Appendix D

2002 Emissions Inventory Methodology and Documentation, and Supplements A through E

2002 OZONE PRECURSOR EMISSIONS INVENTORY METHODOLOGY FOR THE DEVELOPMENT OF A REDESIGNATION REQUEST FOR A KENTUCKY 8-HOUR OZONE NONATTAINMENT AREA

AS REQUIRED BY THE CLEAN AIR ACT

FOR THE KENTUCKY PORTION OF THE CLARKSVILLE-HOPKINSVILLE 8-HOUR OZONE NONATTAINMENT AREA LOCATED WITHIN

(CHRISTIAN COUNTY)

Prepared by

THE KENTUCKY DIVISION FOR AIR QUALITY

Submitted by

THE KENTUCKY ENVIRONMENTAL AND PUBLIC PROTECTION CABINET

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1.0 BACKGROUND AND EMISSIONS SUMMARY

1.1 BACKGROUND

Kentucky has developed a 2002 ozone precursor emissions inventory to support the redesignation request for the Kentucky portion of the Clarksville-Hopkinsville 8-hour ozone nonattainment area (i.e., Christian County). The Clarksville-Hopkinsville area, which also includes Montgomery County, Tennessee, was designated nonattainment for the 8-hour ozone standard effective June 15, 2004, per an April 30, 2004, *Federal Register* notice. This document presents Kentucky's 2002 ozone precursor emissions inventory for Christian County, Kentucky. This inventory was developed based on EPA guidance, direct consultation with EPA personnel, and previous emission inventory development experience. The inventory includes reactive volatile organic compounds (VOC), oxides of nitrogen (NO_x), and carbon monoxide (CO) emissions for area, point, non-highway mobile, highway mobile and biogenic sources.

The point source inventory was developed using the Division's existing emissions inventory database (i.e., I-Steps). The existing I-Steps database was updated using questionnaires and annual surveys completed by the sources.

Nonattainment area population information for Kentucky is provided in Table 1-1. The data provided in Table 1-1 is vital to many emission calculation procedures used to develop the emissions inventory, particularly for area and nonroad mobile sources. This data is frequently referenced throughout this document.

TABLE 1-1
2002 POPULATION

Kentucky Portion of the Clarksville-Hopkinsville Ozone Nonattainment Area

COUNTY	AREA APPORTIONMENT FACTOR	TOTAL POPULATION	POPULATION APPORTIONMENT FACTOR	APPORTIONED COUNTY POPULATION
Christian	1.000	71,267	1.000	71,267
Total		**71,267**		**71,267**

1.2 EMISSIONS SUMMARY

In preparing this inventory, several other agencies contributed information to the Division necessary for completing emission calculations. The Kentucky Transportation Cabinet[1] provided information essential for completing the mobile emissions portion of this document. The Kentucky Economic Development Cabinet[2] and the State Data Center[3] provided valuable population information used primarily in the preparation of the area source inventory.

Within the nonattainment areas, VOC, NO_x, and CO emissions were calculated for point, area, nonroad mobile, onroad mobile and biogenic sources.

The Division's existing point source emissions inventory database (I-Steps) was used to produce point source information. This database is updated annually for Title V major and minor sources and on a varying schedule for other sources. A copy of the point source inventory survey is included as *Supplement A* to this appendix.

Area source emissions were generally calculated based on current population, employment, and commodity data. Population related information was provided by the State Data Center[3] and the Kentucky Economic Development Cabinet.[2]

Highway vehicle emissions were estimated by using Mobile6.2 generated emission factors and daily vehicle miles traveled (DVMT) estimates. DVMTs and speed information were obtained from the Kentucky Transportation Cabinet[1].

The VOC emissions calculated in this document are for those VOC emissions determined by EPA to be photochemically reactive. All identified nonreactive VOC emissions were addressed. Specifically, perchloroethylene emissions from dry cleaning and surface cleaning have been removed from the area source emissions found in this document.

A summary of the VOC, CO, and NO_x emissions in tons per summer day for the nonattainment area is provided in Table 1-2.

Point source emissions are described in Section 2 with supporting information provided in *Supplement A*. Section 3 documents the area source inventory process with supporting information in *Supplement B*. Non-highway mobile emissions are discussed in Section 4 with supporting information in *Supplement C*. Mobile source emissions are discussed in Section 5 with supporting information in *Supplement D*. Biogenic emissions are documented in Section 6 and *Supplement E*.

TABLE 1-2
SUMMARY OF 2002 EMISSIONS
(Tons Per Summer Day)

Kentucky Portion of the Clarksville-Hopkinsville Ozone Nonattainment Area

	MOBILE			AREA			POINT			NON-HIGHWAY MOBILE			BIOGENIC			TOTAL EMISSIONS##		
COUNTY	**VOC**	**CO**	**NOx**	**VOC**	**CO**	**NOx**	**VOC**	**CO**	**NOx**	**VOC**	**CO**	**NOx**	**VOC**	**CO**	**NOx**	**VOC**	**CO**	**NOx**
Christian	4.30	48.18	10.62	4.36	1.83	0.14	1.77	0.07	1.38	1.44	20.78	3.89	49.70	-	1.10	61.57	70.86	13.23
Total Emissions	**4.30**	**48.18**	**10.62**	**4.36**	**1.83**	**0.14**	**1.77**	**0.07**	**1.38**	**1.44**	**20.78**	**3.89**	**49.70**	**-**	**1.10**	**61.57**	**70.86**	**13.23**

Certain applicable federal VOC emission control measures are reflected in the 2002 emission

1.3 REFERENCES FOR SECTION 1

1. Kentucky Transportation Cabinet, Daily Vehicle Miles Traveled, 2002. Frankfort, Kentucky.

2. Kentucky Economic Development Cabinet, 2002 Kentucky Deskbook of Economic Statistics, Frankfort, Kentucky.

3. University of Louisville, State Data Center, 2002 Population Statistics, Louisville, Kentucky.

TABLE 1-3 LIST OF CONTACT PERSONS FOR THE KENTUCKY 2002 EMISSIONS INVENTORY

Kentucky Division for Air Quality 803 Schenkel Lane Frankfort, Kentucky 40601	Lead agency contact, overall inventory coordination and supervision	John Gowins (502) 573-3382
Kentucky Division for Air Quality 803 Schenkel Lane Frankfort, Kentucky 40601	On-Highway mobile and area source emissions and data activity levels	Joe Forgacs (502) 573-3382
Kentucky Division for Air Quality 803 Schenkel Lane Frankfort, Kentucky 40601	Point, area, biogenic, non-highway mobile, and on-highway mobile source emissions and data activity levels	Martin Luther (502) 573-3382

2.0 POINT SOURCES

2.1 INTRODUCTION AND SCOPE

This section documents the development of the 2002 point source emissions inventory for the Kentucky portion of the Clarksville-Hopkinsville 8-hour ozone nonattainment area, which includes Christian County. For the purpose of this inventory, point sources are defined as stationary commercial or industrial operations that emit 10 tons or more per year of volatile organic compounds (VOC) or 100 tons or more of nitrogen oxides (NO_x) or carbon monoxide (CO). Due to the lower cut-off size for VOC sources, the majority of point sources in the nonattainment area have VOC emissions; therefore, most of this section is dedicated to these sources. This point source inventory consists of actual emissions for 2002, and includes sources in the ozone nonattainment county.

Emissions from point sources are presented using two emission rate formats: annual (TYR) and daily (TSD) rates. Although not specifically required, annual emission rates are provided in order to assist the review agency and the public in performing comparison checks against the existing I-Steps[5] database. In addition, the annual emission rate identifies point sources impacting on the area.

The remainder of this chapter is divided three parts. Section 2.2 describes the approach used in developing and compiling the point source listing for the ozone nonattainment area. Section 2.3 presents an overall summary of the point source VOC, NO_x, and CO emissions. Section 2.4 lists the references used in preparing this section.

2.2 METHODOLOGY AND APPROACH

This section describes the methodology and approach used in developing information for the 2002 point source emissions inventory. The purpose for including this section is to provide sufficient detail to the review agency and the public to assist them in determining the adequacy of this inventory based on the most recent guidance. In addition, specific elements of the methodology and approach are being described in order to minimize the need for later clarifications.

The development activities for the 2002 point source emissions inventory were initiated in the spring of 2004. The approach used in compiling the point source listing and emissions data was based on guidance issued by the U.S. Environmental Protection Agency.[1,2]

As mentioned previously, the Kentucky Division for Air Quality (DAQ) was the agency

responsible for development of the 2002 emissions inventory. Data collection activities began in the spring of 2004. Since Kentucky already had an existing emissions database of air pollution sources in the state, a thorough review of this database formed the starting point for overall inventory development. A brief description of the methodology and approach used to accomplish these tasks is presented in the following subsections.

2.2.1 Review of Existing Database

The review of the Division's I-Steps[5] database allowed personnel to identify which sources in a given geographical area would need to be updated for this inventory effort. Also, a review of each source in the existing system provided information on whether specific sources had been updated during the normal yearly update or if they would need to be updated separately.

2.2.2 Source Survey

Point source emission surveys were mailed to appropriate point sources (*Please see related survey information provided in Supplement A*). The surveys were designed to have the facilities update specific information as outlined in EPA guidance. In some instances follow-up telephone calls were made to clarify responses given by sources.

2.2.3 Data Evaluation

The next step in developing the point source inventory was to evaluate the collected data. All information received from the sources was checked by emission inventory personnel to ensure that the responses were within reasonable levels.

Another aspect of data evaluation was the application of rule effectiveness for sources subject to regulatory emission limitations and a seasonal adjustment factor for facilities not operating on a uniform schedule. A factor of 80 percent was applied to the control device efficiency to adjust the resulting emission estimates to account for rule effectiveness. The rule effectiveness factor, pursuant to EPA Region 4 guidance,[3] was applied to VOC, CO, and NO_x annual emissions totals and is therefore also reflected in daily emissions. Seasonal adjustment was applied only to daily emission totals.

2.2.4 Data Compilation

One of the final steps in developing the point source inventory involves submitting the data in an acceptable format. Division personnel routinely submit point source data to EPA's National Emissions Inventory (NEI) database.

2.2.5 Emission Calculations

Point source emissions were calculated using the following equations and variables. *Supplement A* contains point source emissions information utilized to calculate the point source emissions (*Please see emissions information provided in Supplement A*). Information requested by a source to be confidential in accordance with applicable laws is omitted from *Supplement A*.

1. Control Efficiency Adjusted for Rule Effectiveness

CTEFFN = (1 - ((CTEFF)(RE))
CTEFFN = Actual Control Efficiency Adjusted for Rule Effectiveness
CTEFF = Actual Control Efficiency
RE = Rule Effectiveness = .80

2. Actual Process Rate for Typical Summer Day

CPROD
NPROD = ((FUELP) (ATHJ) / 100) / ((DWK) (WKYR) (.25))
VPROD

CPROD, NPROD, and VPROD = Actual Process Rate for Typical Summer Day for CO, NOx, and VOC, respectively

FUELP = (Actual) Annual Process Rate = Total Throughput
ATHJ = Summer Seasonal Activity
DWK = Number of Days Per Week Source is in Operation
WKYR = Number of Weeks Per Year Source is in Operation

3. Actual Emissions for Typical Summer Day

CATND
NATND = ((_PROD) (EF) (CTEFFN)) / 2000
VATND

CATND, NATND, and VATND = Typical Summer Day Emissions for CO, NOx, and VOC, respectively

_PROD = CPROD, NPROD, or VPROD as Appropriate

EF = Emission Factor

4. Annual Actual Emissions

CATNY
NATNY = ((FUELP) (EF) (CTEFFN)) / 2000
VATNY

CATNY, NATNY, and VATNY = Annual Emissions for CO, NOx, and VOC, respectively

FUELP = (Actual) Annual Process Rate = Annual Throughput

EF = Emission Factor

2.3 SUMMARY OF POINT SOURCE EMISSIONS

2.3.1 KENTUCKY PORTION OF THE CLARKSVILLE-HOPKINSVILLE, TN-KY, AREA

This inventory includes VOC, CO, and NO_x point source emissions for Christian County, Kentucky. County level point source emission totals are provided in Table 2-1. Additionally, Table 2-1 catalogues point source emissions by facility, by county, and provides a county total. This tables lists the facilities; the facility identification numbers; SIC codes[4], and the 2002 annual emissions, adjusted for rule effectiveness, in tons per year; and the 2002 daily emissions with seasonal adjustments, in tons per summer day.

