COLORADO STATE IMPLEMENTATION PLAN FOR OZONE

TECHNICAL SUPPORT DOCUMENT

Denver Metropolitan Nonattainment Area

Emission Inventories for the Maintenance Plan and Redesignation Request

Adopted January 11, 2001

Colorado Department of Public Health and Environment

Prepared by
The Colorado Department of Public Health and Environment
Air Pollution Control Division
4300 Cherry Creek Drive South
Denver, Colorado 80222 - 1530
(303) 692-3100

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1.0 INTRODUCTION AND SUMMARY OF EMISSIONS

1.1 Introduction

This document presents the ozone precursor gas emission inventories for the preparation and submission of the Denver Ozone redesignation request and maintenance plan for the Denver Ozone Nonattainment Area. AThe emission inventories are necessary for purposes of meeting the redesignation maintenance plan requirements of Section 175A of the amended Clean Air Act (CAA), redesignation requirements of the April 16, 1992, General Preamble for the Implementation of Title I of the CAA (57 FR 13561 - 13564), and the Environmental Protection Agency=s September 4, 1992, redesignation policy entitled AProcedures for Processing Requests to Redesignate Areas to Attainment@.@

1.2 Geographical Area

The Denver ozone nonattainment area, as described in the Federal Register (56 FR 56735, dated November 6, 1991), includes the areas west of Kiowa Creek in Adams and Arapahoe County, Boulder County except for Rocky Mountain National Park, Denver, Jefferson and Douglas Counties. Figure 1.1 includes a map of the Denver ozone nonattainment area.

1.3 Inventory Descriptions

As part of the ozone attainment and redesignation effort, a 1993 attainment year emission inventory was developed. In addition, projected emission inventories for 2006 and 2013 were developed. Maintenance of the ozone standard can be demonstrated if the future emissions of a pollutant or its precursors will not exceed the level of the attainment inventory.

Section 172(c)(3) of the CAAA requires an emissions inventory as part of an area's attainment demonstration. The State has developed a base year attainment emissions inventory to identify the level of emissions in the Denver metro area which is sufficient to attain the National Ambient Air Quality Standards (NAAQS) for ozone. The attainment year inventory is consistent with EPA's most recent guidance on emission inventories for ozone nonattainment areas available at the time of building the inventory.

The attainment year emission inventory is based on actual "typical high ozone day" emissions. Although the ozone monitoring season runs from March through September, as defined in the Code of Federal Regulations at 40 CFR 58, Appendix D, monitoring data indicates that the highest ozone readings occur during the hotter days from June through August. The "typical high ozone" day is a day that would occur during these summer months.

The maintenance inventory is based on 2006 and 2013 projections. The EPA requirements for maintenance inventories for redesignation requires an emission inventory at least 10 years beyond the attainment inventory and 10 years beyond the date of EPA approval. The 2006 emission inventory serves as an interim emission inventory within the 10 year maintenance plan.

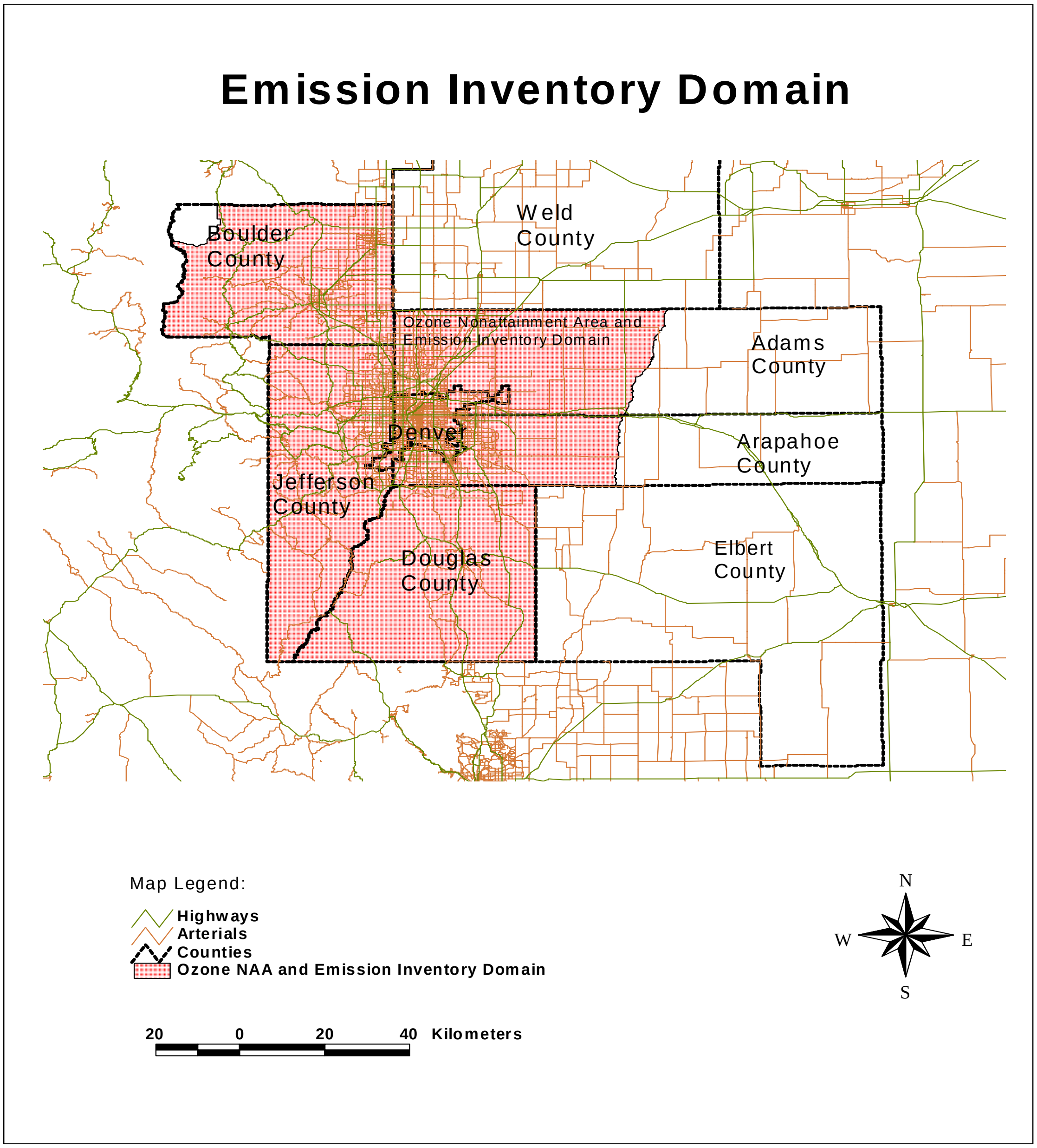

Figure 1: Emission Inventory Domain

1.4 Roles of Organizations Involved

Preparation of the Denver ozone maintenance, State Implementation Plan (SIP) involves a cooperative effort between the Colorado Department of Public Health and Environment (CDPHE-APCD), Colorado Air Quality Control Commission (AQCC), Regional Air Quality Council (RAQC) and the Environmental Protection Agency (EPA). In addition to the above organizations, the Colorado State Legislature also reviews and either approves, amends, or disapproves the entire SIP through its SB 110 review process. Following is a discussion summarizing the role of each agency in the maintenance SIP process:

Colorado Air Quality Control Commission

The AQCC is a citizen panel appointed by the Governor to perform a variety of regulatory duties outlined in state statute. The Commission adopts rules and regulations to implement state law, and, is also responsible for adopting a comprehensive SIP meeting all requirements of the federal and state Clean Air Acts. The commission adopts rules and regulations necessary to implement the SIP.

Colorado Department of Public Health and Environment-Air Pollution Control Division

The Air Pollution Control Division (APCD) within the Colorado Department of Public Health and Environment (CDPHE) is responsible for developing, administering, and enforcing air quality control programs adopted by the AQCC, including State Implementation Plans. The APCD conducts research, collects, and analyzes air quality data.

For the Denver ozone maintenance demonstration, the APCD is primarily responsible for performing the technical analysis that serves as the basis for strategy development and attainment demonstration. The Division prepares emission inventories, conducts air quality modeling (if needed), analyzes air quality data, and provides technical advice and assistance. APCD assists the RAQC with identifying and analyzing the effectiveness of control measures, reviews recommended measures and provides general oversight of the ozone maintenance SIP process.

Regional Air Quality Council

In compliance with Section 174(a) of the federal CAAA, the Governor created the RAQC to serve as the lead agency for air quality planning in the Denver metro area. The council consists of locally elected officials and citizen members representing a broad spectrum of interests.

The Council is primarily responsible for identifying, analyzing, and recommending control measures to be included in the SIP. The RAQC works with industry and state and local governments to obtain the necessary commitments to effectively implement and enforce the control measures. The RAQC assists the APCD with portions of the technical analysis and review of technical results.

Denver Regional Council of Governments

Denver Regional Council of Governments (DRCOG) is the Denver metro area's regional planning commission and serves as the metropolitan planning organization (MPO). As the region's MPO, DRCOG is responsible for developing the long-range transportation plan. Through agreement between RAQC, APCD, and AQCC, the region's air quality and transportation planning are coordinated to ensure effective integration of the respective planning processes. DRCOG provides demographic and transportation data that form the basis for emission inventory development.

Environmental Protection Agency

Under the CAAA, EPA is responsible for reviewing and approving any implementation plan submitted by the State. EPA provides guidance, advice and technical assistance that aids development of the plan in accordance the CAAA requirements.

1.5 Demographic Data and Growth Indicators

Basic demographic data such as population, households, and employment come from the DRCOG. Many of the area source emissions are dependent on these key demographic indices. Table 1.5-1 presents a summary of the demographic data.

Table 1.5-1 Demographic Data for 1993, 2006, and 2013

DEMOGRAPHIC INDICATOR	1993	2006	2013
POPULATION:			
Ozone nonattainment area	1919407	2562039	2821543
HOUSEHOLDS:			
Ozone nonattainment area	786783	1070513	1213566
EMPLOYMENT:			
Ozone nonattainment area	1044681	1553625	1697977

1.6 Emission Summary

Table 1.6-1 presents a summary of the 1993, 2006, and 2013 emissions inventories by source category. The emission rates presented in these tables are for a typical high ozone day that occurs during the summer season. Details on how each source category was compiled are presented in Sections 2 through 7. Figures 1.6-1 through 1.6-6 present a graphical representations of what proportion of point sources, on-road mobile, non-road mobile, area sources, and biogenic emissions are to the total inventories for NO_x and VOC on a typical high ozone day in 1993, 2006, and 2013.

