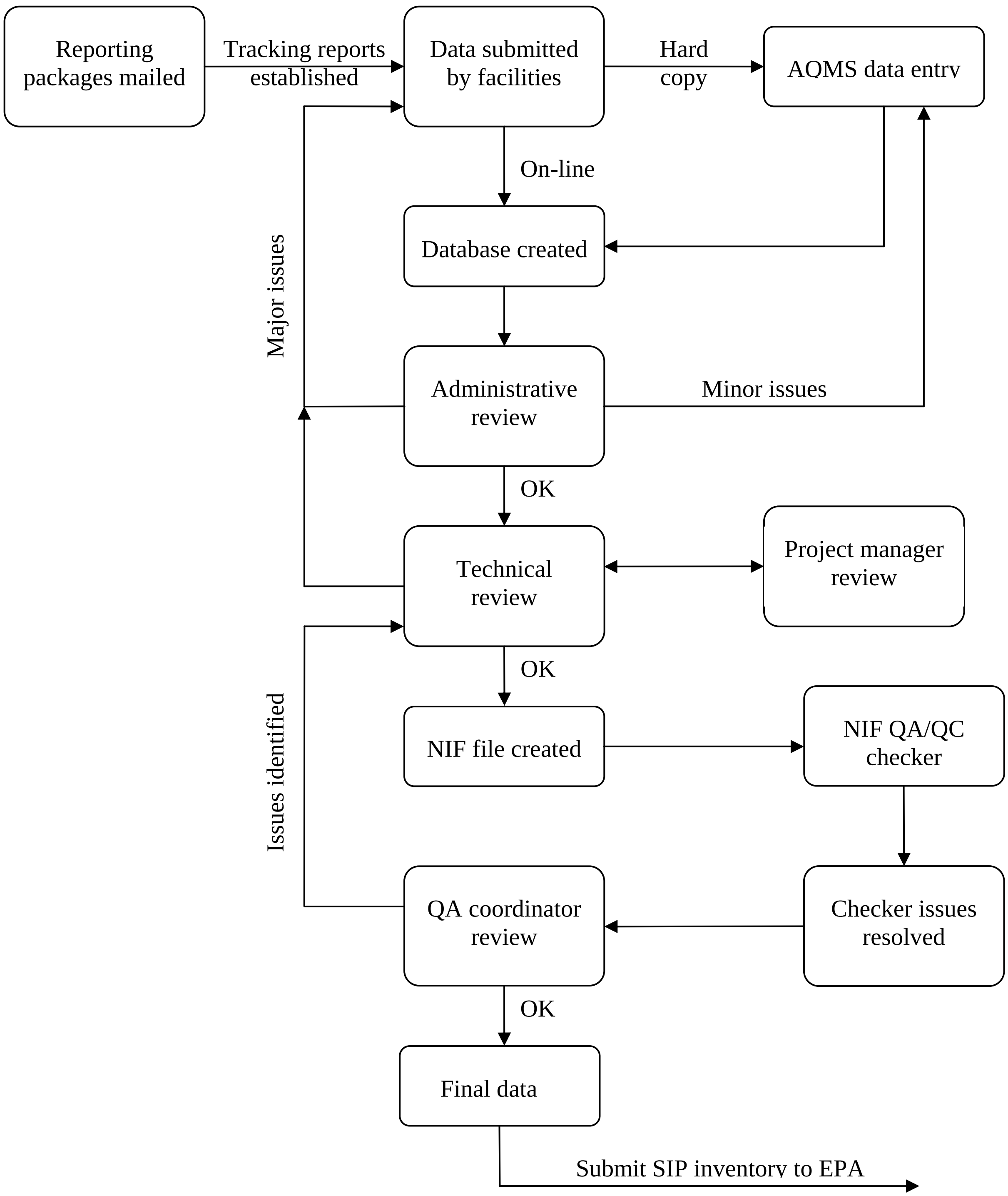
Figure 7-1. Project Organizational Chart



7.2 QA/QC for Point Source Inventory

The point source inventory was prepared by AQMS staff with assistance from Pechan after data were received from facilities. Figure 7-2 provides a data flow diagram employed for developing the point source inventory.