Table 2-1 Kentucky Portion of Clarksville-Hopkinsville Area 2002 Point Source Emissions

COUNTY	FACILITY NAME	Plant I.D. #	SIC Code	VOC tpy	VOC tpd	CO tpy	CO tpd	NO2 tpy	NO2 tpd
CHRISTIAN	FREUDENBERG NONWOVENS LTD	21-047-00019	2297	11.94	0.03	5.6	0.02	4.7	0.02
CHRISTIAN	SUPERIOR GRAPHITE	21-047-00025	3295	0	0	0.48	0	476.74	1.32
CHRISTIAN	HQ 101ST AIRBORNE DIV	21-047-00030	9711	13.92	0.04	29.12	0.03	12.31	0.02
CHRISTIAN	VENTURE WESTERN MICHIGANN	21-047-00043	3714	283.09	0.84	5	0.01	1	0
CHRISTIAN	US TOBACCO MFG LP	21-047-00055	5194	45.62	0.23	0.28	0	3.84	0.02
CHRISTIAN	COPAR INC	21-047-00067	3714	48.79	0.19	0	0	0	0
CHRISTIAN	DANA CORPORATION	21-047-00069	3714	13.87	0.03	5.82	0.01	1.23	0
CHRISTIAN	F P INTERNATIONAL	21-047-00099	3086	125.84	0.34	0	0	0	0
CHRISTIAN	AG SPRAY EQUIPMENT, INC	21-047-00103	3523	17.12	0.07	0	0	0.04	0
			CHRISTIAN COUNTY TOTAL	**560.19**	**1.77**	**46.30**	**0.07**	**499.86**	**1.38**

2.4 REFERENCES FOR SECTION 2

1. U.S. Environmental Protection Agency. *Emission Inventory Requirements for Post-1987 Ozone State Implementation Plans.* EPA-450/4-88-019. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. December 1988.

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

3. Telecon. U.S. Environmental Protection Agency, Region 4, Ms. Yasmin Yorker, February 4, 1992, concerning rule effectiveness.

4. Executive Office of the President, Office of Management and Budget. *Standard Industrial Classification Manual.* Order no. PB 87-100012. National Technical Information Service, Springfield, Virginia 22161. 1987.

5. Kentucky Division for Air Quality's I-Steps Point Source Database for the Year 2002.

3.0 AREA SOURCES

3.1 INTRODUCTION AND SCOPE

This section documents the development of the 2002 area source emissions inventory for the Kentucky portion of the Clarksville-Hopkinsville 8-hour ozone nonattainment area (i.e., Christian County). Area sources include non-traditional sources whose emissions are too small to be treated as stationary point sources. The emissions documented in this section are presented on an annual basis and for a typical summer day during the ozone season.

Including this introduction and scope, Section 3 is organized into four other subsections. Section 3.2 describes the approach taken to estimate emissions from each source category. Section 3.3 provides a summary of the area source emissions in the nonattainment area. Information explaining the calculations used to derive the area source emissions is discussed in Section 3.4. The references used in developing the area source portion of the inventory are located in Section 3.5.

3.2 METHODOLOGY AND APPROACH

3.2.1 Source Category Identification

The majority of area source categories considered in this inventory were identified from *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I.*[1] In addition, the U.S. EPA's Emission Inventory Improvement Program (EIIP) guidance[26] was consulted and utilized where feasible. Emissions estimates for some area source categories are not included in the inventory. Agricultural and slash burning, snowmobiles, and orchard heaters are not commonplace in Kentucky and therefore do not warrant inclusion. Rationale for not including these categories is discussed later in this narrative.

3.2.2 Emission Estimation Approach

Generally, area source emissions are calculated using factors based on one of four criteria for the inventoried areas: (a) population (per-capita), (b) commodity consumption, (c) level-of-activity, or (d) employment. These calculations are further explained in Section 3.4.

3.3 SUMMARY OF AREA SOURCE EMISSIONS

Table 1-3 through 3-35 provides the inventory results for each category of area source emissions. Table 3-36 contains the contribution of each county for each area source category and provides a total for that portion located in Kentucky.

3.4 DISCUSSION OF THE AREA SOURCE CATEGORIES

Subsections 3.4.1 through 3.4.6 contain the descriptions for individual area source types and the methods used to calculate emissions for each. Calculations used to determine emissions are included within the narrative.

3.4.1. Gasoline Distribution.

Four categories are included under gasoline distribution: (a) Storage tank breathing losses; (b) Tank trucks in transit; (c) Tank truck unloading; and (d) Vehicle refueling. Vehicle refueling emissions are included in the Highway Mobile Source Inventory (Section 5) in the Mobile6.2 modeling runs.

Retail gasoline service station sales in 1997, for both the state and individual counties, were obtained from the 1997 *Economic Census Retail Trade* publication for Kentucky.[6] The 2002 taxable gasoline sales were only available for the state and were obtained from the Kentucky Revenue Cabinet's Motor Fuels Tax Section.[7] The 2002 statewide gasoline sales were segregated to the county level using 1997 retail trade sales information. 2,191.84 million gallons of gasoline were sold in Kentucky in 2002. Emission factors were obtained from Tables 5.2-5 and 5.2-7 of AP-42, Volume I.[2, 26]

To calculate the emissions of VOC from any of the sources noted above, it was necessary to determine the total sales, in gallons, of gasoline in the nonattainment area. Only the *Census Retail Trade* publication[6] lists county and state gasoline sales. Therefore, the percentage of county gasoline sales relative to the statewide gasoline in 1997 was calculated. State sales were obtained from Table 1 of the *Census Retail Trade* publication,[6] and county sales obtained from Table 3 of that document. This percentage was applied to the total state taxable gasoline sales in 2002 to determine county gasoline sales in 2002. After the county gasoline sales in 2002 were determined, specific methods were used to calculate the emissions of VOC from each of the categories listed. The calculations and

procedures described in EPA guidance,[1] were utilized. County-specific gasoline marketing data are shown in Table 3-1.

Table 3-1
Gasoline Marketing Data

County	2002 Gasoline Sales (1000 Gallons)
Christian	30,226

3.4.1.1 Storage Tank Breathing Losses

County gasoline sales were multiplied by the emission factor found in Table 5.2-7 of AP-42, Volume I.[2] Tons of VOC emissions per year were converted to tons per typical summer day in accordance with Section 5.9 of reference 1. The seasonal adjustment factor (SAF) was determined by adding the total gasoline sales for June, July, and August of 2002--then dividing that total by the total state gasoline sales for 2002. This dividend was then divided by 0.25 to determine the percentage of activity, which occurred during those months. The seasonal adjustment factor applied for the gasoline marketing was 1.079. The activity days per week were considered to be 7.

The calculations used to determine emissions from storage tank breathing losses are as follows.

$$TPY = \left(\frac{\text{County Sales}}{\text{(gallons)}} \times \frac{1.0 \text{ lbs.}}{1000 \text{ (gal)}} \right) \times \frac{1 \text{ ton}}{(2000 \text{ lbs})}$$

$$TSD = (TPY \times SAF) / (7 \times 52)$$

The emissions, by county, produced by storage tank breathing losses are shown in Table 3-2.

3.4.1.2 Tank Trucks in Transit

Since some gasoline is delivered to bulk plants rather than delivered directly to service stations from bulk terminals, the amount of gasoline transferred in any area may exceed the total gasoline consumption, due to the additional trips involved. Reference 1 makes the following statements relating to this matter:

Table 3-2
Summary of Emissions From
Gasoline Breathing Losses

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	15.11	0.04

"A nationwide average of roughly 25 percent of all gasoline consumed goes through bulk plants. Hence, gasoline distribution in an area could be multiplied by 1.25 to estimate gasoline transported." and

"Emissions from tank trucks in transit, however, will generally be minimal, in most areas. Hence, a great deal of effort is not warranted in making this adjustment."

Based on these statements, and in the absence of specific bulk plant throughput information, 2002 county gasoline sales were multiplied by 1.25 to obtain the total gasoline transported in 2002. Per EPA EIIP guidance[26], the midpoints of the typical AP-42 Table 5.2-5 emission factors for tank trucks or bulk tanks loaded with product and return with vapor were determined, combined, and applied to gasoline transported in each county to determine the emissions of VOC per year. The yearly emissions were then converted to tons per typical summer day. The seasonal adjustment factor used for tank breathing losses was 1.079. The activity days per week were considered 6. The calculation used to figure emissions from tank trucks in transit are as follows.

$$TPY = \left(\text{County Gas Sales (gallons)} \times 1.25\right) \times \frac{.060 \text{ lbs.}}{1000 \text{gals.}} \times \frac{1 \text{ ton}}{2000 \text{ lbs}}$$

$$TSD = (TPY \times SAF) / (6 \times 52)$$

The emissions, by county, produced by tank trucks in transit are provided in Table 3-3.

Table 3-3
Summary of Emissions From
Tank Trucks In Transit

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	1.13	0.00

3.4.1.3. Vehicle Refueling

The emissions for vehicle refueling have been calculated by Mobile6.2 and are included in the Mobile Source Emissions Inventory in Section 5, but are not listed separately.

3.4.1.4 Tank Truck Unloading

To calculate the emissions of VOC produced by tank truck unloading, the division performed a review of gasoline stations located in the ozone nonattainment area. The following assumptions were made.

For the ozone nonattainment area (i.e., Christian County) 90% of the gasoline throughput was subject to submerged filling and the remaining 10% of the gasoline throughput was subject to splash filling techniques.

Based on these assumptions, the fraction of gallons of gasoline throughput using each fill method was multiplied by the appropriate emission factors from Table 5.2-7 of AP-42, Volume I[2] to derive emissions. Rule penetration was implicitly applied by allocating the gasoline throughput for each fill method. The yearly emissions were converted to tons per typical summer day in accordance with Section 5.9 of Reference 1. The seasonal adjustment factor of 1.079 for gasoline marketing was applied. The activity days per week for tank truck unloading was 6.[1] The calculations used to determine emissions from this category are as follows.

Submerged Fill

$$TPY = \text{Apportioned ((County Sales (gallons))} \times .90 \times \frac{(7.3\ lbs.)}{1000\ gals} \times \frac{1\ ton}{(2000\ lbs)}$$

$$TSD = (TPY \times SAF) / (6 \times 52)$$

Splash Fill

$$TPY = \text{Apportioned ((County Sales (gallons))} \times .10 \times \frac{11.5 \text{ lbs.}}{1000 \text{ gals}} \times \frac{1 \text{ ton}}{2000 \text{ lbs}}$$

$$TSD = (TPY \times SAF) / (6 \times 52)$$

Total Tank Truck Unloading Annual Emissions = Submerged Fill Annual + Splash Fill Annual

Total Tank Truck Unloading Summer Daily Emissions = Submerged Fill Daily + Splash Fill Daily

The emissions, by county, produced by tank truck unloading are shown in Table 3-4.