When comparing the emission inventories for 1993 to 2013, a decrease in NO_x and VOC emissions is anticipated. The total NO_x emissions for a typical summer day in 1993 is 332 tpsd. By 2013, the total NO_x emissions are expected to be 308 tpsd. Between 1993 and 2013, NO_x emissions are expected to decrease by 24 tpsd. Decreases in NO_x are due almost entirely to reductions in on-road and non-road mobile source emissions.

Similarly, VOC emissions are also expected to decrease from 1993 to 2013. Total VOC emissions for 1993 are estimated at 507 tpsd. By 2013, VOC emissions are expected to be 459 tpsd. Between the attainment year and maintenance year, VOC emissions are expected to decrease by 48 tpsd. Decreases in VOC emissions are expected for both on-road mobile sources and non-road source categories.

Table 1.6-1 Denver Ozone-Summary of the 1993, 2006 and 2013 Precursor Gas Inventory

SOURCE CATEGORY	1993 NOx (tpsd)	1993 VOC (tpsd)	2006 NOx (tpsd)	2006 VOC (tpsd)	2013 NOx (tpsd)	2013 VOC (tpsd)
POINT SOURCES						
MAJOR	112.7	22.8	113.9	25.7	116.3	27.1
MINOR	9.1	23.0	9.5	26.7	9.7	28.7
POINT SOURCE-SUBTOTAL	121.8	45.8	123.4	52.4	126.0	55.8
ON-ROAD						
EXHAUST, RUNNING LOSS, RESTING LOSS	134.0	90.7	115.2	64.6	117.2	55.8
EVAPORATIVE AND REFUELING LOSS	0.0	28.3	0.0	19.8	0.0	17.8
ON-ROAD-SUBTOTAL	134.0	119.0	115.2	84.4	117.2	73.6
NON-ROAD						
AIRCRAFT	7.1	1.9	12.7	1.9	17.2	2.1
LOCOMOTIVES	3.7	0.3	2.5	0.3	1.2	0.1
CONSTRUCTION EQUIPMENT	38.5	6.5	28.5	3.8	20.0	2.9
INDUSTRIAL EQUIPMENT	4.5	2.0	3.6	1.6	3.1	1.6
LAWN & GARDEN/LOGGING	0.7	28.0	0.7	14.4	0.7	15.0
FARM EQUIPMENT	4.3	0.9	3.4	0.5	2.8	0.4
AIRPORT SERVICE	4.2	0.4	3.2	0.6	2.6	0.7

Table 1.6-1 Denver Ozone-Summary of the 1993, 2006 and 2013 Precursor Gas Inventory

SOURCE CATEGORY	1993 NOx (tpsd)	1993 VOC (tpsd)	2006 NOx (tpsd)	2006 VOC (tpsd)	2013 NOx (tpsd)	2013 VOC (tpsd)
EQUIPMENT						
LIGHT COMMERCIAL	1.1	7.7	1.2	5.0	1.0	4.9
RECREATIONAL VEHICLES	0.0	2.6	0.0	3.2	0.0	3.5
RECREATIONAL BOATS	1.0	7.2	1.2	7.4	1.4	7.1
NON-ROAD-SUBTOTAL	65.1	57.5	57.0	38.7	50.0	38.3
AREA SOURCES						
GASOLINE: DISTRIBUTION-TRANSPORT	0.0	0.3	0.0	0.4	0.0	0.5
GASOLINE: DISTRIBUTION-BREATHING LOSS	0.0	0.6	0.0	0.8	0.0	0.9
*DRY CLEANING	0.0	0.0	0.0	0.0	0.0	0.0
DEGREASING	0.0	12.8	0.0	6.6	0.0	7.3
ARCHITECTURAL SURFACE COATING	0.0	15.7	0.0	16.8	0.0	18.5
AUTO REFINISHING	0.0	13.6	0.0	12.8	0.0	14.0
TRAFFIC MARKING/STRIPING	0.0	2.4	0.0	3.3	0.0	3.6

Table 1.6-1 Denver Ozone-Summary of the 1993, 2006 and 2013 Precursor Gas Inventory

SOURCE CATEGORY	1993 NOx (tpsd)	1993 VOC (tpsd)	2006 NOx (tpsd)	2006 VOC (tpsd)	2013 NOx (tpsd)	2013 VOC (tpsd)
GRAPHIC ARTS	0.0	3.2	0.0	4.3	0.0	4.7
ASPHALT USE	0.0	0.0	0.0	0.0	0.0	0.0
PESTICIDE APPLICATION	0.0	0.1	0.0	0.2	0.0	0.2
COMMERCIAL/CONSUMER SOLVENT USE	0.0	19.4	0.0	20.7	0.0	22.8
PUBLICLY OWNED TREATMENT WORKS	0.0	0.0	0.0	0.0	0.0	0.0
WASTEWATER TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0
TREATMENT, STORAGE AND DISPOSAL FACILITIES	0.0	0.0	0.0	0.0	0.0	0.0
LANDFILLS	0.0	2.1	0.0	2.8	0.0	3.1
LEAKING UNDERGROUND STORAGE TANKS	0.0	1.4	0.0	1.4	0.0	1.4
WOOD STOVE/FIREPLACES	0.0	0.0	0.0	0.0	0.0	0.0
BAKERIES	0.0	1.2	0.0	1.6	0.0	1.8
NATURAL GAS	6.8	0.4	9.7	0.5	10.8	0.6
COAL	0.0	0.0	0.0	0.0	0.0	0.0
FUEL OIL	0.0	0.0	0.0	0.0	0.0	0.0
BREWERIES,WINERIES, DISTILLERIES	0.0	0.0	0.0	0.0	0.0	0.0

Table 1.6-1 Denver Ozone-Summary of the 1993, 2006 and 2013 Precursor Gas Inventory

SOURCE CATEGORY	1993 NOx (tpsd)	1993 VOC (tpsd)	2006 NOx (tpsd)	2006 VOC (tpsd)	2013 NOx (tpsd)	2013 VOC (tpsd)
ACCIDENTAL RELEASES	0.0	0.0	0.0	0.0	0.0	0.0
SYNTHETIC ORGANIC CHEMICAL TANKS	0.0	0.0	0.0	0.0	0.0	0.0
TANK TRUCK, RAIL CAR, DRUM CLEANING	0.0	0.0	0.0	0.0	0.0	0.0
INCINERATION	0.0	0.0	0.0	0.0	0.0	0.0
FOREST FIRES/PRESCRIBED BURNS	0.0	0.0	0.0	0.0	0.0	0.0
STRUCTURAL FIRES	0.1	0.5	0.1	0.6	0.1	0.6
OPEN BURNING/AG BURNING	0.0	0.0	0.0	0.0	0.0	0.0
AIRCRAFT ENGINE TESTING	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL GRILLING	0.0	0.0	0.0	0.0	0.0	0.0
AREA SOURCE-SUBTOTAL	6.9	73.7	9.8	72.8	10.9	80.0
TOTAL FROM ANTHROPOGENIC SOURCES	327.8	296.4	305.4	248.4	304.1	247.6
BIOGENIC	3.7	211.2	3.7	211.2	3.7	211.2

Table 1.6-1 Denver Ozone-Summary of the 1993, 2006 and 2013 Precursor Gas Inventory

SOURCE CATEGORY	1993 NOx (tpsd)	1993 VOC (tpsd)	2006 NOx (tpsd)	2006 VOC (tpsd)	2013 NOx (tpsd)	2013 VOC (tpsd)
TOTAL FROM ALL SOURCES	**331.5**	**507.2**	**309.1**	**459.5**	**307.8**	**458.9**

tpsd = tons per summer day

* Perchloroethylene, the main solvent used in dry cleaning is no longer considered to be a photoreactive species

NOTE: Emission rates are reported with one decimal place precision to provide representation for smaller source categories. This level of precision is not intended to suggest a level of accuracy.

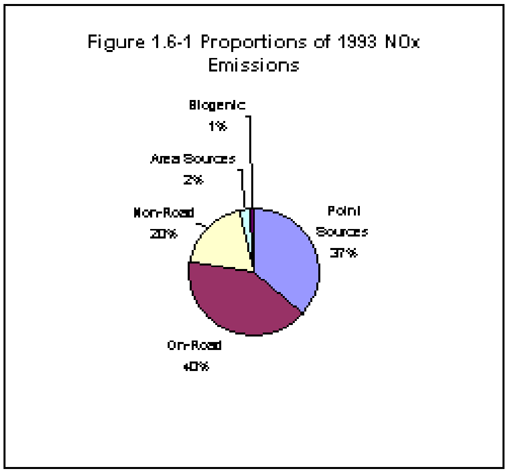
Figure 1.6-1 Proportions of 1993 NOx Emissions
Biogenic 1%
Area Sources 2%
Non-Road 20%
Point Sources 37%
On-Road 40%

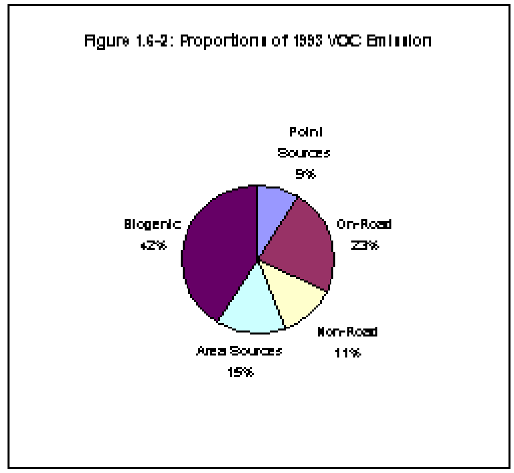
Figure 1.6-2: Proportions of 1993 VOC Emission
Point Sources 9%
Biogenic 42%
On-Road 23%
Non-Road 11%
Area Sources 15%