Figure 7-2. Point Source Inventory Data Flow Diagram



The AQMS point sources inventory staff followed up with every facility that received a reporting package until either the facility submitted inventory data or it was determined the facility did not need to report (either it did not operate in 2002 or did not meet the reporting criteria.) Therefore, 100% of Delaware facilities known to AQMS to meet the reporting criteria were successfully surveyed.

Next, staff reviewed all facility submissions through the use of the Administrative Completeness Determination checklist followed by a detailed technical review. Emissions data were compared to previous years' data to assess reasonableness and comparability. Data entered into the database by AQMS staff were spot checked by the technical lead. The technical review involved creating a detailed report from the database for each facility. The report allowed AQMS inventory staff to identify missing, suspicious or conflicting data. Any critical issues were identified and noted on the report. Corrections were made on the report as well as within the database. For QA purposes, the database automatically creates an audit trail of changes made.

Besides the detailed report, numerous database queries, reports and spreadsheets were created to identify information that appeared to be missing, in error, or inconsistent with other related information. The ozone season QA/QC report was generated for each facility to assist in analyzing ozone season daily emissions.

AQMS staff identified all EGUs that reported CEM data for NO_x to EPA's Emissions Tracking System (ETS). Staff compared 2002 emissions reported to ETS against emissions recorded in *i*-STEPS® and resolved several discrepancies between the two sets of data. ORIS facility codes are used by the EPA to identify EGUs in the NEI. Pechan identified ORIS IDs for Delaware facilities using in-house data it obtained from the U.S. Energy Information Administration. Pechan added the ORIS IDs in the NIF 3.0 site table since *i*-STEPS® does not contain a field to hold the ORIS ID.

Once all corrections were made to the data based on the technical review, the NIF files were created. EPA's QA/QC checker was used to verify the integrity of the NIF files. The checker was used to validate FIPS codes, SCCs, SIC codes, and North American Industry Classification System **(**NAICS) codes. The checker was also used to validate the following fields: actual throughput units, material, material input/output, emission factor units, emission numeric value units, seasonal throughput percentages, and operating time fields. These checks were completed periodically throughout the inventory development process. Any duplicate records, invalid codes, or missing data that are necessary to the NEI were flagged by the checker and addressed.

The technical lead periodically presented summaries of the point source inventory database to the project manager for review. Finally, once the technical lead and project manager deemed the inventory to be accurate and complete, the data were sent to the QA Coordinator for a final review.

Pechan augmented the QA/QC of the point source inventory in a number of ways. Pechan created a QA/QC tracking spreadsheet containing numerous issues that they would address in the course of developing the point sources inventory. The results of the QA/QC review and the final resolution of the issue were documented in the tracking spreadsheet. The tracking spreadsheet is provided in the supporting documentation contained on the CD accompanying this report.

Pechan reviewed emission factors to verify correct matching of emission factors and process SCCs. Emission factor values expressed in units other than SCC units were converted to match the SCC units. The conversion factors were documented and checked to ensure that they were correct and correctly applied.

Pechan evaluated MACT standard compliance status for all facilities known to be subject to one or more MACT standards. Pechan also analyzed TRI data, to identify emissions not reported to AQMS and to assess the accuracy of VOC emissions data that were reported.

Due to reported discrepancies by the Delaware Solid Waste Authority regarding amounts of landfill gas recovered being larger than estimated landfill gas generated, Pechan independently calculating emissions for the active landfills based on the latest models and site-specific data and assumptions.

Pechan supported AQMS in QA of the data in *i*-STEPS® using spot checks of data to identify data gaps and data codes that did not comply with NIF data coding specifications. Pechan reviewed throughput data to identify processes with emissions greater than zero but with missing actual throughput values. Pechan also analyzed the NIF PrimaryPCTControlEfficiency, PCTCapture Efficiency, and TotalCaptureControlEfficiency fields to identify potential inconsistencies between the fields. Pechan reported the results to AQMS who evaluated the results and corrected the errors.

Pechan verified that data collected from various data sources were correctly entered or transcribed into a common format. Pechan assisted AQMS point source staff with compiling emission factors and speciation data from several data sources into the *i*-STEPS® database management system. After the data were compiled into the database, the data were compared to the original data sources to verify that the data were correctly transcribed. Documentation of the sources of the data was verified to ensure the references for the data were documented correctly.