Table 3-4
Summary of Emissions From
Tank Truck Unloading

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	116.67	0.40

3.4.1.5 Aircraft Refueling

Emissions from this category occur when vapor-laden air in a partially empty fuel tank is displaced to the atmosphere when the tank is refilled. The quantity of vapor displaced depends on the fuel temperature, fuel true vapor pressure, fuel molecular weight, aircraft fuel tank temperature and fuel dispensing rate. The most commonly used types of aircraft fuels in the United States fall into three categories:

- Jet kerosene, primarily used by commercial turbojet and turboprop aircraft,
- Jet Naphtha, used primarily by military aircraft, and
- Aviation Gasoline, primarily used by aviation reciprocating engines.

Based on federal guidance found in Volume I,[1] emissions from aircraft refueling were estimated by multiplying apportioned fuel sales data[32], for each type of aircraft by the corresponding calculated fuel emission factors. Local fuel sales were obtained by apportioning state-level fuel sales to airports based on flight activities (LTOs) reported in Kentucky Airport Master Records[30] compiled by the Kentucky Division of Aeronautics for general aviation aircraft and Airport Activity Statistics[31] for commercial aircraft. Emissions were calculated for *General Aviation Refueling* and for *Refueling*

with Jet Kerosene. Emissions for Jet Naptha, used in military aircraft, were not calculated because the Petroleum Marketing Annual 2002[32] did not list this type of fuel. However, the absence of emissions for jet naphtha refueling is not considered a significant problem since its true vapor measure is such that any calculated emissions would be negligible.

The calculated annual tons of VOC emissions were multiplied by a seasonal adjustment factor and then divided by the number of activity days per week, in this case 365. The seasonal adjustment factor for jet kerosene and for aviation gasoline is 1.10. The seasonal adjustment factor was obtained based on conversations with the airport officials. Annual fuel sales data provided in the Petroleum Marketing Annual 2002[21] was utilized to determine county-level fuel sales. Emission factors were developed using the following method, pursuant to Volume I guidance.[1]

$$EF = \frac{(12.46)(S)(P)(M)}{T}$$

where: EF = emission factor in pounds VOC per 1,000 gallons fuel throughput

S = saturation factor of 1.45 (from Table 4.4-1 of AP-42)

P = fuel true vapor pressure in psia (from Table 4.3-2 of AP-42)
at 90°F = .021 psia for jet kerosene
at 90°F = 8.8 psia for aviation gasoline RVP 10

M = fuel molecular weight in lb/lbmol (from Table 4.3-2 of AP-42)
at 60°F for Jet Kerosene = 130
at 60°F for Aviation Gasoline RVP 10 = 66

T = study temperature in °R (°F + 460 degrees)

The calculations used to estimate emissions from aircraft refueling are as follows.

TPY = EF x Apportioned County Fuel Sales

TSD = (TPY x SAF) / 365

The VOC emissions, by county, from aircraft refueling are found in Tables 3-5 and 3-6. Airport information used to calculate these emissions are located in Table 3-7.

Table 3-5
Summary of Emissions From
General Aviation Refueling

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	0.27	0.00

Table 3-6
Summary of Emissions From
Commercial Aircraft Refueling

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	0.00	0.00

Table 3-7
Aircraft Fuel

County	Commercial Jet Fuel (1000 Gallons)	General Aviation Gasoline (1000 Gallons)
Christian	115	28

3.4.1.6 Petroleum Vessel Loading & Unloading

This category is included in the Point Source Inventory, Section 2.

3.4.2 Stationary Source Solvent Evaporation

The following eight subcategories are included in this area source category. All of these emit Volatile Organic Compounds (VOCs) because of their solvent usage. They are:

(1) Dry Cleaning;

(2) Surface Cleaning;

(3) Surface Coating;

(4) Graphic Arts;

(5) Cutback Asphalt Paving;

(6) Pesticide Applications; and,

(7) Commercial/Consumer Solvent Use.

Each of the previous-mentioned subcategories is discussed individually in the following subsections.

3.4.2.1 Dry Cleaning

Dry cleaning operations vary in size, type of service, and type of solvent used. Industrial, commercial, and self-service facilities clean not only personal clothing, but also uniforms, linens, drapes, and other fabric materials. These three types of dry cleaning facilities correspond to the Standard Industrial Classification (SIC) Codes of 7218, 7216, and 7215, respectively.

Dry cleaning involves the use of organic solvents -- petroleum-based solvents (blends of paraffinic, naphthalenic, and aromatic compounds), chlorinated hydrocarbons, but primarily tetrachloroethylene (perchloroethylene).

VOC emissions vary with the type of process and solvent used. The major source of VOC emissions is the hot air tumble process of drying solvent-soaked garments. Fugitive losses occur from valves, flanges, and seals as a result of poor maintenance.

Federal guidance[1] provided the methodology used for calculating the VOC emissions for this area source category. The methodology involves multiplying the following per capita VOC emission factors by an area's population to estimate the dry cleaning emissions:

Dry Cleaning (total): 1.8 lb/capita/yr

Coin Operated plants: 0.009 lb/capita/yr

Mineral Spirits & other solvent facilities: 1.1 lb/capita/yr

Commercial/Industrial dry cleaning : 0.73 lb/capita/yr

Population statistics for the counties examined were obtained from information provided by the Kentucky State Data Center[3,4] and are found in Table 3-8.

Table 3-8
Area Population Information

County	Population Apportionment Factor	2002 Population
Christian	1	71,267

Annual tons of VOC were calculated by multiplying the per capita emission factor by the county population. Rule penetration is implicitly applied by using the distinct per capita emission factors for each type of dry cleaning facility.

Emissions per typical summer day for this area source category were calculated using federal guidance.[1] The calculated annual tons of VOC emissions were then divided by the product of the number of activity days per week and the number of weeks in a year. For dry cleaning, no seasonal adjustment factor was applied since activity was considered uniform year round and the activity days per week was 5.

The calculations for this category are as follows:

$$TPY = ((EF_{Coin\ Op} \times population) \times \frac{1\ ton}{2000\ lbs}) + ((EF_{Other\ Solvents} \times population) \times \frac{1\ ton}{2000\ lbs}) + ((EF_{Industrial/Com.} \times pop) \times \frac{1\ ton}{2000\ lbs})$$

$$TSD = TPY / (5 \times 52)$$

Per previous EPA guidance[27], since emissions for coin operated and commercial/industrial dry cleaning are considered to be nonreactive (i.e., perchloroethylene emissions) only other solvent emissions are reflected in the VOC emissions provided for dry cleaning. Emissions from dry cleaning activities are provided for individual counties in Table 3-9.

Table 3-9
Summary of Emissions From Dry Cleaning

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	39.20	0.15

3.4.2.2 Surface Cleaning

Surface cleaning or degreasing is a physical method of removing grease, wax, or dirt from metal, glass, and fabric surfaces by exposing the material to an organic solvent. Degreasing activity is one of the many production steps associated with industrial categories involving metal furniture, primary metals, fabricated products, machinery, electric equipment, and instrumentation. In addition, there are many miscellaneous degreasing operations associated with auto repair shops, gasoline stations, and maintenance shops. There are three types of degreasers: small cold cleaners, open top vapor degreasers, and conveyorized vapor degreasers.

Surface operations, which include cold cleaning, manufacturing, and vapor in-line cleaning and others use organic solvents as room temperature liquids. Uses include wiping, spraying, or dipping parts in the solvent. In open top vapor degreasing, cleaning takes place by exposing the part to solvent vapor. Conveyorized vapor degreasing entails the same activity as open top degreasing except that the parts to be cleaned continuously move in and out of the degreaser.

Federal guidance[1] provided the methodology the division used for calculating VOC emissions for this area source category. It involves multiplying the following per capita VOC emission factors by an area's population to estimate total surface cleaning emissions. Per EPA guidance[28], to avoid double counting, point source degreasing emissions were subtracted from the area source surface cleaning VOC emissions as appropriate.

Surface Cleaning Total: 4.3 lb/capita/yr
- Cold Cleaning
  - Auto Repair: 2.5 lb/capita/yr
  - Manufacturing: 1.1 lb/capita/yr
- Vapor & In-Line Cleaning
  - Electronics & Electrical : 0.21 lb/capita/yr
  - Other: 0.49 lb/capita/yr

Emissions per typical summer day for this area source category were calculated using section 5.9 of the federal guidance document.[1] The calculated annual tons of VOC divided by the product of the number of activity days per week and the number of weeks in a year. For surface cleaning, as found in Table 5.8-1,[1] no seasonal adjustment factor was applied since activity was considered uniform year round and the activity days per week was 6.

Emissions were calculated using the following method.

Cold Cleaning
Auto Repair
$$TPY = ((EF \times population) \times \frac{1\ ton}{2000lbs}) * .77^{29} \quad --- \quad TSD = TPY / (6 \times 52)$$

+

Cold Cleaning
Manufacturing
$$TPY = ((EF \times population) \times \frac{1\ ton}{2000lbs}) * .77^{29} \quad --- \quad TSD = TPY / (6 \times 52)$$

+

Vapor & In-Line
$$((EF \times population) \times \frac{1\ ton}{2000lbs}) * .77^{29} \quad --- \quad TSD = TPY / (6 \times 52)$$

Area Source Surface Cleaning VOC Emissions (TSD) = TSD – Pt. Source Surface Cleaning VOC Emissions[28]

Per EPA guidance[29], perchloroethylene emissions have been removed from the surface cleaning emissions by reducing the emissions by 23 percent. Surface cleaning emissions are provided for individual counties in Table 3-10. Population information is provided in Table 3-8 and perchloroethylene removal and double counting information for surface cleaning is provided in *Supplement E.*

Table 3-10
Summary of Emissions* From
Surface Cleaning Operations

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	116.98	0.38

*Perchloroethylene emissions have been removed from the surface cleaning emissions by reducing the emissions by 23 percent per EPA's May1993 Helms guidance memorandum[29].

3.4.2.3 Surface Coating

Surface coatings include paints, enamels, varnishes, lacquers and other product finishes. All of these products include either a water-based or solvent-based liquid carrier, which generally evaporates in the drying or curing process.

VOC emissions result from the evaporation of the paint solvent and any additional solvent used to thin the paint. Substantial emissions also result from the use of solvents in cleaning the surface prior to painting and in cleaning painting equipment after use.

Surface Coating operations are separated into two groups, industrial and nonindustrial. Industrial surface coating operations for such products as appliances, automobiles, paper, fabric and cans are included in the point source inventory. Non-industrial surface coating includes refinishing of automobiles, architectural coating, and traffic paints and are inventoried as area sources.

3.4.2.3.1 Architectural Surface Coating

Architectural surface coatings, often called "trade paints," are used primarily by homeowners and painting contractors to coat the interior/exterior of houses and buildings and on the surfaces of other structures such as pavements, curbs, or signs. Coating materials are applied to surfaces by spray, brush, roller, and dry at ambient conditions. Architectural coatings differ from industrial coatings, which are applied to manufactured products and are usually oven cured. Painting contractors and homeowners are the major users of architectural coatings.

Federal guidance[1] provided the methodology the division used for calculating VOC emissions for this area source category. This methodology involves multiplying the following per capita VOC emission factor by an area's population to estimate the architectural surface coating emissions:

Architectural Surface Coating: 4.6 lb/capita/yr (Represents reactive VOC). Population statistics for all areas examined were obtained from the University of Louisville, Urban Data Center.[3,4] Solvent use, which accounts for 25 to 40 percent of all solvent loss associated with architectural surface coating, is included in this per capita factor. Solvents used in architectural surface coatings or thinning and cleanup contain almost 100 percent reactive compounds.

Emissions per typical summer day for this area source were calculated using Section 5.9 of Reference 1. The calculated annual tons of VOC were multiplied by an appropriate seasonal adjustment factor and then divided by the product of the number of activity days per week and the number of weeks in a year. For architectural surface coating the seasonal adjustment factor was 1.3 and the activity days per week was 7.[1]

The following calculation was used to estimate emissions from architectural surface coating.

$$TPY = (EF \times Population) \times \frac{1\ ton}{(2000\ lbs)}$$

$$TSD = (TPY \times SAF) / (7 \times 52)$$

Architectural surface coating emissions are provided in Table 3-11.