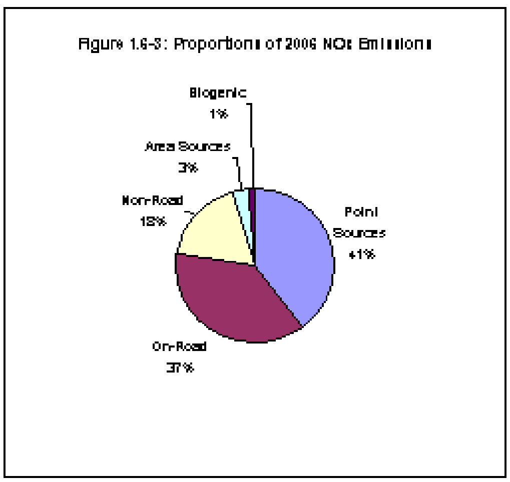
Figure 1.6-3: Proportions of 2006 NOx Emissions
Biogenic 1%
Area Sources 3%
Non-Road 18%
Point Sources 41%
On-Road 37%

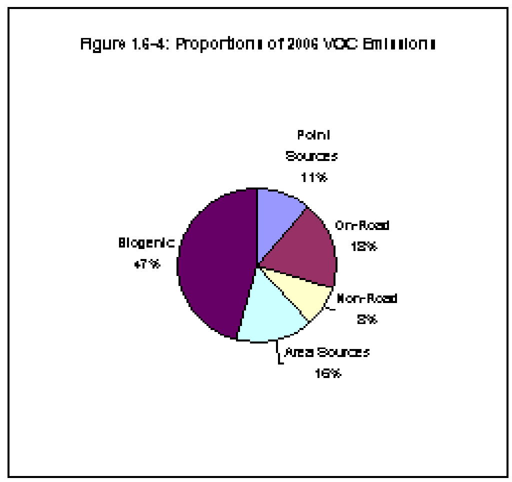
Figure 1.6-4: Proportions of 2006 VOC Emissions
Point Sources 11%
On-Road 18%
Biogenic 47%
Non-Road 8%
Area Sources 16%

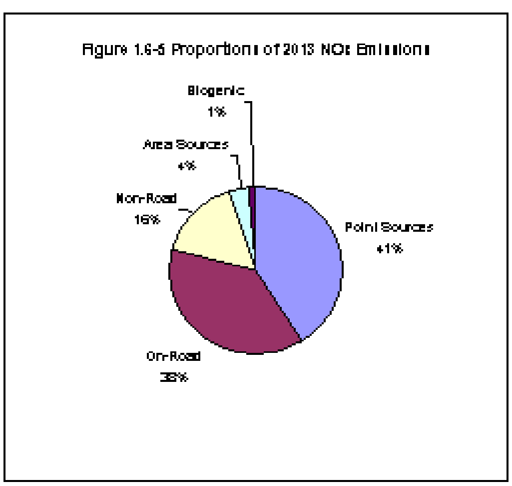
Figure 1.6-5 Proportions of 2013 NOx Emissions
Biogenic 1%
Area Sources 4%
Non-Road 16%
Point Sources 41%
On-Road 38%

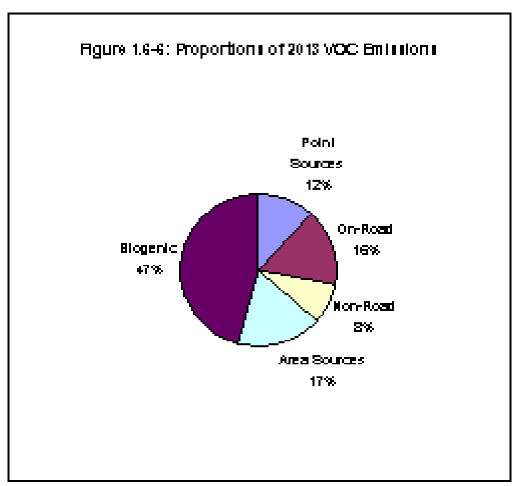
Figure 1.6-6: Proportions of 2013 VOC Emissions
Point Sources 12%
On-Road 16%
Biogenic 47%
Non-Road 8%
Area Sources 17%

1.7 Organization of the Document

The key points and format of the material presented in the remaining sections of this document are outlined below:

Section 1: Introduction and Summary of Emissions

- This section presents the purpose of the document, background material and an overall summary of the precursor gas inventory for the attainment and maintenance year.

Section 2: Point Sources

- Contains a description of assumptions and methodologies used to compile the major and minor point source inventories for NO_x and VOC.

Section 3: On-Road Mobile Sources

- Presents a summary of on-road mobile source emissions for the attainment and maintenance years.

Section 4: Non-Road Mobile Source

- Presents emissions from non-road mobile sources such as aircraft, locomotives, and small gasoline or diesel engines associated with industrial equipment, lawn and garden, construction equipment, etc.

Section 5: Area Sources

- Contains methodologies for estimating and emission summaries for those source categories that are inventoried as area sources. Area sources are those source categories that are not on AIRS or may be partially on the AIRS database.

Section 6: Biogenic Emissions

- Describes the use and resulting emissions estimates for biogenic emissions by using the EPA's Biogenic Emissions Model, PCBEIS2.

Section 7: Excluded and Uninventoried Source Categories

- Presents those source categories with very small or no emissions that were negatively declared in the emission inventory.

2.0 POINT SOURCES

2.1 Abstract

Point source emissions are maintained by the Air Pollution Control Division's Stationary Source Program within the EPA's AIRS data base. Data was extracted from the AIRS database and processed to delineate major and minor point sources. Major point sources are those facilities emitting more than 100 tpy, actual. Base year emissions for point sources were projected to 2010 using output from the EPA model, Economic Growth and Analysis System (E-GAS). A linear relationship was established between the total major and minor 1993 and 2010 emissions for VOC and NO_x From this linear relationship for VOC and NO_x, the 2006 emissions were interpolated, and, the 2013 emissions were extrapolated.

2.1.1 Source Identification

All sources in Colorado emitting criteria and/or hazardous air pollutants (HAPs), including those emitting such ozone formation contributors (OFCs) as volatile organic compounds (VOCs) and criteria pollutants such as nitrogen oxides (NO_x) specifically, are required to submit an Air Pollutant Emission Notice (APEN) to the Colorado Department of Public Health and Environment's Air Pollution Control Division (APCD). The de minimis level for reporting criteria pollutants is 1 ton/year (tpy) in nonattainment areas and 2 tons/year in attainment areas (actual uncontrolled emissions). In addition, source inspections, the active contacting of sources identified from mailing lists, and stricter permitting requirements contribute to the APCD's knowledge of potential emissions sources of OFCs.

For HAPs the de minimis levels for reporting vary based on a combination of the specific HAP's toxicity and scenario[a] for its release, but can be as low as 50 pounds/year. The data submitted on APENs is entered into the EPA's AFS data subsystem of AIRS and represents an accurate inventory of all major and minor sources of VOCs and NO_x in the state. Since APENs are valid for a period of five years, and are generally not revised before expiration unless a significant increase in emissions occurs, this database represents the most accurate basis for identifying sources of OFC emissions in Colorado and thus was used in compiling the Denver ozone SIP inventory.

[a] Height of emission and distance to property boundary

2.1.2 1993 Data Year

The 1990 base year inventory of VOC and NO_x emissions was "rolled forward" statewide to 1993. Specifically for the Ozone SIP inventory, a county by county extraction of VOC and NO_x sources within the Denver Ozone nonattainment (NAA) area was performed to delineate a population of all plants appropriate to the ozone SIP inventory boundary. Next, a list of all plants with VOC and NO_x emissions in 1990 was produced.

The SIP Program and SIP Status Area fields in AIRS were then populated and VOC and NO_x sources outside of the specific Denver Ozone nonattainment area were further identified by use of a Geographic Information System (GIS) application. After identification as a non-SIP plant, these sources were so delineated in AFS.

Segments at each plant were next populated using Estimated Emissions with Rule Effectiveness. The data was then rolled forward to the current data year to establish an inventory. Plants with a data year of 1993, but with no emissions, have been entered in AFS as such and do not affect the SIP inventory. In some cases where the data had already been entered for 1994 a retrospective creation of 1993 data was not possible. Therefore, the inventory used for the ozone SIP is essentially latest year of record inventory, but for the most part 1993. A few VOC and NO_x plants may show 1994 data and rarely a 1995 entry occurs.

2.1.3 Area Definition

The Denver Ozone SIP inventory was established by extracting from AIRS all VOC sources greater than 10 tons/year, and all major NO_x sources (>100 tpy), within all of Denver, Boulder, Jefferson and Douglas Counties and those portions of Adams and Arapahoe Counties west of Kiowa Creek. These counties, and portions thereof, define the Denver Ozone NAA.

Based on these geographic parameters, all SIP plants were "flagged" as such and then extracted from AFS in list form. These lists were submitted to local agencies for a final review of those actually contained within the appropriate Ozone NAA boundary. Based on that input, those plants outside a NAA boundary, or inoperative in 1993, were not used in developing the ozone inventory.

2.1.4 Quality Assurance

As a result of the passage of Colorado State Senate Bill 105 in 1992, revised APENs (Air Pollution Emission Notices) were required from all facilities emitting air pollutants at reportable levels in Colorado. This provided an opportunity to accurately update the entire emissions inventory on a statewide basis.

The APEN process in part involved searching for, locating, and contacting any facility potentially emitting OFCs, at reportable levels, in the state, which included both those sources already in an existing inventory (EIS - Emission Inventory System) as well as any new facility or ones previously unknown to the APCD. A comprehensive instruction packet[a] was developed, containing a list of reportable hazardous and criteria air pollutants, and mailed to all known facilities. In addition, note that all VOC emissions above established de minimis levels are reportable under Colorado Law, regardless of whether they appear as a listed hazardous air pollutant or not. Where available an EIS printout of the existing inventory data for each facility was included in the mailing. In addition, simplified instructions for calculating emissions from particular types of small business operations were provided.

Facilities responded by either correcting, or verifying as accurate, the existing facility data, or by completing a new APEN form listing the compounds emitted and in what amount, in addition to providing numerous pieces of data regarding operating parameters (e.g. stack data, process rate, etc.). Since previously existing inventories of hazardous air pollutants and VOCs were deficient, a great deal of current VOC emission data was acquired in this process. After arrival at the APCD and complete verification of the data, the information contained in each APEN was then entered into the AIRS database according to the requirements of that format.

Comparison with existing inventory data and master files (while exercising engineering judgement and performing calculations), coupled with telephone and written contact with the source, served as the means of data verification and quality assurance. In addition, the cost of $100/ton of HAPS at $14.98/tons of VOCs (and the fact that a HAP which is also a VOC can be double-charged with both fees) forces a facility emitting OFCs to pay particular attention to their annual inventory billing received from the APCD. Any changes in emission information from this process are used to update AIRS emission data.