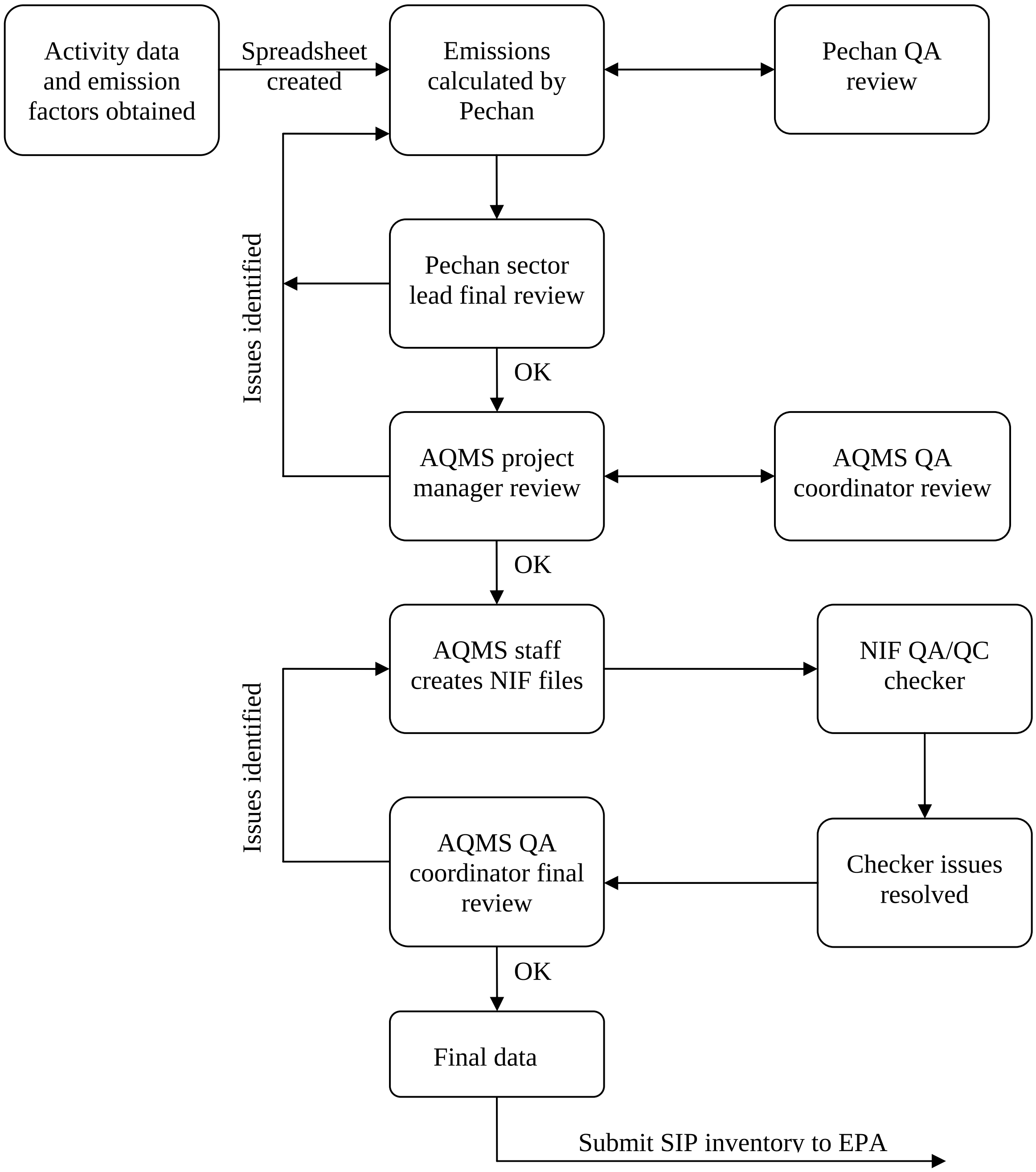
Regarding control equipment data, Pechan identified records with control efficiencies of less than one percent. AQMS investigated and corrected the data as needed (e.g., decimal values were converted to percentage values, if necessary). Pechan confirmed that emissions are zero for all processes that show the overall control efficiency (capture and control) as 100 percent for a given pollutant. AQMS confirmed that *i*-STEPS® is correctly accounting for and recording the overall control efficiency in the NIF for processes with multiple control devices.