Table 3-11
Summary of Emissions From
Architectural Surface Coating

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	163.91	0.59

3.4.2.3.2 Automobile Refinishing

Automobile refinishing is the repainting of worn or damaged automobiles, light duty trucks, and other vehicles. Surface coating during manufacturing is not considered refinishing. In automobile refinishing, lacquers and enamels are usually sprayed in paint booths. Since vehicles contain heat sensitive plastics and rubber, the solvent borne coatings are used in low temperature ovens. Paint booths may be equipped with paint arresters or water curtains to handle overspray. Solvents used in auto body refinishing will consist almost entirely of reactive VOC.

Federal guidance[1] provided the methodology the division used for calculating VOC emissions for this area source category. This methodology involves multiplying the following VOC per capita emission factor by an area's population to estimate auto body emissions:

Auto Body Refinishing: 2.3 lb/capita/yr

According to federal guidance, because auto body refinishing may be generally expected to relate to human activity, such a population based approach will provide reasonable emission estimates for this area source category. Population statistics for all areas examined were obtained from state references.[3,4]

Emissions per typical summer day for this area source category were calculated using federal guidance[1]. The calculated annual tons of VOC divided by the product of the number of activity days per week and by the number of weeks in a year. For auto body refinishing no seasonal adjustment

factor was applied since the activity was considered uniform year round. The activity days per week was 5.

The calculations used to figure yearly and daily VOC emissions for this category are as follows.

$$TPY = (EF \times population) \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = TPY / (5 \times 52)$$

Auto body refinishing emissions are provided for individual counties in Table 3-12. Population information for individual areas is provided in Table 3-8.

Table 3-12
Summary of Emissions From
Automobile Refinishing

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	81.96	0.32

3.4.2.3.3 Traffic Markings

Traffic paints are used to mark pavement. These markings include dividing lines for traffic lanes, parking space markings, crosswalks, arrows, and other markings. These markings are usually applied by state or local highway maintenance crews or by contractors during road construction. VOC emissions result from the evaporation of organic solvents during and shortly after the application of the marking paint. Traffic paint emissions are included in the area source inventory the emissions are not from any specific plant, but instead emanate from the roadways and surfaces where markings are applied.

Federal guidance[1] provided the methodology the division used for calculating VOC emissions for this area source category. This methodology involves multiplying the following VOC per capita emission factor by an area's population to estimate traffic marking emissions.

Traffic marking: 0.5 lb/capita/yr

According to federal guidance, because traffic marking emissions may be generally expected to relate to human activity, such a population based approach will provide reasonable emission estimates for this area source category. The activity level was considered 5 days per week. No

seasonal adjustment factor was applied for this category since none was provided in Volume I guidance.

The calculations used to derive yearly and daily VOC emissions for this category are as follows.

$$TPY = (EF \times population) \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = TPY / (5 \times 52)$$

Traffic marking emissions are provided in Table 3-13. Population statistics for individual areas are provided in Table 3-8.

Table 3-13
Summary of Emissions From Traffic Markings

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	17.82	0.07

3.4.2.3.4 Other Small Industrial Surface Coating

Industrial surface coating includes the coating, during manufacture, of magnet wire, automobiles, cans, metal coils, paper, fabric, metal and wood furniture, and miscellaneous products. According to federal guidance,[1] to the maximum extent possible, small industrial surface coating operations should be treated as point sources. Therefore, the division will include small industrial surface coating emissions in the point source emissions inventory.

3.4.2.4 Graphic Arts

The graphic arts or printing industry consists of approximately 60,000 facilities (SIC 27) nationwide. About half of these establishments are in-house printing services in nonprinting industries. Printing newspapers, books, magazines, fabrics, wall coverings, and other materials, is considered a graphic arts application. Five types of printing are used in the industry: letterpress, flexography, lithography, (roto)gravure, and screen process printing.

Solvent use is an integral part of the process and is the primary source of VOC emissions.

Associated cleanup operations also require the use of solvents, thereby contributing to VOC emissions for the industry. All solvents used in the graphic arts industry are considered reactive.

Federal guidance[1] provided the methodology the division used for calculating VOC emissions for this area source category. This methodology involves multiplying the following per capita VOC emission factor by an area's population to estimate VOC emissions from graphic art facilities, which emit less than 100 tons:

Graphic Arts: 1.3 lb/capita/yr

In accordance with federal guidance,[1] any emissions associated with point source graphic arts facilities, which emit under 100 tons per year, should be subtracted from the area source inventory. Graphic arts emissions from point sources greater than or equal to 100 tons per year should not be subtracted, since they have already been excluded from the area source graphic arts emission factor of 1.3 lb/person/yr.

Population statistics for all areas examined were obtained from state references.[3,4]

Emissions per typical summer day for this area source category were calculated using federal guidance.[1] The calculated annual tons of VOC were then divided by the product of the number of activity days per week and the number of weeks in a year. For graphic arts no seasonal adjustment factor was applied since the activity was considered uniform year round and the activity days per week was 5.[1] Calculations for this category are as follows:

$$TPY = \left((EF \times Population) - Point\ Source\ Emissions \right) \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = TPY / (5 \times 52)$$

Graphic arts emissions are provided in Table 3-14. Population information is provided in Table 3-8.

Table 3-14
Summary of Emissions From Graphic Arts

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	46.32	0.18

3.4.2.5 Cutback Asphalt Paving

Cutback asphalt is a type of liquefied road surface that is prepared by blending or "cutting back" asphalt cement with various kinds of petroleum distillates. Cutback asphalt is used as a pavement sealant, tack coat, and as a bonding agent between layers of paving material. VOCs are emitted as the cutback asphalt cures and the petroleum distillates evaporate.

According to federal guidance,[1] because paving operations may be generally expected to relate to human activity, a population based approach will provide reasonable emission estimates for this area source category. The emission factor used for this category is as follows.

Cutback Asphalt Paving: 0.37 lb/capita/yr

The activity level was considered to be 5 days per week. The calculations for estimating emissions from this category are as follows.

$$TPY = (EF \times population) \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = TPY / (5 \times 52)$$

Cutback asphalt emissions are provided in Table 3-15. Population for individual counties is found in Table 3-8.

Table 3-15
Summary of Emissions From
Cutback Asphalt Paving

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	13.18	0.05

3.4.2.6 Emulsified Asphalt

Emissions from emulsified asphalts were not calculated. Any emissions from this category would have been negligible since emulsified asphalt is water based.

3.4.2.7 Pesticide Application

Pesticides broadly include any substances used to kill or retard the growth of insects, rodents, fungi, weeds, or microorganisms. Pesticides fall into three basic categories: synthetics, nonsynthetics (petroleum products), and inorganics. Formulations are commonly made by

combining synthetic materials with various petroleum products. The synthetic pest killing compounds in such formulation are labeled as "active" ingredients, and the petroleum product solvents acting as carriers or diluents for the active ingredients are labeled "inert." Neither of these toxicologic designations, active or inert, should be interpreted as indicators of photochemical reactivity; these designations refer only to their toxicological action.

The federal procedures document[1] described an emissions estimation process which requires the quantity and types of pesticides used in a study area. Contacts with both the Kentucky Department of Agriculture[8] and the University of Kentucky[9,10] revealed that such data is not available.

The Kentucky Division for Air Quality requested the use of an alternative method on September 30, 1989.[11] Since the largest single source of pesticide use is through agricultural application, the alternative method links pesticide application to harvested acreage. Utilizing the alternative method, VOC emissions were determined by multiplying an emission rate of two pounds of VOC per harvested acre by an area's 2002 harvested acreage.[25] The product was then multiplied by a factor of 0.9 to approximate the amount that evaporated and can be considered photochemically reactive VOC. This alternative method was approved by the U.S. EPA, Region 4 on November 7, 1989.[12] The yearly emissions were then converted to tons emitted per typical summer day in accordance with Section 5.9 of reference 1. The seasonal adjustment factor was 1.3, and the activity days per week was 6. The calculations for estimating emissions for this category are as follows.

$$TPY = ((\underset{Acres}{Harvested} \times \underset{Factor(lbs)}{Emission}) \times 0.9) \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = (TPY \times SAF) / (6 \times 52)$$

The emissions, by county, produced by pesticide application are shown in Table 3-16. 2000 harvested acre information[25] used to calculate emissions for this category are found in Table 3-17.

Table 3-16
Summary of Emissions From Pesticide Application

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	188.17	0.78

Table 3-17
Harvested Acres

County	2002 Harvested Acres
Christian	209,075

3.4.2.8 Commercial/Consumer Solvent Use

Many commercial/consumer products in common use contain VOCs. Some examples are household and automobile cleaners and polishes. These products have varying VOC content and the quantities used are difficult to estimate; therefore, the resulting VOC emissions are considered to be an area source.

EPA guidance[26, 1] provided the methodology the Division used for calculating the VOC emissions for this area source category. This methodology involves multiplying the following per capita VOC emission factor by an area's population to estimate commercial/consumer solvent use emissions.

Commercial/Consumer Solvent Use: 7.84 lb/capita/yr

The above EPA EIIP[26] per capita emission factor includes emissions from household products (cleaners, laundry detergents); personal care products (e.g., toiletries, aerosol products); automotive aftermarket products (e.g., rubbing compounds, windshield washing fluids, polishes and waxes); non-industrial adhesives and sealants; pesticide products (home or business); and miscellaneous products.

Population statistics for all areas examined were obtained from state references.[3,4] Emissions per typical summer day for this area source category were calculated using a federal guidance document.[1] The calculated annual tons of VOC was divided by the product of the number of activity

days per week and the number of weeks in a year. For commercial/consumer solvent use, no seasonal adjustment factor was applied since activity was considered uniform year round and the activity days per week were 7. The calculations for estimating emissions from this category are as follows.

$$TPY = \underset{(lbs)}{(EF \times Population)} \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = TPY / (7 \times 52)$$

Commercial/Consumer solvent use emissions are provided for individual counties in Table 3-18. Population information for individual areas is provided in Table 3-8.

Table 3-18
Summary of Emissions From
Consumer Solvent Usage

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	279.37	0.77

3.4.3 Waste Management Practices

The handling and management of solid and liquid waste depends on such factors as the type of waste generated and the form and composition of the waste. The following methods of waste disposal were examined in this inventory:

(1) Publicly Owned Treatment Works (POTW);

(2) Industrial Waste Water Treatment;

(3) Hazardous Waste (TSDFs);

(4) Municipal Landfills; and

(5) Solid Waste Incineration -- On-site Incineration and Open Burning

3.4.3.1 Publicly Owned Treatment Works

Federal guidance indicates that research has shown that approximately 85% of all volatile pollutants discharged to unacclimated wastewater treatment systems are stripped to the ambient air. Additionally, the concentration of volatile organic compounds found in POTW influent has been

shown to be directly proportional to the industrial contribution to a POTW.

Federal guidance[1] provided the methodology the division used for calculating the VOC emissions for this area source category. The methodology involves multiplying the following emission factor by the number of gallons of industrial wastewater discharged to a POTW: 1.1×10^{-4} (.000110 lbs. of VOC emitted per gallon of industrial wastewater discharged to a POTW.

The amount of industrial wastewater discharged to a POTW was obtained from the Kentucky Division of Water.[13]

Emissions per typical summer day for this area source category were calculated using federal guidance.[1] The calculated annual tons of VOC was multiplied by an appropriate seasonal adjustment factor and then divided by the product of the number of activity days per week and the number of weeks in a year. For POTW a seasonal adjustment factor of 1.4. was applied and the number of activity days per week were 7.

$$TPY = \underset{\text{Flow (gallons)}}{(\text{Industrial Wastewater}} \times \underset{\text{(lbs)}}{EF)} \times \frac{1\ ton}{(2000\ lbs)}$$

$$TPD = (TPY \times SAF) / (7 \times 52)$$

POTW VOC emissions are provided for Christian County in Table 3-19. Additionally, total industrial wastewater discharge information to POTW for the nonattainment area is provided in Table 3-20.