While improved quality of the NO_x emissions data base was acquired in the process, the APCD feels the discussion of the following three important points serve to illustrate that the APEN database is sufficient to serve as support for the ozone SIP VOC inventory in particular:

1) *The APEN process captured most, if not all, of the facilities emitting VOC's in Colorado.* Approximately 2500 facilities in Colorado were known to exist in previous databases and they were contacted in the APEN process. Roughly 1800 of them responded, the difference due to closure, merger, or non-response. Investigative efforts to acquire data from the non-responding facilities included a certified letter sent to all of them where projected emission of criteria pollutants exceeded 20 tons/year. Additional research and outreach concerning all of the remaining significant non-responding VOC emitters will be conducted in order to acquired the appropriate data for their emissions as well.

Added to the initial 1800 responders of 2500 potential facilities were approximately 2000 other facilities identified in the outreach aspect of the APEN process where new or previously unknown emitters of VOCs were sought out. A total of almost 4000 facilities have now been entered into the AIRS database as a result of this process, providing the state and the EPA with an accurate assessment of total VOC emissions in Colorado.

2) *Are all potential or likely VOC species accounted for?*

While all VOC emissions above de minimis are reportable, Colorado State Senate Bill 105 also defined a list of approximately 600 hazardous air pollutants to be reported in Colorado. Approximately 80% of them are VOCs as well and are therefore also important to the Ozone SIP inventory. The result of this two-fold approach to VOC reporting is that the data concerning VOC emissions is now probably better refined than in the past. This is because the process of totaling emission VOC compounds that also are listed HAPs probably leads to more accurate emission tallies when accounted for on the individual species level rather than as just the family "VOC".

While no inventory process short of stack-testing each facility (to examine the full suite of VOCs emitted) could account for all potential VOC sources in the state, the APCD feels that the majority of the significant Colorado VOC sources and species are tallied in the APEN inventory.

Therefore, the APCD is also confident that the APEN inventory represents the best, and most accurate, estimate possible of VOC emissions in Colorado given the extensive resources already allocated to the APEN process and the lack of identified alternative strategies to better acquire the same information.

3) *Quality of data*

Extensive attempts to acquire data from all known or possible facilities were the core of the APEN process. The data that was received was extensively examined and cross-checked for accuracy by such various means as follows.

Stack parameters were checked by examining relationships among height, stack diameter, exhaust temperature, and exhaust velocity to make sure the provided values were reasonable and accurate. Values calculated from such examination were used in place of provided values when a conflict was discovered. Sometimes the associated units (e.g. lb/yr, ton/yr, etc.) themselves for a provided value were the source of error and such problems could often be resolved by consulting the master files and inspection reports, or contacting the facility by telephone. When usable stack data was not available, default values for ambient temperature (70^{o} F) and plume height (10 ft.) were used.

SCC codes were evaluated for correct matching with the point description and modified where necessary. Sulfur, ash, and heat content of fuels were examined to determine validity and boiler capacities were checked, and located when missing. Design capacity as well was checked and verified. "Obviously" erroneous data supplied by the facility was left uncorrected only when a calculation using other variables or background data from other sources could not be used in place of it.

Emission factors were provided for all pollutants but if the stack test data was valid and could provide more realistic and accurate emission factors by calculation, they were used instead. The general hierarchy for emission factor determination established in the APEN instructions was: 1) a verifiable stack test or other monitoring data, 2) mass balance calculations, 3) a published verifiable emission factor, or 4) engineering calculations.

As a result of all of the above efforts a large inventory of data has been acquired, verified, and quality assured from a number of standpoints and now represents the APEN database. Some errors probably do exist (omissions, data entry errors, etc.) however, but the APCD's experience with various quality control and quality assurance exercises that have been performed so far have found that these types of errors are not extensive and are easy to correct. Therefore, the extensive APEN inventory is the basis for the data placed into AIRS and serves as the accurate repository of Colorado's OFC emissions to the best of the APCD's knowledge.

The Air Pollution Control Division of the Colorado Department of Public Health and Environment feels that the process of acquiring, reviewing, and entering the updated information efficiently serves as both the quality assurance and quality control process for the OFC emission inventory which is to be incorporated into the Denver Ozone State Implementation Plan (SIP). For this reason the APCD requests that the EPA accept the extensive APEN process as the QA/QC process for the Denver Ozone SIP.

2.1.5 Projection of 1993 Base Year Inventories to 2006 and 2013

In order to determine the growth factors to be used for each point source, EPA guidance on emissions projections and inventory requirements was reviewed. Emissions projection guidance is summarized in *Procedures for Preparing Emissions Projections*[a]; and inventory requirements for the photochemical models is contained in *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume II: Emission Inventory Requirements for Photochemical Air Quality Simulation Models*[a]

If emission source growth estimates are not available from individual plants or other local sources, a surrogate growth indicator must be used. Economic variables which may be used as indicators of emission source growth are product output, value added, earnings, and employment. Product output is measured in physical units; value added is the difference between the value of industry outputs and inputs; earnings denotes wage earnings in an industry; and employment measures the number of workers in an industry. The emission projection guidance suggests that product output is the best indicator of future emission source growth and that its use is "preferable to any of the [other] indicators, if it is available". If product output projections are not available, value added data should be used, and if they are not available, earnings data may be used. Finally, employment projections may be used, but are not considered to be "an effective growth indicator in most cases". The emissions projection guidance also indicates that for the purposes of projecting SIP inventories, States are expected to use earnings, value added, or product output data.[1] For past SIP efforts in the Denver nonattainment area, point source projections have been accomplish by applying general surrogate growth factors based on employment or population.

Further, the emission projection guidance suggests that plant-specific surveys may not always be a reliable source of information because much of the information that is relevant to emission projections (*e.g.*, growth or decline in output, plans for expansion) may be confidential. To project VOC and NO_x emissions for the Denver ozone inventory, the EPA model Economic Growth and Analysis System[(a)], along with a survey of major point sources[(a)] was utilize to project emissions to 2010. For each type of process counted in the AIRS database for the Denver nonattainment area, a growth surrogate was produced by E-GAS. The growth surrogate was then applied on a process by process level to estimate 2010 emissions. The major point source surveys were then used to verify growth estimates from the E-GAS model. A linear relationship was then established between 1993 and 2010. From this linear relationship, 2006 VOC and Nox emissions were interpolated, and, 2013 emissions were extrapolated.

2.2 Major Point Sources

Major point sources for NO_x and VOCs are defined as those facilities having actual emissions greater than 100 tpy. Tables 2.2-1 and 2.2-2 present plant wide total emissions for those facilities having 1993 emissions greater than 100 tpy. For 1993, the total major point source emissions for VOCs are 7502.91 tpy, or, 22.81 tpsd. NO_x emissions for the base year, 1993, are estimated at 35,156.56 tpy, or, 112.69 tpsd. The projected 2006 emissions from major stationary sources for VOCs are estimated to be 8457.2 tpy, or, 25.7 tpsd, and, NO_x emissions are expected to be 35530.9 tpy or 113.9 tpsd. By 2013, VOC emissions from major point sources are projected to increase slightly to 8905.6 tpy, or, 27.1 tpsd. In 2013, NO_x emissions from major point sources are expected to be 36,352.0 tpy, or, 116.5 tpsd.

Table 2.2-1 Major Point Sources-NOx

Source ID	Source Name	1993 (tpy)	1993 (tpsd)	2006 (tpy)	2006 (tpsd)	2013 (tpy)	2013 (tpsd)
	ADAMS COUNTY						
080010001	PUBLIC SERVICE COMPANY - CHEROKEE	17924.2	59.8	18115.0	60.5	18533.6	61.9
080010003	CONOCO INC. - DENVER REFINERY	774.0	2.0	782.2	2.1	800.3	2.1
080010004	COLORADO REFINING COMPANY / TOTAL PETR.	368.1	1.1	372.0	1.1	380.6	1.1
080010025	AMOCO PRODUCTION CO. - WATTENBERG PLANT	574.6	1.2	580.7	1.2	594.1	1.2
080010036	COLORADO INTERSTATE GAS CO - WATKINS	392.8	1.0	397.0	1.0	406.1	1.1
080010051	KN WATTENBERG TRANS LLC BRIGHTON COMP	133.0	0.4	134.4	0.4	137.5	0.4
080010229	KOCH HYDROCARBON CO. - RADAR PLANT	153.4	0.4	155.0	0.4	158.6	0.4
	ADAMS COUNTY TOTAL	**20320.0**	**65.9**	**20536.3**	**66.6**	**21010.9**	**68.2**
	ARAPAHOE COUNTY						
080050028	BUCKLEY ANG BASE - COLO. AIR NAT'L GUARD	263.2	1.0	266.0	1.1	272.1	1.1
080050051	KOCH HYDROCARBON CO. - DRAGOON STATION	146.2	0.4	147.8	0.4	151.2	0.4
080050055	COLORADO INTERSTATE GAS COMPANY LATIGO	125.9	0.4	127.2	0.4	130.1	0.4
080051113	KOCH HYDROCARBON CO. MITCHELL STATION	175.8	0.5	177.7	0.5	181.8	0.5
	ARAPAHOE COUNTY TOTAL	**711.0**	**2.3**	**718.6**	**2.4**	**735.2**	**2.4**
	BOULDER COUNTY						
080130001	PUBLIC SERVICE COMPANY - VALMONT	2177.6	9.7	2200.8	9.8	2251.7	10.0
080130003	SOUTHWESTERN PORTLAND CEMENT	1858.0	6.2	1877.8	6.3	1921.2	6.4
	BOULDER COUNTY TOTAL	**4035.7**	**15.9**	**4078.6**	**16.0**	**4172.9**	**16.4**
	DENVER COUNTY						
080310007	PUBLIC SERVICE COMPANY - ZUNI	223.3	0.5	225.7	0.5	230.9	0.5
080310008	PUBLIC SERVICE COMPANY - ARAPAHOE	5795.7	16.9	5857.5	17.1	5992.8	17.5
080310012	THE GATES RUBBER COMPANY	202.8	0.6	204.9	0.6	209.7	0.6
080310041	PUBLIC SERVICE COMPANY - DELGANEY	318.3	0.7	321.7	0.7	329.2	0.8
080310950	KOCH HYDROCARBON CO. THIRD CREEK PLANT	504.3	1.6	509.6	1.6	521.4	1.6