After internal *i*-STEPS calculations were executed, AQMS generated a NIF transaction file. Pechan reviewed this file to verify that emissions had been calculated correctly and that the routine used to extract data from *i*-STEPS to NIF worked correctly. Pechan analyzed the emissions data for unexpectedly high values relative to other records in the inventory. For each pollutant, Pechan ranked emission records in descending order and reviewed the top records to identify any potential outliers.

7.3 QA/QC for Non-point and Non-road Inventory

The non-point and non-road sector inventories were prepared by Pechan with assistance by AQMS inventory staff in obtaining local activity data. AQMS was an integral part of the review process of these source sectors, as can be seen in Figure 7-3.

Figure 7-3. Non-point and Non-road Inventory Data Flow Diagram



AQMS and Pechan implemented multiple QA/QC activities during the development of the 2002 non-point and non-road inventory. These activities were conducted during inventory planning, data collection and analysis, emission calculations and the development of data files. Three levels of QA/QC activities were conducted during each phase of the project. The first level was conducted by Pechan who developed the emission estimates for non-point and non-road source categories. Pechan performed internal QA/QC checks employing senior staff to review the work performed by other members of the Pechan team. Results of the checks were documented in a QA/QC workbook contained within each source category spreadsheet. When issues were identified, the resolution of the issue was also documented in the spreadsheet. Once Pechan's final draft numbers were received by the AQMS inventory team a second level of QA/QC checks were performed on the data. Any errors identified by AQMS staff were brought to Pechan's attention for correction. Every source category was reviewed by AQMS inventory staff during this second level of QA/QC. The third level of QA/QC checks were conducted by staff of AQMS' Planning Branch not involved with the development of the inventory. AQMS' Planning Branch was considered an objective third party that had the technical skills to fully grasp the complexities of the inventory, but was removed enough from the methodologies and procedures that they could review the inventory in an objective manner.

The Inventory Preparation Plans (IPPs) for the non-point and non-road source sectors were developed by Pechan. AQMS was directly involved in the development of the IPPs and conducted a technical review of two draft versions and the final version. AQMS approved the methodologies to be used for each non-point and non-road source category. Data collection was conducted by both AQMS and Pechan. All 2002 activity data collected were compared to past inventories, where possible, to check for reasonableness.

Pechan performed numerous QA checks to the non-point and non-road data. The first QA review they performed involved a check of the emission factors presented in the IPP against the emission factors used in the calculation spreadsheets and the emission factors reported in the NIF files. Any discrepancy in factors was corrected. A check was also performed on the activity data in the spreadsheets and NIF files to verify they were in the correct units, as specified in the IPP. Pechan performed spot checks to verify that all data received was transcribed or compiled correctly. Any necessary assumptions or conversion factors were documented and reviewed before application to the activity data calculations. Spot checks on the calculations were performed (one for each SCC) to verify the results. Also, the control parameters, temporal allocation profiles, and spatial surrogates (as applicable) were checked to verify that they correspond to the values provided in the IPP. After being applied to the activity data or emissions, Pechan checked that the emission factors and temporal profiles were applied correctly by doing spot checks and sample hand calculations. For source categories that were geo-coded, Pechan plotted these in GIS to verify that sources fell within the appropriate county.

AQMS also performed extensive checks of the spreadsheets after receiving them from Pechan. Errors were brought to Pechan's attention, corrected by Pechan, and documented in the QA/QC workbook. For most source categories, at least three iterations of the calculation spreadsheets were developed based on the several levels of review.

In running the NONROAD model, the user must specify a modeling scenario by the inventory year, geographic area (nation, state, county), time period (annual, seasonal, monthly, daily), and the equipment categories. For all other required variables, the NONROAD model provides default input values. When the user prepares an input file (referred to in NONROAD as an "option file"), the model creates a corresponding ASCII text file. This file was printed so that the scenario inputs, as well as any default input values that were changed, could be reviewed for correctness.

Pechan created four NONROAD input files (fall, spring, summer, and winter) for each county. An additional option file to represent typical summer work weekday emissions was also prepared. Pechan reviewed all option files to ensure that the input values were correct. For those equipment categories where Pechan obtained State-specific or local data, Pechan replaced appropriate inputs in the model population and county allocation fraction files, and reviewed the updated files for accuracy before the model runs were performed.