Table 3-19
Summary of Emissions From POTW

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	14.73	0.06

Table 3-20
Industrial Discharge Into POTW

County	POTW (Million Gallon Per Year)
Christian	0.73385

3.4.3.2 Industrial Wastewater

The first step in estimating emissions from this category was to determine what facilities should be treated as point sources. Radian provided guidance[19] on how to determine what sources should be treated as point sources and what sources could be inventoried as area sources. The County Business Patterns[5] was used to determine the number of facilities within a given SIC code and the number of employees by facility within that code. In order to determine the number of employees for a particular SIC code a conversion from the NAICS code to the SIC code was completed, since the county business patterns now uses the NAICS code.

Table 2 of Radian's guidance[19] provided the number of employees a facility would have to employ before the emissions for that facility would reach 10 tons or more. Based on the information provided in that table and a list of category types and SIC codes found in Appendix A of a Background Document for the Surface Impoundment Modeling System, Version 2,[20] a determination was made on which sources should be treated as point sources.

The majority of manufacturing sources within the nonattainment area was determined to be too small to have emissions of 10 tons per year. These facilities were therefore considered as area sources and their emissions calculated accordingly.

Once the larger sources (those with suspected emissions of 10 tons or greater) were pinpointed, a review of Kentucky's existing I-Steps database showed that wastewater emissions were included in the total plant emissions. Therefore, industrial wastewater treatment emissions for these sources are included in the point source inventory.

In order to calculate area source emissions for this category, the SIC employment figures from County Business Patterns[5] and Worst Case VOC Emissions from Table 2 of Radian's guidance[19] were used. Since County Business Patterns[5] does not list specific employment data, only ranges, mid-range employment figures were used to calculate emissions. Based on EPA guidance,[1] a seasonal adjustment factor of 1.2 was used and activity days per week were considered 7.

The calculations used to estimate emissions for area source industrial wastewater emissions are as follows:

$$TPY = EF_{tons} \times \text{employment data}$$

$$TPD = (TPY \times SAF) / (7 \times 52)$$

Employment data by SIC code and industrial category type can be found in Table 3-21 and in *Supplement E.* Emissions for the area source industrial wastewater category are located in Table 3-22.

Table 3-21
Manufacturing Employees By SIC Category
For Industrial Waste Water Emissions

County	Category	Emission Factor	Total Employees
Christian	NA	NA	NA

Table 3-22
Summary of Emissions From
For Industrial Waste Water Emissions

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	0.00	0.00

3.4.3.3 Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)

This is a relatively new inventory category. In view of the confusion, and resultant frustration, regarding emission estimates from TSDFs, the Division for Air Quality considered the allowance of one ton of VOC per year per facility in order to report *any* figures for the inventory. However, such a blind apportionment of emissions undermined the intent of the inventory.

Assistance had been requested from Radian, in performing emission calculations for this category. However, in a letter received from Steve McCary, U.S. EPA, Region 4 on November 12, 1992, sufficient guidance is not available to inventory emissions from TSDFs at this time. It is expected that most emissions from these sources will be reported in the point source inventory.

3.4.3.4 Municipal Landfills

VOC emissions are produced from municipal solid waste landfills by three mechanisms: volatilization, chemical reaction, and biological decomposition of liquid and solid compounds into

other chemical species. Based on EPA guidance,[1] since Kentucky has an average precipitation level over 23 inches, an emission factor of 13.6 tons of VOC per million tons of refuse in-place plus an additional factor of 2.6 tons per year. No seasonal adjustment was applied since this activity is considered uniform according to *Volume I* guidance.

The amount of refuse in-place at facilities located in the nonattainment area in Kentucky was obtained in a municipal solid waste survey developed by the Kentucky Division for Air Quality.[17]

The calculations used to estimate emissions from this category are as follows.

$$TPY = \text{tons of municipal solid waste} \times \frac{13.6 \text{ tons VOC}}{1{,}000{,}000 \text{ tons of waste}} \times (2.6)$$

$$TSD = TPY / (7 \times 52)$$

A summary of emissions for this category may be found in Table 3-23. The tons of solid waste impounded are found in Table 3-24.

Table 3-23
Summary of Emissions From Municipal Landfills

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	18.95	0.05

Table 3-24
Tons of Solid Waste In Municipal Landfills

County	Landfill Waste (tons)
Christian	536,048

3.4.3.5 Solid Waste Incineration

Solid waste may consist of any discarded solid materials from industrial, commercial, or residential sources. The materials may be combustible or non-combustible and are often burned to reduce bulk, unless direct burial is either available or practical.

The solid waste disposal category includes on-site refuse disposal by residential, industrial,

landscape refuse, or other refuse or rubbish. Open burning is the unconfined burning of solid waste material.

3.4.3.5.1 On-Site Incineration

A federal guidance document[1] provides waste generation factors to estimate the tons of solid waste burned in on-site incineration. The amount of waste incinerated by residential, commercial/institutional and industrial sources was multiplied by the appropriate VOC, NO_x, and CO emission factors obtained from a federal reference document.[2]

The waste generation factors for on-site incineration appropriate for Region 4 are: 4 tons per 1000 population per year for residential sources; 23 tons per 1000 population per year for commercial/institutional sources; and 395 tons per 1000 manufacturing employees per year for industrial sources. The emission factors applied for on-site incineration are: 1.7 for VOC, 60 for CO, and 11 for NO_x. The emission factors are in pounds of pollutant per ton of solid waste incinerated.

Population statistics and manufacturing employment information for all areas examined for on-site incineration were obtained from state references.[4,5] Emissions per typical summer day for this area source category were calculated using a federal guidance document.[1] The calculated annual tons of VOC were divided by the product of the number of activity days per week and the number of weeks in a year. For on-site incineration, no seasonal adjustment factor was applied since activity was considered uniform year round and activity days per week were 7. Calculations for estimating emissions from this category are as follows.

Residential

$$TPY = \left(\frac{4\ \text{Tons of waste}}{1000\ \text{pop.}} \times \text{county pop.}\right) \times EF\ (\text{lbs}) \times \frac{1\ \text{ton}}{(2000\text{lbs})}$$

$$TSD = TPY / (7 \times 52)$$

Commercial/Institutional

$$TPY = \left(\frac{23\ \text{Tons of waste}}{1000\ \text{pop.}} \times \text{county pop.}\ (\text{lbs})\right) \times EF \times \frac{1\ \text{ton}}{(2000\ \text{lbs})}$$

$$TSD = TPY / (7 \times 52)$$

TSD = TPY / (7 x 52)

Industrial

$$TPY = \frac{(395\ tons}{(1000\ mfg\ employees)} \times \#\ employees) \times \frac{EF)}{in\ mfg\ SICs\ 20\text{-}39\ (lbs))} \times \frac{1\ ton}{(2000\ lbs)}$$

TSD = TPY / (7 x 52)

On-site incineration emissions are provided for the ozone nonattainment area in Table 3-25. Manufacturing employee information for individual areas is provided in Table 3-26.

Table 3-25
Summary of Emissions From
On-Site Incineration

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	3.45	0.01	121.98	0.34	22.36	0.05

Table 3-26
Manufacturing Employee Population

County	2002 Manufacturing Employment (Employees)
Christian	5,424

3.4.3.5.2 Open Burning

A federal guidance document[1] provides waste generation factors to estimate the tons of solid waste burned in open burning. The amount of waste burned by residential, commercial/institutional, and industrial sources was multiplied by the appropriate VOC, NO_x, and CO emission factors obtained from a federal reference document.[2] The waste generation factors for open burning appropriate for Region 4 are: 450 tons per 1000 rural population per year for residential sources; 24 tons per 1000 rural population per year for commercial/institutional sources; and 160 tons per 1000 manufacturing employees per year for industrial sources. The emission factors applied for open burning are: 30 for VOC, 85 for CO, and 6 for NO_x. The emission factors are in units of pounds of

pollutant per ton of solid non-agricultural waste burned. For an example of how the above information is utilized for this area source category, please see 3.4.3.5.1 regarding on-site incineration.

Rural population statistics and manufacturing employment information for all areas examined for open burning were obtained from state references.[3,4]

Emissions per typical summer day for this area source category were calculated using a federal guidance document.[1] The calculated annual tons of VOC was then divided by the product of the number of activity days per week and the number of weeks in a year. For open burning, no seasonal adjustment factor was applied since activity was considered uniform year round and activity days per week was 7. Emissions for this category were calculated as follows.

Residential

$$TPY = \left(\frac{450 \text{ Tons of waste}}{1000 \text{ rural population}} \times \frac{\text{county pop.}}{}\right) \times EF) \times \frac{1 \text{ ton}}{(2000 \text{ lbs})}$$

$$TSD = TPY / (7 \times 52)$$

Commercial/Institutional

$$TPY = \left(\frac{24 \text{ Tons of waste}}{1000 \text{ rural population}} \times \frac{\text{county pop.}}{}\right) \times EF \times \frac{1 \text{ ton}}{(2000 \text{ lbs})}$$

$$TSD = TPY / (7 \times 52)$$

Industrial

$$TPY = \left(\frac{160 \text{ tons}}{1000 \text{ mfg employees}} \times \frac{\# \text{ employees in mfg SICs } 20\text{-}39}{}\right) \times EF \times \frac{1 \text{ ton}}{(2000 \text{ lbs})}$$

$$TSD = TPY / (7 \times 52)$$

Open burning emissions are provided for Christian County in Table 3-27. Manufacturing employee information is provided in Table 3-26 and rural population information is provided in Table 3-28.

Table 3-27
Summary of Emissions From
Open Burning of Solid Waste

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	151.92	0.42	430.44	1.18	30.38	0.08

Table 3-28
Rural Population

County	2002 Rural Population
Christian	19,520

3.4.4 Small Stationary Source Fossil Fuel Use

The category includes small boilers, furnaces, heaters, and other heating units too small to be considered point sources. A federal guidance document[1] indicates that it may not be worthwhile for an agency to perform the detailed procedures to calculate emissions for this entire fuel combustion category if: (1) its primary concern is updating the VOC inventory and (2) if an existing inventory already includes combustion. Since the division meets the aforementioned conditions it did not calculate emissions for this area source category.

3.4.5 Bioprocess Emissions Sources

Bioprocess emissions sources include those sources whose emissions result from biological processes (e.g. fermentation). Source categories include bakeries, breweries, distilleries, wineries, and silage storage.

3.4.5.1 Bakeries

The methodology used to estimate emissions from bakeries was prepared by Radian Corporation.[21] A review of *County Business Patterns*,[5] provided the number of bakeries listed under retail bakeries (SIC 546) and larger manufacturing bakeries (SIC 2051). For the purposes of this inventory, all bakeries in the county were considered area sources and their emissions were

calculated using Radian's guidance. A factor of .155 tons VOC/yr/1000 population was applied to county populations. This activity was considered uniform year round and activity days per week were 6.[1]

The calculations used to determine source emissions from this category are as follows.

$$TPY = \underbrace{\frac{.155\ tons}{(1000\ pop.)} \times population}_{\text{Area Source Emissions}} + \underbrace{\left(\left(\frac{lbs\ produced}{1000\ lbs} \times EF\right) \times \frac{1\ ton}{2000\ lbs}\right)}_{\text{Point Source Emissions}}$$

$$TSD = TPY / (6 \times 52)$$

Bakery emissions are shown in Table 3-29. Population information necessary for calculating these emissions is found in Table 3-8.