Table 2.2-1 Major Point Sources-NOx

Source ID	Source Name	1993 (tpy)	1993 (tpsd)	2006 (tpy)	2006 (tpsd)	2013 (tpy)	2013 (tpsd)
080310951	KOCH HYDROCARBON CO. - BOXELDER STATION	115.0	0.3	116.2	0.3	118.9	0.3
080311191	PRESBYTERIAN/ST LUKES	110.2	0.3	111.4	0.3	113.9	0.3
	DENVER COUNTY TOTAL	**7269.6**	**20.8**	**7347.0**	**21.1**	**7516.8**	**21.5**
	JEFFERSON COUNTY						
080590003	ROCKY FLATS ENVIRONMENTAL TECH SITE	195.9	0.6	198.0	0.6	202.6	0.7
080590006	COORS BREWING CO.	2099.7	5.7	2122.0	5.7	2171.0	5.9
080590008	ROCKY MOUNTAIN BOTTLE COMPANY	424.0	1.1	428.5	1.2	438.4	1.2
080590701	PUBLIC SERVICE COMPANY - LEYDEN STATION	100.7	0.3	101.8	0.3	104.1	0.3
	JEFFERSON COUNTY TOTAL	**2820.3**	**7.7**	**2850.3**	**7.8**	**2916.2**	**8.0**
	TOTAL MAJOR POINT SOURCES	**35156.6**	**112.7**	**35530.9**	**113.9**	**36352.0**	**116.5**

Table 2.2-2 Major Point Sources-VOC

Source ID	Source Name	1993 (tpy)	1993 (tpsd)	2006 (tpy)	2006 (tpsd)	2013 (tpy)	2013 (tpsd)
	ADAMS COUNTY						
080010003	CONOCO INC. - DENVER REFINERY	559.4	1.5	630.5	1.7	663.9	1.8
080010004	COLORADO REFINING COMPANY / TOTAL PETR.	2577.4	7.7	2905.2	8.6	3059.2	9.1
080010005	WYCO PIPE LINE COMPANY DUPONT TERMINAL	232.7	0.6	262.2	0.7	276.1	0.8
080010014	CHASE TERMINAL CO.	186.6	0.7	210.3	0.7	221.5	0.8
080010025	AMOCO PRODUCTION CO. - WATTENBERG PLANT	320.1	0.8	360.8	0.9	379.9	1.0
080010036	COLORADO INTERSTATE GAS CO - WATKINS STA	162.3	0.5	183.0	0.5	192.7	0.5
080010481	MASTERCRAFT	110.1	0.4	124.1	0.5	130.6	0.5
	ADAMS COUNTY TOTAL	**4148.4**	**12.1**	**4676.0**	**13.7**	**4923.9**	**14.4**
	BOULDER COUNTY						
080130025	SYNTEX CHEMICALS, INC.	377.9	1.0	426.0	1.2	448.6	1.2
080130046	GRAPHICS PACKAGING CORPORATION	169.0	0.6	190.4	0.7	200.5	0.7
080130556	AVEDON ENGINEERING	109.2	0.3	123.1	0.3	129.7	0.3
	BOULDER COUNTY TOTAL	**656.1**	**1.9**	**739.6**	**2.1**	**778.8**	**2.3**
	DENVER COUNTY						
080310012	THE GATES RUBBER COMPANY	105.0	0.4	118.4	0.5	124.6	0.5
080310020	UNION CHEMICALS DIVISION UNION OIL OF CA	143.0	0.5	161.2	0.6	169.7	0.6
080310138	PILLOW KINGDOM MFG	213.0	0.7	240.1	0.8	252.8	0.8
080310535	PARADE PACKAGING MATERIALS CO.	124.3	0.5	140.1	0.5	147.5	0.6
080310910	SCHAFER COMMERCIAL SEATING INC	100.1	0.4	112.8	0.4	118.8	0.5
080311206	THE HIBBERT GROUP	600.0	2.3	676.3	2.6	712.2	2.7
	DENVER COUNTY TOTAL	**1285.3**	**4.8**	**1448.8**	**5.4**	**1525.6**	**5.7**
	DOUGLAS COUNTY						
080350007	MOLYCORP INC	112.1	0.4	126.4	0.5	133.1	0.5
	DOUGLAS COUNTY TOTAL	**112.1**	**0.4**	**126.4**	**0.5**	**133.1**	**0.5**

Table 2.2-2 Major Point Sources-VOC

Source ID	Source Name	1993 (tpy)	1993 (tpsd)	2006 (tpy)	2006 (tpsd)	2013 (tpy)	2013 (tpsd)
	JEFFERSON COUNTY			0.0	0.0	0.0	0.0
080590006	COORS BREWING CO.	945.9	2.6	1066.2	2.9	1122.8	3.0
080590010	BALL METAL CONTAINER DIV.	355.0	1.0	400.2	1.2	421.4	1.2
	JEFFERSON COUNTY TOTAL	**1300.9**	**3.6**	**1466.4**	**4.0**	**1544.1**	**4.2**
	TOTAL MAJOR POINT SOURCES	**7502.9**	**22.8**	**8457.2**	**25.7**	**8905.6**	**27.1**

2.3 Minor Point Sources

Minor point sources for VOC and NO_x emissions are defined as those facilities emitting less than 100 tpy. Table 2.3-1 presents total county emissions from NO_x. As shown in Table 2.3-1, NO_x emissions from minor point source emissions for 1993 are 2,791.03 tpy, or, 9.11 tpsd. Emissions from minor point sources are projected to 2006 and 2013 using the E-GAS model and linear interpolation. By 2006 and 2013, minor point source emissions are expected to grow to 2,820.8 tpy, or, 9.21 tpsd, and, 2838.1 tpsy or 9.9 tpsd, respectively.

Table 2.3-2 present VOC emissions from minor point sources for 1993 and 2010. For SIP reporting purposes as defined in the CAAA, the point source emissions cutoff definition for VOC sources is 10 tpy. Table 2.3.1-1 presents a breakdown summary of minor point sources in three emission ranges for 1993. These ranges are minor point source emissions between 25 tpy and 100 tpy (25<tpy<100), emissions between 10 tpy and 25 tpy (10<tpy<25), and emissions less than 10 tpy (<10 tpy). Total minor point source emissions for the base year are 6,499.22 tpy or 23.0 tpsd. By 2006 and 2013, these emissions are expected to grow to 7544.7 tpy or 26.6 tpsd, and, 8109.9 tpy or 28.6 tpsd.

Table 2.3-1 Summary of County Total Emissions From Minor Point Sources - NOx

County	1993 (tpy)	1993 (tpsd)	2006 (tpy)	2006 (tpsd)	2013 (tpy)	2013 (tpsd)
Adams	1186.04	4.07	1198.66	4.11	1206.03	4.33
Arapahoe	247.35	0.76	249.98	0.77	251.52	0.89
Boulder	302.41	0.85	305.63	0.86	307.51	0.94
Denver	601.13	2.13	607.53	2.15	611.26	2.30
Douglas	131.33	0.39	132.73	0.4	133.55	0.43

Jefferson	322.78	0.91	326.22	0.92	328.22	1.01
TOTAL	**2791.03**	**9.11**	**2820.75**	**9.21**	**2838.09**	**9.91**

Table 2.3-2 Summary of County Total Emissions From Minor Point Sources - VOC

County	1993 (tpy)	1993 (tpsd)	2006 (tpy)	2006 (tpsd)	2013 (tpy)	2013 (tpsd)
MINOR VOC SOURCES 25<TPY<100						
ADAMS	796.6	2.6	924.8	3.1	994.1	3.3
ARAPAHOE	218.4	0.8	253.5	0.9	272.5	1.0
BOULDER	424.0	1.7	492.2	2.0	529.1	2.1
DENVER	511.7	1.7	594.1	2.0	638.6	2.1
DOUGLAS	0.0	0.0	0.0	0.0	0.0	0.0
JEFFERSON	404.3	1.3	469.3	1.6	504.5	1.7
SUBTOTAL	**2355.1**	**8.2**	**2733.9**	**9.5**	**2938.7**	**10.2**
MINOR VOC SOURCES 10<TPY<25						
ADAMS	275.3	1.0	319.5	1.2	343.5	1.3
ARAPAHOE	180.5	0.7	209.6	0.8	225.3	0.8
BOULDER	155.4	0.6	180.4	0.7	193.9	0.8
DENVER	432.0	1.6	501.5	1.9	539.1	2.0
DOUGLAS	35.5	0.1	41.2	0.1	44.2	0.1
JEFFERSON	138.4	0.5	160.7	0.6	172.7	0.6
SUBTOTAL	**1217.1**	**4.5**	**1412.9**	**5.2**	**1518.7**	**5.6**
MINOR VOC SOURCES TPY<10						
ADAMS	633.2	2.3	735.1	2.7	790.1	2.9
ARAPAHOE	529.1	1.8	614.2	2.1	660.2	2.2
BOULDER	334.1	1.2	387.9	1.4	416.9	1.5
DENVER	906.0	3.3	1051.7	3.8	1130.5	4.1
DOUGLAS	75.9	0.3	88.1	0.3	94.7	0.3
JEFFERSON	448.8	1.5	521.0	1.7	560.0	1.8
SUBTOTAL	**2927.1**	**10.3**	**3397.9**	**11.9**	3652.5	12.8
MINOR POINT SOURCE TOTAL	**6499.2**	**23.0**	**7544.7**	**26.6**	**8109.9**	**28.6**

3.0 ON-ROAD MOBILE SOURCES

Estimates for carbon monoxide (CO) emissions from on-road mobile sources are based on the Environmental Protection Agency (EPA) Mobile Source Emissions Model B MOBILE5b.

3.1. Control Strategy Recommendations

Regional Air Quality Commission Mobile Source Carbon Monoxide Control Strategy Recommendation for 2006 and 2013:

$ I/M 240 program with newest 4 model-year exemption
$ No oxygenated fuel program (summer season conditions)
$. 80% Remote Sensing Device (RSD) program for 2006, no RSD program for 2013

3.2. Vehicle Miles Traveled (VMT)

The DRCOG 1999-2004 Transportation Improvement Conformity networks were utilized as the basis for the vehicle miles traveled (VMT) estimates. DRCOG has revised population and household growth estimates since this TIP Conformity analysis was complete in August 1998. Incorporating the revised growth rates results in 2006 and 2013 VMT estimated as follows:

2006 magnitude and distribution of VMT in the Denver-Boulder NAA represented by 2011 DB Network 2020 AC

2013 magnitude and distribution of VMT in the Denver-Boulder NAA represented by 2020 AC Network multiplied by a factor on 1.037

The VMT totals are summarized in the following two tables.