After the model runs, Pechan checked each message file (.msg file) associated with an output file for errors. Pechan investigated all error messages, took corrective actions if necessary, and repeated the run. Once the output files were checked, an SCC-level, county-level emission summary was generated. Pechan performed spot checks to ensure that emission results seemed reasonable and matched the results obtained using the NONROAD reports.

Once the emission calculations were deemed accurate and complete, Pechan created NIF files. Pechan reviewed the NIF data files for duplicate records based on FIPs codes (state and county) and SCCs. Pechan ranked emission records in descending order and review the top records to identify any potential outliers. As an overall check, Pechan and AQMS reviewed State and SCC-level annual emissions summaries for reasonableness compared to previous inventories and emission estimates reported by other states in the Mid-Atlantic region.

AQMS applied the QA/QC checker to the non-point and non-road NIF files. The checker evaluated formatting and content of the NIF files. The checker also flagged duplicate records and performed integrity checks to verify the relationships between the five NIF tables. Any record violating the integrity check was analyzed and corrected. Range checks of the emission estimates are also performed by the checker. Each flagged out-of-range value was evaluated and corrected. If a flagged value was deemed correct, an explanation in a notes field was added to the checker output file to verify the appropriateness of the emission value despite being flagged by the range check. The outputs of the QA/QC checker are included in the source documentation accompanying this report.