Table 3-29
Summary of Emissions From Bakeries

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	11.05	0.04

3.4.5.2 Breweries

A review of *County Business Patterns*[5] showed no breweries in the nonattainment area in Kentucky. Therefore, this category was not inventoried.

3.4.5.3 Wineries

Based on EPA guidance,[1] a review of *County Business Patterns*[5] showed no wineries located in the nonattainment area in Kentucky. Therefore, this category was not inventoried.

3.4.5.4 Distilleries

Emissions for this category are included in the point source portion of this inventory.

3.4.5.5 Silage Storage

EPA guidance[1] stated that this was not a required source category. Since emissions from silage would be typically during the winter months, this category was not inventoried.

3.4.6 Other Area Sources

Sources included in this category are miscellaneous combustion sources and leaking underground storage tanks.

3.4.6.1 Miscellaneous Combustion Sources

Several types of fires and burning activities potentially contribute to this subcategory. They are as follows:

(1) Forest Fires;

(2) Slash Burning and Prescribed Burning;

(3) Agricultural Burning;

(4) Structure Fires; and,

(5) Orchard Heaters.

The division calculated emissions for forest fires and structure fires. The remaining miscellaneous combustion activities were found not to be widespread in Kentucky and therefore were not addressed.

3.4.6.1.1 Forest Fires

A federal guidance document[1] provided the methodology the division used for calculating emissions for this area source category. This methodology involves estimating the amount of material consumed by multiplying the number of acres burned in each area examined by a fuel loading factor (i.e., material consumed per acre of land burned). A fuel loading factor of 6.6 tons of material consumed per acre burned and the number of acres burned in each area examined was obtained from the Kentucky Division of Forestry.[14] Appropriate emission factors from a federal reference document[2] are: 24 for Total Hydrocarbons (THC), 140 for CO, and 4 for NO_x. However, according to another federal reference document,[15] only 79.71 percent of the THC emissions derived from the above THC emission factor are reactive. Therefore, the VOC emission factor utilized for this area source category was 19.13. This VOC emission factor information is based on information derived from a federal reference document.[16] The emission factors are in units of pounds per ton of material burned.

Emissions per typical summer day for this area source category were calculated using a federal guidance document.[1] The calculated annual tons of VOC emissions was divided by the product of the number of activity days per week and the number of weeks in a year. For forest fires no seasonal adjustment factor was applied since activity was considered uniform year round and the activity days per week was 7. The calculations used to determine emissions from this category are as follows.

$$TPY = (\text{\# of Acres Consumed per County} \times \text{Tons of Growth per Acre consumed}) \times \frac{EF}{(lbs)} \times \frac{1\ ton}{(2000\ lbs)}$$

$$TSD = TPY / (7 \times 52)$$

Forest fire emissions are provided in Table 3-30. Additionally, acreage burned for individual areas is provided in Table 3-31.

Table 3-30
Summary of Emissions From Forest Fires

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	3.47	0.01	25.40	0.07	0.73	0.00

Table 3-31
Acreage Burned By Forest Fires

County	2002 Forest Fires Acres Burned
Christian	55

3.4.6.1.2 Structure Fires

Federal guidance[1] provided the methodology the division used for calculating emissions for this area source category. This methodology involves estimating the amount of material consumed by multiplying the number of structure fires occurring in each area examined by a fuel loading factor (i.e., material consumed per structure fire). A fuel loading factor of 6.8 tons of material consumed

per fire was provided in a federal guidance document[1] and information on the number of structure fires which occurred in Kentucky in 2002 was derived by assuming an average of 6 fires per 1000 population in an area in accordance with Volume I guidance. Based on federal guidance,[1] the emission factors applied are: 11 for VOC, 60 for CO, and 1.4 for NO_x. The emission factors are in units of pounds per ton of material burned.

Emissions per typical summer day for this area source category were calculated using federal guidance.[1] The calculated annual tons of VOC emissions were divided by the product of the number of activity days per week and the number of weeks in a year. For structure fires no seasonal adjustment factor was applied since activity was considered uniform year round and the activity days per week were 7. The calculations used to estimate emissions from this category are as follows.

$$TPY = \left(\frac{6\ fires}{1000\ pop.} \times population\right) \times \left(\begin{array}{c}6.8\ tons\ of \\ (material\ burned) \\ per\ fire\end{array}\right) \times \left(\begin{array}{c}EF \\ (lbs))\end{array}\right) \times \left(\frac{1\ ton}{2000\ lbs}\right)$$

$$TSD = TPY / (7 \times 52)$$

Structure fire emissions are provided in Table 3-32. The data used to calculate these emissions is located in Table 3-33.

Table 3-32
Summary of Emissions From Structure Fires

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	16.01	0.04	87.31	0.24	2.04	0.01

Table 3-33
Number of Structure Fires

County	Number of Structure Fires
Christian	428

3.4.6.1.3 Slash Burning and Prescribed Burning

Information received from the Kentucky Division of Forestry[22] revealed that these activities are not widespread in Kentucky and emissions for this category were not inventoried.

3.4.6.1.4 Agricultural Burning

Information received from the Kentucky Division of Forestry[22] showed that this is not a widespread practice in Kentucky and emissions for this category were not inventoried.

3.4.6.1.5 Orchard Heaters

The use of orchard heaters is not common in Kentucky. Therefore, this category was not inventoried.

3.4.6.2 Leaking Underground Storage Tanks

Leaking underground storage tanks typically do not become quantifiable sources of VOC air emissions until excavation and remediation efforts are initiated. Remediation efforts vary widely depending upon the type of contaminant, magnitude of the leak and the extent of groundwater contamination, if any.

Methodology developed by Radian Corporation[23] was used to derive emissions from this category. An emission factor of 28 lbs per remediation was used in estimating these emissions. Remediation information was obtained from the Division of Waste Management's Leaking Underground Storage Tank Branch.[24] Calculations to estimate emissions for a typical summer day from this category are as follows.

$$TSD = \#\ of\ Remediations\ x\ \frac{EF\ lbs}{Per\ Remediation}\ x\ \frac{1\ ton}{2000\ lbs.}$$

Emissions for this area source are located in Table 3-34. Remediation information used to calculate these emissions are located in Table 3-35.

Table 3-34
Summary of Emissions From
Leaking Underground Storage Tanks

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)
Christian	0.00	0.00

Table 3-35
Number of Remediations

County	Number of Remediations
Christian	0

Table 3-36
Summary of Area Source Emissions

Source Category	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian County						
Gasoline Breathing	15.11	0.04				
Gasoline Transit	1.13	0.00				
Total Gas Unloading	116.67	0.40				
Total Air Refueling	0.28	0.00				
Solvent Dry Cleaning	39.20	0.15				
Surface Cleaning Degreasing	116.98	0.38				
Architectural Surface Coating	163.91	0.59				
Auto Refinishing	81.96	0.32				
Traffic Markings	17.82	0.07				
Graphic Arts	46.32	0.18				
Cutback Asphalt Paving	13.18	0.05				
Pesticide Application	188.17	0.78				
Commercial/Consumer Use	279.37	0.77				
POTW	14.73	0.06				
Ind. Wastewater	0.00	0.00				
Municipal Landfills	18.95	0.05				

Source Category	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Total Onsite Incineration	3.45	0.01	121.98	0.34	22.36	0.05
Total Open Burning	151.92	0.42	430.44	1.18	30.38	0.08
Bakeries	11.05	0.04	0	0	0	0
Forest Fires	3.47	0.01	25.41	0.07	0.73	0.00
Structure Fires	16.01	0.04	87.31	0.24	2.04	0.01
Leaking Underground Storage Tanks	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total Area Emissions	**1,299.68**	**4.36**	**665.14**	**1.83**	**55.51**	**0.14**

3.5 REFERENCES FOR SECTION 3

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4.0 NON-HIGHWAY EMISSIONS

4.1 INTRODUCTION

This section documents the development of the 2002 nonroad emissions inventory for the Kentucky portion of the Clarksville-Hopkinsville 8-hour ozone nonattainment area (i.e., Christian County). Nonroad sources include motorized vehicles and equipment, which are normally not operated on public roadways to provide transportation. The study and regulation of nonroad emission sources were mandated by the Clean Air Act Amendments of 1990.

4.2 METHODOLOGY AND APPROACH

Nonroad emissions were calculated in accordance with EPA's Mobile Volume IV[1] and EPA's National Emissions Inventory (NEI) development guidance[5]. For this inventory, nonroad emissions have been divided into three categories. Separate emission categories include aircraft, locomotives, and other nonroad (i.e., Non-Highway) sources. Methodologies for each of these categories are discussed separately.

4.3 SUMMARY OF EMISSIONS

Table 4-1 summarizes the inventory results for the other nonroad (i.e., Non-Highway) source emissions. Tables 4-2 and 4-3 summarize emissions from aircrafts. Tables 4-5 and 4-6 summarize emissions from locomotives. Table 4-8 summarizes emissions from all non-highway mobile emission categories.

4.4 DISCUSSION OF NONROAD CATEGORIES

4.4.1 Other Nonroad (i.e., Non-Highway) Sources

Emissions for the other nonroad source categories (e.g., construction and agricultural equipment) were estimated using EPA's Nonroad Model (June 2000 version) in accordance with EPA Region 4 direction[6] and EPA's NEI guidance[5]. As for inputs for the nonroad model RVP and temperature information was provided in accordance with EPA Volume IV guidance[1] and EPA Region 4 direction[6] (*See Appendix E for more information on temperature determinations and*

Appendix G for nonroad model output and.)

The model provided county level ton per day (tpd) emission estimates for base year 2002 and for the projection years of 2004, 2007, 2010, 2013 and 2016. Where necessary county level emissions were allocated to a portion of a county as follows:

Portion of County Emissions = (Nonroad Model County Level Emissions * Fraction of Population in Portion of County)

The emissions for this category are provided in Table 4-1.

Table 4-1
Summary of Emissions
Other Non-Highway Mobile Sources

County	*Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	*Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	*Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	0.00	1.15	0.00	15.16	0.00	3.34

*Annual other non-highway emissions not provided.

4.4.2 Aircraft Emissions

Emissions from aircraft have been determined in accordance with EPA's Volume IV[1] and NEI[5] guidance for nonroad mobile sources. The basic methodology determines aircraft fleet make-up and level of activity and then calculates air pollutant emissions on an annual basis.

Preparing an emissions inventory for aircraft focuses on the emission characteristics of this source relative to the vertical column of air that ultimately affects ground level pollutant concentrations. This portion of the atmosphere, which begins at the earth's surface and is simulated in air quality models, is often referred to as the mixing zone. The aircraft operations of interest within this layer are defined as the landing and takeoff (LTO) cycle. The cycle begins when the aircraft approaches the airport on its descent from cruising altitude, lands, and taxis to the gate. It continues as the aircraft taxis back out to the runway for subsequent takeoff and climbout as it heads back up to cruising altitude. Thus, the five specific operating modes in a LTO are:

- Approach
- Taxi/idle-in
- Taxi/idle-out
- Takeoff
- Climbout

Most aircraft go through a similar sequence during a complete operating cycle. Helicopters may combine certain modes such as takeoff and climbout.

The LTO cycle provides a basis for calculating aircraft emissions. During each mode of operation, the aircraft engines operate at a fairly standard power setting for a given aircraft category. Emissions for one complete cycle for a given aircraft can be calculated by knowing emission factors for specific aircraft engines at those power settings. Then, if the activity of all aircraft in the modeling zone can be determined for the inventory period, the total emissions can be calculated.

4.4.2.1 Emissions for Commercial Aircraft

Commercial aircraft include those used for scheduled service transporting passengers, freight, or both. Commercial aircraft typically are the largest source of aircraft emissions. Although they makeup less than half of all aircraft in operation around a metropolitan area their emissions usually represent a large fraction of the total because of their size and operating frequency.