Table 1 . Daily VMT totals in the Denver-Boulder Ozone Nonattainment Area.

Year	AM Peak	PM Peak	Off-Peak	Total
2006	9,763,271	21,952,324	32,103,532	63,819,127
2013	11,110,419	25,054,030	37,619,679	73,784,128

Table 2 . VMT totals in the Denver-Boulder carbon monoxide Urban Airshed Modeling domain.

Year	AM Peak	PM Peak	Off-Peak	Total
2006	10,179,724	22,873,759	33,706,082	66,759,564
2013	11,582,081	26,104,812	39,499,790	77,186,683

The tabular summaries of vehicle miles traveled by area type and functional classification and the ten peak periods are included in Appendix A.

3.3. Mobile5b Emission Factor Modeling

Elements of Mobile5b Emission Factor Modeling:

$ I/M 240 program with newest four model years exempt
$ No oxygenated fuel
$ 80% RSD program in 2006; No RSD in 2013
$ National Low Emitting Vehicle(NLEV) program commencing in 2001
$ Mechanics training credit
$ The most stringent cut-points available in Mobile5b for an I/M 240 program

I/M 240 program on light duty gasoline powered vehicles is characterized as follows:

$ Start year (January 1): 1982
$ Pre-1981 MYR stringency rate: 20%
$ First model year covered: 1982
$ Last model year covered: 2002 in 2006; 2009 in 2013
$ Waiver rate (pre-1981): 0%
$ Waiver rate (1981 and newer): 0%
$ Compliance Rate: 98%
$ Inspection type: Test Only
$ Inspection frequency: Biennial
$ Vehicle types covered: LDGV LDGT1 LDGT2
$ 1981 & later MYR test type: IM240 test
$ Cutpoints: HC: 0.600 CO: 10.000 NOx: 1.500

I/M 240 program on heavy duty gasoline powered vehicles is characterized as follows:

$ Start year (January 1): 1982
$ Pre-1981 MYR stringency rate: 20%
$ First model year covered: 1982
$ Last model year covered: 2002 in 2006; 2009 in 2013
$ Waiver rate (pre-1981): 0%
$ Waiver rate (1981 and newer): 0.%
$ Compliance Rate: 98.%
$ Inspection type Test Only
$ Inspection frequency: Biennial
$ Vehicle types covered: HDGV
$ 1981 & later MYR test type: 2500 rpm / Idle
$ Cutpoints: HC: 220.000 CO: 1.200 NOx: 999.000

Anti-tampering program for all gasoline-powered vehicles is characterized as follows:

$ Check: ATP
$ Start Model Year: 1982
$ Model Years Covered: 1975-2002 for 2006; 1975-2009 for 2013
$ Vehicle Classes Covered: LDGV LDGT1 LDGT2 HDGV
$ Inspection Type: Test Only

- $ Frequency: Biennial
- $ Compliance Rate: 98.0%
- $ Air pump system disablement: Yes
- $ Catalyst removals: Yes
- $ Fuel inlet restrictor disablement: No
- $ Tailpipe lead deposit test: No
- $ EGR disablement: No
- $ Evaporative system disablement: No
- $ PCV system disablement: No
- $ Missing gas caps: Yes

$The following maximum, minimum and ambient temperatures were used in the Mobile5b. These temperatures were determined according to guidance in Volume IV.

AM Peak ambient temperature	= 64 deg F
PM Peak ambient temperature	= 77 deg F
OFF Peak ambient temperature	= 71 deg F
Minimum temperature	= 78 deg F
Maximum temperature	= 58 deg F

The ambient temperatures were used to estimate exhaust, running loss and resting loss components of the volatile organic compound emissions. TEMFLG is set to ›2⁼ in the Mobile5b input stream to indicate the use of the ambient temperatures in the emission rate calculations.

Volume IV guidance indicates that the evaporative and refueling components of the volatile organic compound inventories are to be determined using the maximum and minimum temperature rather than the ambient temperature. TEMFLG is set to ›1⁼ in Mobile5b input stream to indicate the use of the maximum and minimum temperatures rather than the ambient temperature. In order to determine scenario records input appropriate for a 24-hour period, the speed, vehicle mixes, and operating modes were weighted with vehicle miles traveled over the ten time periods. This results in one scenario for each area type and roadway class. The Mobile5b input stream for the evaporative and refueling components is included in Appendix B.

3.4. NLEV Credit Estimate

The emission reduction affects of the National Low Emission Vehicle program on light-duty gas vehicles (LDGV) and light-duty truck 1 vehicles (LDGT1) was estimated for purposes of this analysis though two Mobile5b emission factor runs. Mobile5b runs are made for high altitude as described above. In order to estimate the NLEV benefit on LDGV and LDGT1, a similar run was made for low altitude with the flags set to include the NLEV program starting in 2001. The emission factors for LDGV and LDGT1vehicles were taken from the low altitude mobile5b runs to replace the same emission factors from the high altitude runs. The composite (vehicle mix weighted) emission factor was then re-calculated. The FORTRAN algorithm used to accomplish these calculations is included in Appendix B.

3.5. RSD Program

$RSD Modeling Inputs:

- $ RSD Fleet Coverage Option 2 (Commitment to vehicle coverage)
- $ Program type = 5 (Clean screening remote-sensing program)
- $ RSD cutpoint .5% CO, 200ppm HC
- $ RSD clean screening with I/M 240 final cutpoint effectiveness

$ 2006 Vehicle Population of 2,459,748 (Based on 2 million vehicles in 1999 with 3% annual increase)
$ Fleet subject to clean screen = 100%
$$ 80% Clean Screen (80% of vehicle population per vehicle age)
$ Colorado=s registration distribution

Table 3. Input file in the EPA RSD model to generate the 80% credit file.

```
0 Clean screen, vehicles projected 2006, 80% rsd
1          2 Commitment to vehicle coverage
2          5 Clean screening RSD

5 Imdata.d
7 Tech12.d
5 Im.d
7 Tech.d
4          2 ELIGIBLE CLEAN SCREEN PRE 75
5          2 ELIGIBLE CLEAN SCREEN 75-80
6          2 ELIGIBLE CLEAN SCREEN 81-85
7          2 ELIGIBLE CLEAN SCREEN 86-89
8          2 ELIGIBLE CLEAN SCREEN 90 +
9          4 RSD
UTPOINTS AND LEP VALUES (1=.5/200)
4          2 RSD
INAL CUTPOINT
0 NUMBER OF VEHICLES ELIGIBLE FOR CLEAN SCREEN
0 80% RSD

0 ---------- ---------
1     120734     96587 TOTAL VEHICLES, VEHICLES ELIGIBLE 0-1
2     140985    112788 TOTAL VEHICLES, VEHICLES ELIGIBLE 1-2
3     134224    107379 TOTAL VEHICLES, VEHICLES ELIGIBLE 2-3
4     146707    117365 TOTAL VEHICLES, VEHICLES ELIGIBLE 3-4
5     155424    124339 TOTAL VEHICLES, VEHICLES ELIGIBLE 4-5
6     186547    149238 TOTAL VEHICLES, VEHICLES ELIGIBLE 5-6
7     180287    144230 TOTAL VEHICLES, VEHICLES ELIGIBLE 6-7
8     153722    122978 TOTAL VEHICLES, VEHICLES ELIGIBLE 7-8
9     146709    117367 TOTAL VEHICLES, VEHICLES ELIGIBLE 8-9
0     100218     80174 TOTAL VEHICLES, VEHICLES ELIGIBLE 9-10
1     131124    104899 TOTAL VEHICLES, VEHICLES ELIGIBLE 10-11
2     125860    100688 TOTAL VEHICLES, VEHICLES ELIGIBLE 11-12
3     108005     86404 TOTAL VEHICLES, VEHICLES ELIGIBLE 12-13
4      78572     62857 TOTAL VEHICLES, VEHICLES ELIGIBLE 13-14
5      67328     53863 TOTAL VEHICLES, VEHICLES ELIGIBLE 14-15
6      60739     48591 TOTAL VEHICLES, VEHICLES ELIGIBLE 15-16
7      58171     46536 TOTAL VEHICLES, VEHICLES ELIGIBLE 16-17
8      55307     44246 TOTAL VEHICLES, VEHICLES ELIGIBLE 17-18
9      52444     41955 TOTAL VEHICLES, VEHICLES ELIGIBLE 18-19
0      30823     24658 TOTAL VEHICLES, VEHICLES ELIGIBLE 19-20
1      24506     19605 TOTAL VEHICLES, VEHICLES ELIGIBLE 20-21
2      18254     14603 TOTAL VEHICLES, VEHICLES ELIGIBLE 21-22
3      11937      9550 TOTAL VEHICLES, VEHICLES ELIGIBLE 22-23
4       4885      3908 TOTAL VEHICLES, VEHICLES ELIGIBLE 23-24
5       1432      1145 TOTAL VEHICLES, VEHICLES ELIGIBLE 24-25
```

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Table 4. Data used in model year calculations of eligible vehicles.