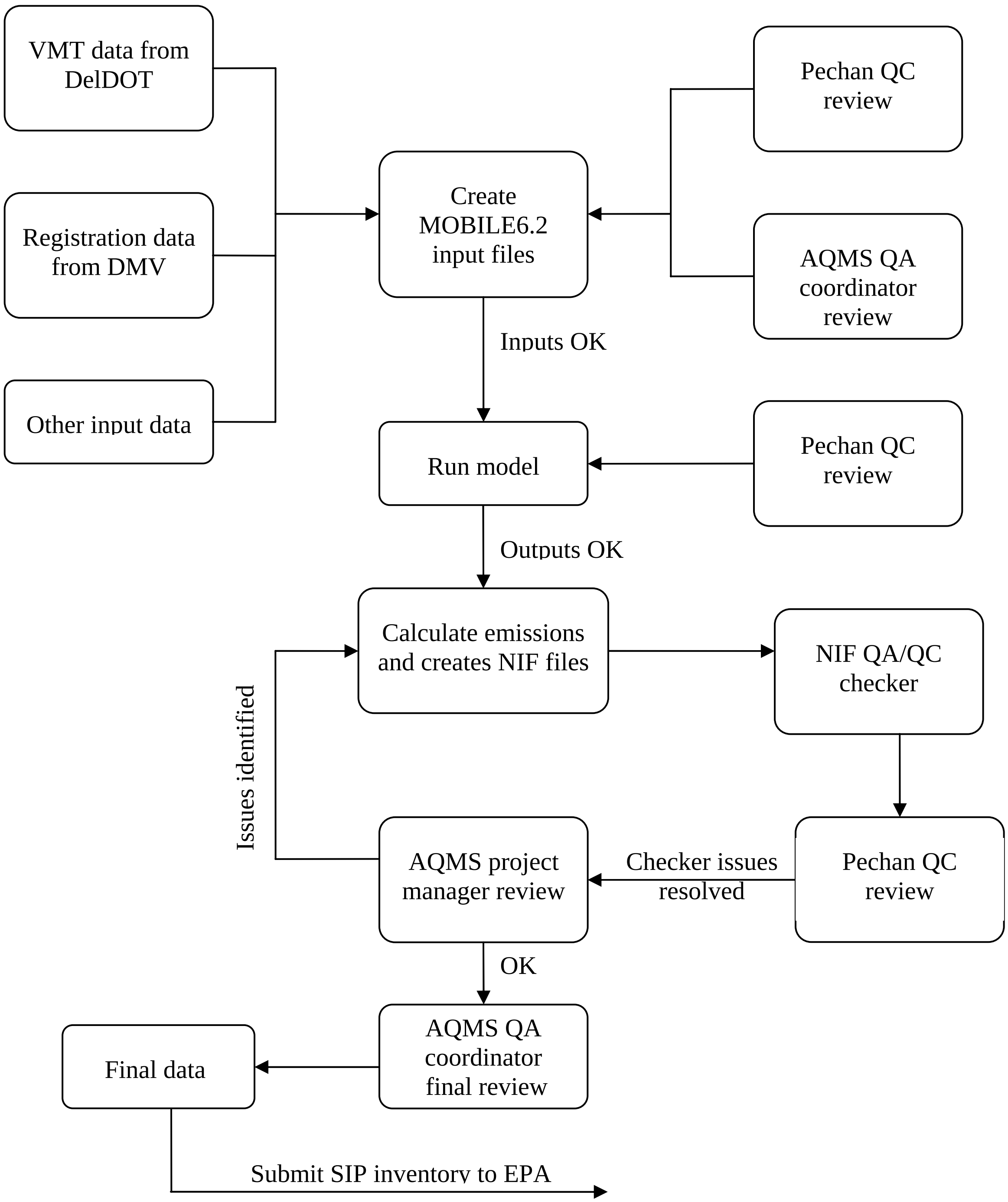
7.4 QA/QC for On-road Mobile Inventory

The on-road mobile inventory was prepared by Pechan with assistance by AQMS inventory staff in obtaining local activity data. Figure 7-4 provides a detailed data flow diagram for the development of the on-road mobile inventory.

To create MOBILE6.2 input files, Pechan prepared databases of the various input parameters, including temperature, fuel inputs, VMT mix data, registration data, and control programs such as inspection and maintenance (I/M) programs associated with each county in the inventory. Each of these input databases were compared to the original source of data and any differences flagged for review and corrected. These input parameters were then pulled into MOBILE6.2 input files using internal database programs. Once the MOBILE6.2 input files were generated, the data in the input files were compared to the data in the databases. Some of the specific checks performed are as follows: Does the temperature data in the MOBILE6.2 input file match the temperature database for the specific county? Is the fuel data incorporated with the correct temperature data? Are the correct external data files, such as registration distributions, being called in the input file? Is the full set of speeds needed modeled for each set of monthly parameters? Is the number of scenarios equal to the number of speed/roadway type combinations multiplied by the number of months or seasons being modeled?

Once the input files were run by MOBILE6.2 and output files created, the following checks were made: Is the number of output files of each type (TB1, TAB) equal to the number of input files? Are all of the TB1 output files of the same size? Do all output files have the same number of scenarios as the input files? Were any error messages generated by MOBILE6.2? For those outputs that did not meet the specified tests, the input files were examined for potential errors and rerun once corrected.

Figure 7-4. On-road Mobile Inventory Data Flow Diagram



All processing of VMT data was checked to ensure the VMT totals remained the same regardless of the level of aggregation or disaggregation of the data. The VMT data were summed at several levels of detail for review. These include VMT totals by functional roadway class and county. These totals were compared to the 2002 Highway Performance Monitoring System (HPMS) county-level functional class VMT provided by DelDOT. After Pechan broke out the VMT data by vehicle class, the VMT data were totaled by vehicle class and the resulting VMT fractions based on these totals were compared to the VMT fractions used to split out the VMT by vehicle type.

For each pollutant, the county-level emission estimates for 12 months were summed to estimate annual emissions. Pechan then back-calculated emission factors for each pollutant by dividing the annual emissions by the annual VMT at the county level and converted to grams per mile. These estimated emission factors were compared to the range of emission factors produced by MOBILE6.2 to ensure that the overall emission factors are of the correct magnitude. Hand calculations were performed on a number of the individual emissions to ensure that the emission calculation programs were working correctly. Pechan checked the overall emissions by pollutant and vehicle type for reasonableness in relation to one another (e.g., VOC emissions highest for gas vehicles, and NO_x highest for heavy-duty diesel vehicles, etc.). The magnitude of the daily seasonal emissions was also compared to the annual emissions to ensure that the magnitude of the daily emissions multiplied by 365 is the same relative magnitude as the corresponding annual emissions.

As an overall check, Pechan and AQMS reviewed State and SCC-level annual emission summaries. Pechan compared emissions to the on-road emission inventory calculated by Pechan for the preliminary 2002 on-road NEI and verified that emissions as reported by State and by SCC were reasonable and expected for 2002.