Pursuant to the EPA NEI guidance[5], a computerized database (i.e., FAA's Emissions Dispersion Modeling System (EDMS Version 4.12) was utilized to calculate emissions for commercial aircraft. The EDMS database was developed by the Federal Aviation Administration (FAA) (*Please see Appendix G for Emissions output from the EDMS model*). Annual average temperature inputs, for EDMS, were obtained from NOAA's 2002 Climatological Data Annual Summary for Kentucky. The EDMS model includes information on the engines mounted on specific aircraft with emission factors fro each of the engines, in addition to a menu-driven procedure for calculating aircraft emissions.

Pursuant to EPA's Volume IV guidance[1] and EIIP guidance[5], commercial LTO annual information was obtained from the FAA document entitled, *Airport Activity Statistics of Certificated Route Air Carriers for 2000*[3].

Seasonal Adjustment to Daily Emissions

Local airports in Kentucky's ozone nonattainment area were contacted by telephone to determine the airport activity levels during the 2002 summer quarter. Based on these contacts, the following seasonal adjustment factors were multiplied by the annual emissions (TYR) divided by 365 days of operation to determine typical summer day emissions (TSD). The seasonal adjustment factors for aircraft that were applied to the annual emissions are as follows:

Typical Summer Day Emissions (TSD) = (Annual Emissions (TYR) x Seasonal Adjustment Factor) / 365

The following seasonal adjustment factors (SAJ) were applied to annual emissions for commercial, general aviation, air taxis, and military aircraft landing at non-military airports:

Hopkinsville-Christian County Airport in Christian County, KY-	SAJ Factor of 1.10 for <u>all types of aircraft;</u>
Fort Campbell Military Airport in Christian County, KY-	SAJ Factor is unknown;

Converting from Total Hydrocarbons (THC) To Volatile Organic Compounds (VOC)

The U.S. EPA recognized that it may be necessary to determine the level of volatile organic compounds (VOC) emitted from aircraft engines. Since the emission factors for exhaust HC contained in this document represent total hydrocarbons (THC), the following illustrates the method that was recommended and utilized for converting THC to VOC emissions.

Commercial THC To VOC Conversions

Commercial aircraft fleets are dominated by turbine engines. Therefore, a single correction factor, pursuant to U.S. EPA Volume IV guidance[1], was utilized to convert THC to VOC emissions for commercial aircraft as follows.

$$VOC_{COMMERCIAL} = THC_{COMMERCIAL} \times 1.0947 \quad (5\text{-}14)$$

Total emissions for commercial aircraft operating in the ozone nonattainment area are included in Table 4-2 and *Appendix G*. Airport documentation (i.e., LTOs) used to calculate these emissions is provided in Table 4-4.

Table 4-2
Summary of Emissions From
Commercial Aircraft

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	0.65	0.00	3.85	0.01	1.66	0.01

4.4.2.2 Emissions for General Aviation, Air Taxis, and Military Aircraft Landing at Non-Military Airports

For the purpose of creating an emissions inventory, business aircraft are combined with general aviation aircraft because of their similar size, use frequency, and operating profiles. In this inventory methodology they are referred to simply as general aviation. Similarly, air taxis are treated much like the general aviation category because they are typically the same types of aircraft. Military aircraft landing at non-military airports are also inventoried and were addressed much like air taxi and general aviation aircraft.

Alternative, Fleet-Average Procedure

Pursuant to U.S. EPA Volume IV guidance[1], an alternative, fleet-average procedure was utilized to estimate emissions for general aviation, air taxi and military aircraft landing at non-military airports. This procedure involves multiplying the number LTOs for each type of aircraft by the following emission factors. Based on September and October 1992 telephone conversations with Joe Mangino, of the Radian Corporation, and Steve McCary, U.S. EPA Region 4, in the absence of fleet average emission factors for military aircraft landing at non-military airports air taxi factors were utilized. This is the same approach that EPA followed in preparing its 1999 National Emissions Inventory (NEI)[5] for these types of aircraft. The calculation for deriving emissions for general aviation, air taxi, and military aircraft landing at non-military airports is shown below.

Annual Aircraft Emissions = (Number of LTOs x Fleet Average Emission Factors) / 2000

General Aviation Fleet-Average Emission Factors:

HC 0.394 pounds per LTO

CO 12.014 pounds per LTO

NO_x 0.065 pounds per LTO

SO_2 0.010 pounds per LTO

Since air taxis have fewer of the smallest engines in their fleet and more turboprop and turbojet engines, their emission factors are somewhat different.

Air Taxi Fleet-Average Emission Factors:
(utilized for the military aircraft landing at non-military airports)

HC 1.234 pounds per LTO

CO 28.130 pounds per LTO

NO_x 0.158 pounds per LTO

SO_2 0.015 pounds per LTO

Airport activity for general aviation aircraft, air taxis, and military aircraft landing at non-military airports was obtained from the 2002 Kentucky Airport Master Records[4] provided by the Kentucky Division of Aeronautics, and direct contact with local airports.

Seasonal Adjustment to Daily Emissions

Based on information obtained from telephone inquiries made to local airports, the same seasonal adjustment factor was also applied to general aviation, air taxis, and military aircraft (landing at non-military airports) annual emissions in the same manner as it was applied for commercial aircraft at this same airport (*Please refer to page 4.5*).

General Aviation and Air Taxi THC to VOC Conversions

Since the alternative, fleet-average procedure was used for general aviation, air taxis, and

military aircraft landing at non-military aircraft, a single conversion factor was used for each aircraft category as follows. In concert with EPA's 1999 NEI[5] and EPA guidance[7] the THC to VOC conversion factor for military aircraft was utilized to better reflect military aircraft VOC emissions[7].

$$VOC_{GA\ FLEET} = THC_{GA\ FLEET} \times 0.9708 \qquad (5\text{-}18)$$

$$VOC_{AT\ FLEET} = THC_{AT\ FLEET} \times 0.9914 \qquad (5\text{-}21)$$

$$VOC_{AT\ FLEET} \text{ used for Military Aircraft} = THC_{AT\ FLEET} \times 1.100003 \qquad (5\text{-}21)$$

Total emissions for general aviation, air taxis, and military aircraft landing at non-military airports are provided in Table 4-3. Airport activity data used to calculate these emissions can be found in Table 4-4.

Table 4-3
Summary of Emissions From
From General Aviation, Air Taxi, & Military Aircraft (Non-Military Airports)

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	88.37	0.27	1842.95	5.56	10.35	0.03

Table 4-4
Airport Activity Levels

County	Commercial Aircraft LTOs	Air Taxi LTOs	General Aviation LTOs	Military LTOs
Christian	58	1690	17600	252855

4.4.3 Locomotives

Emissions for railroad locomotives within Christian County were calculated based upon December 1997 line haul and yard emission factors[5]. EPA utilized these same more recent emission factors in developing locomotive emissions for the 1999 National Emissions Inventory (NEI)[5]. EPA provided guidance to the Division in utilizing the newer locomotive emission factors[8].

Railroad locomotives used in the United States are primarily of two types: electric and diesel-electric. Electric locomotives are powered by electricity generated at stationary power plants and distributed by either a third rail or overhead catenary system. Emissions are produced only at the electrical generation plant, which is considered a point source and therefore not of interest here. Diesel-electric locomotives, on the other hand, use a diesel engine and an alternator or generator to produce the electricity required to power its traction motors. Emissions produced by these diesel engines are of interest in the non-highway emission inventory development. Emissions for hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), sulfur dioxide (SO_2), and particulate matter (PM) from this source are covered in this chapter.

Railroads can be separated into three classes based on size: Class I, Class II, and Class III. Class I railroads represent the largest railroad systems in the country. Because of their size, Class I railroads operate over a large geographic area. Also, they carry most of the interstate freight and carry most of the passenger service. They are required to keep detailed records of their operations and to report yearly to the Interstate Commerce Commission (ICC).

Class II and III railroads represent the remainder of the rail transportation system and generally operate within smaller, localized areas. These smaller railroads are not subject to the same reporting requirements, and their record-keeping may be less extensive. Also, their fleet of locomotives tends to be older, with the Class I railroads buying almost all of the new locomotives.

Locomotives within each of the Classes 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 rail cars within a particular railway yard.

Overview of Recommended Inventory Methodology

4.4.3.1 Line Haul Locomotives

For Class I, II, and III line haul locomotives, emissions were calculated by multiplying the amount of fuel consumed in the inventory area by the appropriate emission factors.

Line Haul Locomotive

Inventory Area Emissions = Fuel Consumption x Emission Factors Fuel Consumption

Line haul locomotive fuel consumption information for Christian County was supplied directly to the Division for Air Quality pursuant to a Division railroad questionnaire that was provided in July, 2003 to all railroads operating in the ozone maintenance area *(Please see a copy of the 2002 railroad questionnaire which is included in Appendix G).* The questionnaire also requested information regarding the number of yard locomotives operating in the nonattainment county.

Emission Factors - Line Haul

With the line haul fuel consumption information obtained from the questionnaire, inventory area emissions were determined by multiplying that value by the fleet average emission factors for each pollutant (converted to pounds per gallon of fuel burned (lbs/gal)). The EPA recommended default emission factors[8] that were utilized for all line haul locomotives are as follows.

Line Haul Locomotive Emission Factors

Pollutant	Emission Factor (g/gal)
HC	10
CO	26.6
NOx	270
PM	6.7

* g/gal emission factors converted to lbs/gal by multiplying the g/gal emission factor by .0022046.

4.4.3.2 Yard Locomotives

The recommended method for yard locomotives was same method used for line haul locomotives. With the line yard locomotive fuel consumption information obtained from the questionnaire, inventory area emissions were determined by multiplying that value by the fleet average emission factors for each pollutant (converted to pounds per gallon of fuel burned (lbs/gal)). Emissions for yard locomotives are calculated using the following formula:

Yard Locomotive

Inventory Area Emissions = Fuel Consumption x Emission Factors

Yard Locomotive Emission Factors

The EPA recommended default emission factors[8] that were utilized for all yard locomotives are as follows.

Pollutant	Emission Factor (g/gal)
HC	21
CO	38.1
NO	362
PM	9.2

g/gal emission factors converted to lbs/gal by multiplying the g/gal emission factor by .0022046.

Seasonal Considerations Line and Yard Locomotives

Based on telephone conversations with Steve McCary[2], Region 4 EPA, during October 1992 and Volume IV guidance[1], activity for railroad locomotives is considered to be uniform throughout the year. Additionally, the number of days of operation was assumed to be 365. Therefore, typical summer day emissions for line haul and yard locomotives were derived by using the following equation.

Typical Summer Day Emissions (TSD) = Annual Locomotive Emissions (TYR) / 365 days

Converting from Total Hydrocarbons (THC) to Volatile Organic Compounds (VOC) For Line and Yard Locomotives

In accordance with Volume IV guidance, the following THC to VOC conversion factor was used to determine the VOC emissions for line and yard locomotives.

VOC Locomotive = THCFID Locomotive x 1.005

Emissions for line haul locomotives are provided in Table 4-5 and emissions for yard locomotives are provided in Table 4-6. Activity data (i.e., fuel consumed) used to calculate locomotive emissions can be found in Table 4-7. Total Non-Highway emissions are provided in Table 4-8.