VEHICLE COUNT FOR 2006
BASED ON 3% INCREASE PER YEAR
1999 = 2,000,000

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2000000	2060000	2121800	2185454	2251018	2318548	2388105	2459748	2533540	2609546	2687833	2768468	2851522

VMT
WEIGHTED AVERAGE VEHICLE MIX FOR 2006

LDGV	0.582	1431573
LDGT1	0.221	543604
LDGT2	0.104	255814
HDGV	0.026	63953
	TOTALS	2294945

VEHICLE AGE

*	LDGV	LDGV TOTALS	LDGT1*	LDGT1 TOTALS	LDGT2*	LDGT2 TOTALS	HDGV*	HDGV TOTALS	GRAND TOTALS
1	0.049	70147	0.058	31529	0.058	14837	0.066	4221	120734
2	0.065	93052	0.055	29898	0.055	14070	0.062	3965	140985
3	0.067	95915	0.044	23919	0.044	11256	0.049	3134	134224
4	0.074	105936	0.047	25549	0.047	12023	0.05	3198	146707
5	0.08	114526	0.047	25549	0.047	12023	0.052	3326	155424
6	0.083	118821	0.078	42401	0.078	19953	0.084	5372	186547
7	0.082	117389	0.071	38596	0.071	18163	0.096	6140	180287
8	0.068	97347	0.065	35334	0.065	16628	0.069	4413	153722
9	0.065	93052	0.062	33703	0.062	15860	0.064	4093	146709
10	0.043	61558	0.045	24462	0.045	11512	0.042	2686	100218
11	0.058	83031	0.056	30442	0.056	14326	0.052	3326	131124
12	0.052	74442	0.06	32616	0.06	15349	0.054	3453	125860
13	0.045	64421	0.051	27724	0.051	13047	0.044	2814	108005
14	0.034	48673	0.035	19026	0.035	8953	0.03	1919	78572
15	0.028	40084	0.032	17395	0.032	8186	0.026	1663	67328
16	0.024	34358	0.031	16852	0.031	7930	0.025	1599	60739
17	0.021	30063	0.033	17939	0.033	8442	0.027	1727	58171
18	0.019	27200	0.033	17939	0.033	8442	0.027	1727	55307
19	0.017	24337	0.033	17939	0.033	8442	0.027	1727	52444
20	0.009	12884	0.021	11416	0.021	5372	0.018	1151	30823
21	0.007	10021	0.017	9241	0.017	4349	0.014	895	24506
22	0.005	7158	0.013	7067	0.013	3326	0.011	703	18254
23	0.003	4295	0.009	4892	0.009	2302	0.007	448	11937
24	0.001	1432	0.004	2174	0.004	1023	0.004	256	4885
25	0.001	1432	0	0	0	0	0	0	1432
	1	1431573	1	543604	1	255814	1	63953	2294945

•* REGISTRATION DISTRIBUTION

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2294945 1 1431573 1 543604 1 255814 1 63953

$* REGISTRATION DISTRIBUTION

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3.6. Oxygenated Fuel Program

An oxygenated fuel program is not included in these inventories since they characterize summer season conditions.

3.7. Mobile5b Scenario Inputs

The scenario section inputs reflect the same assumptions as were used for the Denver-Boulder Carbon Monoxide State Implementation Plan. The Mobile5b scenario section inputs for 2006 and 2013 are included in Appendix D as part on the Mobile5b input files. The vehicle speeds used as Mobile5b input result from the DRCOG Transportation Improvement Plan conformity analysis transportation network modeling. These speed are also included as part of the scenario section inputs.

3.8. Carbon Monoxide Emission Factors for 2006 and 2013

Appendix B includes the Mobile5b inputs and outputs for 2006 and 2013. Appendix C contains the resultant emission factors summarized by road class, area type and the ten peak periods.

3.9. Emission Inventory Calculations

The 2006 and 2013 volatile organic compound and nitrogen oxide emission inventories in the Denver-Boulder Nonattainment area and in the Urban Airshed Modeling domain resultant from the emission factors and the VMT are summarized in the following tables. The 2006 and 2013 volatile organic compound and nitrogen oxide emission inventories in the Carbon Monoxide Dispersion Modeling Domain and the Denver-Boulder Nonattainment Area are summarized by road class and area type in Appendix D.

Table 5 . On-road mobile source emission estimates in tons per day (tpd) in the Denver-Boulder carbon monoxide Urban Airshed Modeling domain.

Year	AM Peak	PM Peak	Off Peak	Total
2006 NOx	18.470	37.943	**66.885**	123.298
2006 VOC	15.949	30.887	41.423	88.258
2013 NOx	18.559	38.370	69.984	125.913
2013 VOC	13.650	26.680	36.801	77.131

Table 6. On-road mobile source emission estimates in tons per day (tpd) in the Denver-Boulder Ozone Nonattainment Area.

Year	AM Peak	PM Peak	Off Peak	Total
2006 NOx	17.389	35.722	62.073	115.184
2006 VOC	15.361	29.736	39.333	84.430
2013 NOx	17.390	35.976	63.833	117.200
2013 VOC	13.121	25.654	34.868	73.643

4.0 NON-ROAD MOBILE SOURCES

Non-road emission inventories were developed for aircraft, railroads and other miscellaneous off-highway vehicles. The miscellaneous non-road emissions inventory contains emissions from a large assortment of off-road vehicles and small engines. The source categories associated with non-road mobile sources include:

- Aircraft
- Locomotives
- Construction Equipment
- Industrial Equipment
- Lawn and Garden/Logging
- Farm Equipment
- Airport Service Equipment
- Light Commercial Equipment
- Recreational Vehicles
- Recreational Boats

4.1 AIRCRAFT

4.1.1 Abstract

EPA methods and emission factors are used to estimate emissions from aircraft at airports within the nonattainment area. For larger airports which inventory their landing and takeoff (LTO) by aircraft type, the Federal Aviation Administration Aircraft Engine Data Base (FAEED) was used to estimate the fleet total emissions. The FAEED data base contains a listing of engines that are installed on the various aircraft along with an emission factor for each engine. For smaller airports that only keep track of the number of LTOs, a fleet average emission factor is used. At larger airports which allow general aviation, a combination of the two methods are used. Activity data, such as LTOs, was solicited by the various airfields and government agency documents.

4.1.2 Introduction

Two methods are available for determining aircraft emissions.[(1)(2)] Large commercial airports and military bases are required by guidance to use FAEED to determine their emissions. These types of facilities generally have the landing and take-off data by aircraft type (e.g., seventeen Boeing 737 model 200 LTO's occurred last year) necessary to run FAEED. At smaller airfields with general aviation or air taxi usage, the number of LTO's are categorized into broad aircraft types, not specific makes and models. For these facilities, a fleet average emissions factor is applied to each LTO based on the general type of aircraft (i.e., general aviation or air taxi). For instance, the emissions factor for general aviation is 12.014 lb of CO per LTO.

The Federal Aviation Administration Aircraft Engine Database (FAEED) is a database application which associates an aircraft (e.g., Lockheed L-1011 model 500) with the emissions from the engines installed on it (e.g., Rolls Royce model RB211-524B4). Since aircraft can have many different engines installed on them, the FAA gathers data describing an engines market share for a given aircraft. FAEED allows the user to calculate weighted average emissions based on these market share data. We chose this option in deriving these inventories. Default time-in-mode values were employed. US fleet averages of engine type distributions for a given airframe were used in FAEED whenever possible. Emissions estimates and activity data references can be found in the appendix.

4.1.3 FAEED Based Emissions Estimates

Unfortunately, not all aircraft, nor aircraft engines are found in FAEED.[b] Therefore, not all commercial, nor all

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Generally older aircraft or more specialized aircraft are not found in FAEED. This is more of a problem for military - as opposed to commercial -

military LTO's can be directly calculated using this application. Since this circumstance is not dealt with in guidance, we proposed a method to EPA Region VIII and they accepted.(3)(4) The FAEED calculated emissions are increased in direct proportion to the ratio of total LTO's to FAEED calculated LTO's. In other words, the FAEED emissions are "scaled-up" to represent all aircraft emissions, even those not in the database. This procedure was used to calculate emissions for both commercial and military aircraft at Peterson Field and is presented in the following equation:

$$\text{Airfield Emissions}_{Total} = \text{Airfield Emissions}_{FAEED} \times \frac{LTO_{Total}}{LTO_{FAEED}}$$

If FAEED could estimate emissions for all aircraft the ratio of LTO's, or the scaling factor, would be equal to 1.0, if none of the LTO's are explained, then scaling factor would be 0. This procedure was applied to commercial aircraft emissions at Stapleton International Airport only, the limited data available for Buckley Air National Guard Base (BANGB) precluded its application here.

LTO data by aircraft type were not available for Buckley ANGB. The data we did have allowed us to make a reasonable estimate of aircraft specific LTO's. BANGB provided the total annual LTO's undifferentiated by aircraft type for 1993, a detailed listing of aircraft which have used the base in 1995 (but not aircraft specific LTO's), and relative usage rates of different kinds of aircraft (i.e., 3 fighter LTO's for every cargo LTO).(5)(6)(7) To estimate the aircraft specific LTO's, the following procedure was used. The annual number of all aircraft models which had used BANGB (i.e., either based or transient) during the year were input to the LTO field of FAEED. These aircraft were defined to be one of the specific types provided by Buckley ANGB, including: fighter, attack, cargo, and trainer. The emissions and "LTO's" from each of these groups were summed. The relative usage proportions were then applied to these aircraft groups. Specifically, in 1993 there were 3 fighter LTO's for every cargo LTO, and 2 fighter LTO's for every trainer LTO. This step corrected the emissions for the differing levels of usage each of these plane types received. The total activity for all aircraft types were then proportionally increased to match the number of LTO's reported for 1993. This step simply forces the estimated activity level to match what was reported. We believe this is a reasonable technique, given the type of data available. Since the same types of aircraft were based at Buckley ANGB in 1995 as there were in 1993, our use of 1995 based aircraft to represent 1993 LTO's seems justifiable.(8)

4.1.4 Fleet Average Based Emissions Estimates

For all other facilities (i.e., those without LTO's by aircraft make and model) emissions were estimated using the fleet average emissions factor. This is EPA's alternative procedure for determining aircraft emissions. It has been applied to all general aviation and air taxi LTO's which occur at both large and small airfields. The FAA reports aircraft activity for air carrier (i.e., commercial), air taxi (i.e., limited regularly scheduled service or mail delivery), general aviation (i.e., smaller business and other private aircraft), and military aircraft.(9) In this report, activity is expressed in "operations", which may be a landing or a take-off, and therefore when divided by two are equivalent to LTO's. Both military and a few air carrier operations are reported at facilities other than Buckley or Stapleton.

After checking with the affected airfield, we found that the military planes using these facilities were "general aviation" in nature, though owned by the military. Additionally, due to the landing weight restrictions at Centennial Airport, the commercial operations reported were related smaller aircraft, therefore we are considering these "air taxi" operations.(10) These assumptions seem reasonable for the purpose of calculating emissions and were necessary since no data were available on the make and model of these aircraft.

aircraft.

4.1.5 Helicopters

Data on helicopter activity is limited. The Denver Regional Council of Governments has estimated helicopter activity levels for 1990 and 1995.[11] Lacking the appropriate data, FAEED could not be used to estimate helicopter emissions. Therefore, the alternative fleet average procedure was applied, treating non-helicopters as general aviation aircraft.[12] Note: Buckley ANGB did not report any helicopter activity to us. Helicopter emissions were estimated along with the other airfields to which the fleet average methodology was applied. These estimates can be found in the appendix.