Table 4-5
Summary of Emissions From
From Line Haul Locomotives

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	6.92	0.02	18.32	0.05	185.99	0.51

Table 4-6
Summary of Emissions From
From Yard Locomotives

County	Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	0.10	0.00	0.17	0.00	1.65	0.00

Table 4-7
Locomotive Fuel Information

County	Line Haul Locomotive Fuel (Gallons)	Yard Locomotive Fuel (Gallons)
Christian	624907	4135

Table 4-8
Summary of Emissions From
Non-Highway Mobile Sources

County	Category	**Annual VOC Emissions (tons/year)	Daily VOC Emissions (tons/day)	**Annual CO Emissions (tons/year)	Daily CO Emissions (tons/day)	**Annual NOx Emissions (tons/year)	Daily NOx Emissions (tons/day)
Christian	Other Non-Highway	0.00	1.15	0.00	15.16	0.00	3.34
Christian	Locomotive	7.02	0.02	18.49	0.05	187.64	0.51
.istian	Aircraft	89.02	0.27	1846.80	5.57	12.01	0.04
Christian Emissions		**96.04**	**1.44**	**1865.29**	**20.78**	**199.65**	**3.89**

**Annual other non-highway emissions not reflected in Table 4-8.

4.5 REFERENCES FOR SECTION 4

1. U.S. Environmental Protection Agency, Procedures for the Emission Inventory Preparation, Volume IV: Mobile Sources, EPA-450/4-81-026d (Revised), U.S. EPA, Office of Mobile Sources, Ann Arbor, MI and Office of Air Quality Planning & Standards, RTP, NC, 1992.

2. Telecon, Steve McCary, US EPA, Region 4, to Martin Luther, Kentucky Division for Air Quality concerning procedures for inventorying other nonroad engine categories, November 4, 1992.

3. U.S. Department of Transportation, Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers for 2000, Office of Management Systems, Washington, DC 20591.

4. Kentucky Transportation Cabinet, Aeronautics Division - 2002 Airport Master Records were obtained for general aviation, air taxi, and military aircraft.

5. U.S. Environmental Protection Agency, National Emissions Inventory (NEI) for 1999.

6. Communications with Dale Aspy, EPA Region 4, regarding nonroad emission inventory development, Summer and Fall 2002.

7. Communications with Dale Aspy, EPA Region 4, and Ken Petche, EPA OMS, regarding aircraft emission inventory development, Fall 2002.

8. Communications with Dale Aspy, EPA Region 4, and Chuck Moulis, EPA OMS, regarding locomotive emission inventory development, Fall 2002.

5.0 HIGHWAY VEHICLES

5.1 INTRODUCTION

This section documents the development of the 2002 highway mobile source emissions inventory for the Kentucky portion of the Clarksville-Hopkinsville 8-hour ozone nonattainment area, which includes Christian County. The inventory addresses highway vehicles using gasoline and diesel. The inventory estimates are for a typical weekday during the summer ozone season (March - October), but more specifically for the summer quarter (i.e., June, July, and August).

In conjunction with Sierra Research, Inc.[1], the U.S. Environmental Protection Agency provided guidance for the preparation of this portion of the inventory.[2]

The Daily Vehicle Miles Traveled (DVMT) data was provided by the Division of Multimodal Programs, Kentucky Transportation Cabinet, who received input on VMT fractions from the University of Tennessee (see *Appendix E*). Emission factors for highway vehicle classes were obtained from EPA's MOBILE6.2 highway mobile source emission factor estimation model. MOBILE6.2 model runs for the nonattainment area were performed by the Kentucky Division for Air Quality.

The highway vehicles inventory discussion is divided into three primary sections. Section 5.2 addresses the emissions estimation process using the MOBILE6.2 model.[3] Section 5.3 addresses the mobile emissions for Christian County. Mobile source references are found in Section 5.4.

5.2 EMISSIONS ESTIMATION PROCESS

5.2.1 Overview of Highway Vehicle Emissions Estimates

Highway vehicle emission estimates for the nonattainment area were calculated using the DVMT estimates and EPA's mobile source emission factor estimation model - MOBILE6.2. The emission factors produced by the MOBILE6.2 model in grams/mile (g/mile) were multiplied by the DVMT estimates and appropriate unit conversions to generate total emissions. Emission estimates were calculated for VOC, NO_x, and CO. Estimates of VOC emissions were made for vehicle exhaust, evaporative, refueling, resting, and running losses. The only sources of NO_x and CO emissions were vehicle exhaust losses. Highway vehicle emission estimates were calculated for base year 2002 and the projection years of 2004, 2007, 2010, 2013 and 2016. The agencies principally involved in producing the highway vehicle emission estimates were the Divisions of Planning and

Multimodal Programs from the Kentucky Transportation Cabinet and the Kentucky Division for Air Quality. The Division of Planning provided the following mobile source information for Christian County: (1) Road classifications, 2) Daily Vehicle Miles Traveled per road classification per county; and (3) Estimated average speeds for each road classification. The Division for Air Quality conducted all of the MOBILE6.2 model runs.

The inputs used to run the MOBILE6.2 model are described and presented in Section 5.2.2. Mobile source highway 2002 emissions are summarized in Table 5-1.

5.2.2 Inputs to MOBILE6.2

The new MOBILE6.2 model is a more-concise model, compared to the MOBILE5 model. The chief inputs to the MOBILE6.2 model can be grouped into two main categories: the run section and the scenario section. Unless otherwise specified, national default values are used in the MOBILE6.2 model. These values are used as they are representative of conditions found in Kentucky. The values used for each grouping in the area analysis are presented below and justified (*Please see Appendix E for mobile model input and output information).*

5.2.2.1 Run Section Data

This section is similar to the one-time data section from the MOBILE5 model. In general, the two main values specified in the run section are the Reid Vapor Pressure for conventional gasoline (identified as "Fuel RVP") and the minimum and maximum summer temperatures. Unlike the MOBILE5 model, ambient temperature values no longer need to be specified. Minimum and maximum summer temperature data will vary depending on the area in Kentucky (*Please see Appendix E for temperature information*).

5.2.2.2 Scenario Section Data

This part of Mobile6.2 allows the specification of data for several parameters that can be varied to evaluate many different mobile source emission scenarios. These parameters are described below:

Scenario Record - This parameter is used to indicate a title. For Kentucky's MOBILE6.2 model runs, the road classification is specified. The 12 road classifications (6 rural, 6 urban)

that were used for the MOBILE5 model are also used for the MOBILE6.2 model runs.

Calendar Year - The calendar years for the analysis was 2002, 2004, 2007, 2010, 2013, and 2016.

Evaluation Month – A value of 7 was used to denote a summer MOBILE6.2 model run.

Average Speed - For each of the highway road classifications, a single speed was applied. Speed data was supplied by the Kentucky Transportation Cabinet.

VMT Fractions – Specific local fractions were used for the MOBILE6.2 model runs. Data for each road classification was calculated for Montgomery County, Tennessee, by Dr. Terry Miller, Associate Professor, Department of Civil Engineering, University of Tennessee. A detailed explanation of Dr. Miller's calculation methodology can be found in *Appendix E.*

In the MOBILE6.2 model, there are four main speed categories: freeway, arterial, local, and ramp. For the 12 road classifications used in Kentucky's MOBILE6.2 model runs, each need to be assigned one of the four speed categories. The 12 road classifications are broken down into 3 freeway road classifications, 8 arterial road classifications, and 1 local road classification. It should be noted that Rural Local has a speed category of Arterial, as advised by EPA.

Specific default speed data are used for specific speed categories. Unless specific local speeds are available, the default local speed of 12.9 mile per hour is used.

For the average speed component, it should be noted that additional data are indicated for the 3 freeway road classifications.[4] The Daily Vehicle Miles Traveled (DVMT) distribution data are represented with 4 percentages: freeway, arterial, local, and ramp. For freeways, studies estimate that freeway and ramp represent 92% and 8% of all freeway VMT, respectively. Unless local data are available for the freeway category, the user needs to indicate "92.0 0.0 0.0 8.0".

Local data for VMT distribution can be used, if available. For example, the VMT distribution may be "92.4 0.0 0.0 7.6". Local data may even indicate that VMT distribution data are not needed for any of the freeway road classifications. The VMT distribution data

will not be indicated in the Mobile6.2 input file for a freeway road classification unless DVMT data are associated with it. The Kentucky Transportation Cabinet has supplied local data for VMT distribution for this emissions inventory that is different from the default values of "92.0 0.0 0.0 8.0". Please see *Appendix E* for more-detailed highway mobile input file and DVMT information.

5.3 Summary of Highway Vehicle Emissions

Highway vehicle emission estimates were calculated by multiplying the Mobile6.2 generated emission factors by the DVMT. Typical Summer Day (TSD) emission totals are listed by county and summarized in Table 5-1.

TABLE 5-1
SUMMARY OF HIGHWAY MOBILE SOURCE EMISSIONS
Kentucky Portion of the Clarksville-Hopkinsville Area

	2002 Highway Mobile Source Emissions (2002 VMT * 2002 EF)		
County	Total VOC TSD*	Total CO TSD*	Total NO_X TSD*
Christian	4.30	48.18	10.62
Total	4.30	48.18	10.62

*Multiply tons per summer (TSD) emissions by 365 to estimate annual emissions.

5.4 REFERENCES FOR SECTION 5

1. Sierra Research, Inc., *MOBILE6 On-Road Motor Vehicle Emissions Model: 5-Day Training Course*, Atlanta, Georgia. February 4-8, 2002.

2. U.S. Environmental Protection Agency. *User's Guide to MOBILE6 – Mobile Source Emission Factor Model.* EPA420-R-02-001. Office of Mobile Sources, Ann Arbor, Michigan. January 2002.

3. U.S. Environmental Protection Agency, Instructions provided with the mobile model - MOBILE6.

4. U.S. Environmental Protection Agency, Dale Aspy, Region 4. Electronic mail correspondence with Joe Forgacs, Kentucky Division for Air Quality. Correction in MOBILE6 model to accurately reflect "Freeway" component. September 9, 2002.

6.0 BIOGENIC EMISSIONS

6.1 BACKGROUND

This section documents the development of the biogenic emissions for the Kentucky portion of the Clarksville-Hopkinsville 8-hour ozone nonattainment area, which includes Christian County. In accordance with EPA guidance[1], the 2002 biogenic emissions presented were obtained and derived from county-specific biogenic emission estimates that EPA developed to assist states with the Consolidated Emissions Reporting Rule (CERR).

6.2 METHODOLOGY

EPA estimated the biogenic emissions for Kentucky counties using the Biogenic Emissions Inventory System - Version 3 (BEIS3.12). Christian County annual biogenic emissions were obtained from the following EPA web site: ftp://ftp.epa.gov/EmisInventory/prelim2002nei/biogenic/.

Daily biogenic emissions were determined as follows:

Summer Seasonal
Adjustment Factor = (Summer County Emissions (June-August) / Annual County Emissions) / .25

Summer Day Emissions = (Annual County Emissions * Summer Seasonal Adjustment Factor) /365
If applicable, for portions of counties the area apportionment factor provided in Table 1-1 was utilized to apportion emissions.

6.3 SUMMARY OF BIOGENIC EMISSIONS

6.3.1 Ozone Nonattainment Area

Biogenic emissions for Christian County can be found in Table 6-1 and also in *Supplement C*. References for biogenic emissions are provided in Section 6.4.

TABLE 6-1
SUMMARY OF 2002 BIOGENIC EMISSIONS
KENTUCKY PORTION OF THE CLARKSVILLE-HOPKINSVILLE, TN-KY, AREA

COUNTY	VOC EMISSIONS	VOC EMISSIONS	NOx EMISSIONS	NOx EMISSIONS
	(tons/yr)	(tons/day)	(tons/yr)	(tons/day)
Christian	8,099.20	49.70	280.34	1.10
Total Emissions	**8099.20**	**49.70**	**280.34**	**1.10**

6.4 REFERENCES FOR SECTION 6

1. U.S. Environmental Protection Agency. EPA's estimate of 2002 Biogenic Emissions to assist states with the Consolidated Emissions Reporting Rule (CERR). Biogenic annual emission estimates are available at: ftp://ftp.epa.gov/EmisInventory/prelim2002nei/biogenic/. For more information please contact Marc Houyoux, with EPA's Emission Factors and Inventory Group, at (919) 541-3649.