4.1.6 Revised Emissions Estimates for Denver International Airport

Denver International Airport released the document, ASummary of 2001 Construction Emissions and Emission Forecasts at Denver International Airport (November 27, 2000). A summary of this document and projections of DIA emissions to 2006 and 2013 was transmitted to APCD on November 30, 2000. This transmittal is included in Appendix D.

In 1993, DIA estimates that aircraft NOx emissions were 2,534.8 tpy or 6.9 tpd at Stapleton Airport. Emissions from airport service equipment in 1993 at Stapleton were 407 tpy or 1.11 tpd of NOx.

The updated DIA inventories for aircraft in 2006 is 12.6 tpd Nox and 1.6 tpsd VOC in 2006. In 2013, these emissions are 17.1 tpsd Nox and 1.68 tpsd VOC. DIA also provided emissions from Interzonal vehicle traffic, construction equipment, industrial equipment, airport service equipment, gasoline distribution and natural gas use. To avoid double counting, it is assumed that these emissions have already been accounted for in the emission inventory. Table 4.1.6-1 presents a summary of emissions for DIA in 2006 and 2013.

TABLE 4.1.6-1 DIA Emission Inventory

Inventory Sub-Category	2006				2013			
	Nox (TPY)	Nox (tpd)	VOC (TPY)	VOC (tpd)	Nox (TPY)	Nox (tpd)	VOC (TPY)	VOC (tpd)
Aircraft	4389.7	12.0	578.4	1.6	6028.2	16.5	602.7	1.7
United Expansion	195.0	0.5	10.8	0.0	195.0	0.5	10.8	0.0
Standard GSE	645.7	1.8	188.7	0.5	757.4	2.1	232.6	0.6
United Expansion GSE	34.2	0.1	9.6	0.0	34.2	0.1	9.6	0.0
Rental Car Shuttles	108.6	0.3	26.2	0.1	138.7	0.4	33.5	0.1
Employee/Public Shuttles	78.1	0.2	0.8	0.0	99.8	0.3	1.0	0.0
City Fleet and Plows	212.0	0.6	75.7	0.2	252.7	0.7	90.2	0.2
Central Plant Engines	21.3	0.1	21.3	0.1	21.3	0.1	21.3	0.1
Central Plant Boilers	18.3	0.1	1.2	0.0	18.3	0.1	1.2	0.0
Misc. Denver Source	6.4	0.0	3.2	0.0	6.4	0.0	3.2	0.0

Inventory Sub-Category	2006				2013			
Misc Nat. Gas Sources	47.7	0.1	2.5	0.0	60.9	0.2	3.2	0.0
Diesel-fueled sources	33.3	0.1	1.2	0.0	42.6	0.1	1.5	0.0
Rental Car Refueling	0.0	0.0	62.1	0.2		0.0	79.3	0.2
Misc. (Paint booths, fuel tank farm)	0.0	0.0	76.7	0.2		0.0	91.5	0.3
Fire Fighter Training	0.2	0.0	0.8	0.0	0.2	0.0	0.8	0.0
Worldport	4.5	0.0	0.7	0.0	4.5	0.0	0.7	0.0
On-Airport Hotel	2.3	0.0	0.4	0.0	2.3	0.0	0.4	0.0
Oil and Gas Production	0.0	0.0	17.1	0.0	0.0	0.0	17.1	0.0
Oil and Gas Well Construction	6.9	0.0	1.0	0.0	6.9	0.0	1.0	0.0
Agricultural Activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Constructions Activities.	638.1	1.7	317.9	0.9	638.1	1.7	317.9	0.9
Totals	6442.1	17.7	1396.1	3.8	8307.3	22.8	1519.4	4.2

Based on this inventory, the Division has specifically identified and accounted for DIA emissions in the maintenance plan. Therefore, for the purposes of General Conformity demonstration, DIA should use the emission inventory from Table 4.1.6-1 and Table 1.6-1 of this Technical Support Document.

4.1.7 Seasonal Adjustments

Seasonal adjustments were made to the airport emissions on a facility specific basis. For Stapleton International Airport, a ratio of the total air-carrier operations which occurred at Stapleton during June 1993, July 1993, and August 1993, divided by the 1993 annual total.[13] Quarterly data for 1993 were available for all other facilities, the first quarter of 1993 was used as a reasonable facsimile to the peak CO season activity and the third quarter of 1993 was used to represent the peak O_3 season activity.[14] The annual to summer ratio used was 0.94.

4.1.8 Conclusions

Table 4.1.8-1 presents a summary of emissions from ozone precursor gases for aircraft at airports for 1993. Total NO_x emissions are 2,596.2 tpy, or, 7.11 tpsd. Hydrocarbon emissions for 1993 are estimated at 655.8 tpy, or, 1.857 tpsd.

By 2013, aircraft Nox emissions are expected to grow to 17.2 tpsd. VOC emissions are projected to be 2.1 tpsd.

Table 4.1.8-1 Cumulative Aircraft Emissions by Airport

Airfield	1993 Annual NO_x (tpy)	1993 Annual VOC (tpy)	1993 Summer Day NO_x Emissions (tpsd)	1993 Summer Day VOC Emissions (tpsd)	Annual Growth Rate (%/yr)	2006 Summer Day NO_X (tpsd)	2006 Summer Day VOC (tpsd)	2013 Summer Day NO_X (tpsd)	2013 Summer Day VOC (tpsd)
Aurora	0.5	3.0	0.001	0.008	0.7	0.001	0.008	0.001	0.009
Boulder	1.7	10.3	0.006	0.038	0.7	0.005	0.029	0.005	0.030
Brighton Van Airs	0.5	3.0	0.001	0.008	0.7	0.001	0.008	0.001	0.009
Buckley ANGB	44.1	16.1	0.121	0.040	0.7	0.124	0.045	0.129	0.047
Centennial	6.8	40.3	0.020	0.125	0.7	0.019	0.113	0.020	0.118
Front Range	1.3	7.4	0.004	0.022	0.7	0.004	0.021	0.004	0.022
Helicopters	2.5	15.0	0.007	0.042	0.7	0.007	0.042	0.007	0.044
Jefferson County	2.5	14.9	0.008	0.047	0.7	0.007	0.042	0.007	0.044
Longmont	1.4	8.3	0.004	0.027	1.7	0.004	0.026	0.005	0.029
Stapleton /DIA	2534.8	552.0	6.944	1.500	1.7	12.5	1.600	17.1	1.700
Total	**2596.2**	**670.3**	**7.116**	**1.857**		**12.7**	**1.9**	**17.2**	**2.1**

4.2 RAILROAD LOCOMOTIVES

4.2.1 Abstract

The methodologies and emission factors used to estimate hydrocarbon (HC) and NO_x emissions from railroad locomotives are estimated using EPA methods. Emissions from locomotives are entirely line sources which are aggregated as area sources. Emissions from line haul and switch yard locomotives are estimated from activity data obtained from the various railroad companies multiplied by specific line haul and switch yard emission factors[(1)].

4.2.2 Introduction

Diesel-electric locomotives - categorized by EPA as non-road mobile sources - have diesel engines and an alternator or generator to produce electricity to provide power for the traction motors. Air pollutants are produced during the combustion process. EPA technical guidance for generating a base-year inventory has been followed to estimate ozone precursor gas emissions.[(2)] The EPA methodology addresses two types of locomotives: line haul and switch (or yard). Railroads are classified as Class I, II, or III.[c] **It should be noted that other railroad related sources such as engines used on refrigerated and heated rail cars are not included in this category since they are considered "off-highway equipment."**

4.2.3 Railroad Locomotive Inventory Methodology

For *line haul locomotives*, annually averaged traffic density estimates in gross tons (GT) or gross ton miles (GTM) are used along with the fuel consumption index (FCI) to estimate fuel consumption for each active segment of railroad track. For Class III railroads, actual fuel consumption data are typically available because all of the activity occurs within Colorado.

Emissions estimates are based on EPA emissions factors which are stated in pounds of pollutant per gallon of fuel consumed. For companies that did not report actual fuel consumption, fuel usage was calculated as follows:

1.) track mileage data were obtained either from the railroad or from GIS technology via ARCVIEW;

2.) if Gross Ton Miles (GTM) data were available, it could be directly used in fuel consumption calculations (see step 3) after being multiplied by the percentage of the track segment within the nonattainment area; if Gross Ton (GT) data were provided, the estimate for each track segment was multiplied by the miles of the track in the nonattainment area to obtain the Gross Ton Mile (GTM) estimate;

3.) annual fuel usage for line haul locomotives was obtained by multiplying the fuel consumption index by the traffic density (GTM).

If a railroad company provided a Colorado specific FCI, it was used. Otherwise, the FCI was calculated with system-wide data (i.e., national data) from the Interstate Commerce Commission's (ICC) "R-1" annual report, as recommended by EPA guidance. If the R-1 report for the appropriate year was not available for a given Class I railroad,

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'he Interstate Commerce Commission (ICC) broadly classifies Class I railroads as those earning adjusted annual operating revenues for three cutive years of $250,000,000 or more. Railroads with less than $250,000,000 revenues are classified as either Class II ($20,000,000 to $250,000,000) or III (less than $20,000,000). All switching and terminal companies are defined as Class III railroads.

national traffic density and fuel expense data were obtained from other ICC documents so that system-wide fuel consumption could be calculated based on the estimated cost per gallon of fuel.[(3), (4)]

For *switch locomotives*, emissions estimates are based on EPA emission factors which are stated either in pounds of pollutant per gallon of fuel consumed *or* in pounds of pollutant per yard locomotive per year. When available, fuel consumption data are the preferred type of activity data. When fuel consumption data were not reported, the number of active switch locomotives was used in the emissions calculations.

Estimated total hydrocarbon (THC) emissions from railroad locomotives can be converted to volatile organic compound (VOC) emissions by multiplying the HC estimate by a correction factor of 1.005.[(5)] The correction factor is necessary because the THC emission factor represents total hydrocarbons as measured by flame ionization detection. Thus, the contribution from some functional groups such as carbonyls (e.g., formaldehyde) are underestimated by the measurement method.[(6)]

4.2.4 Activity Data

According to the railroads contacted, locomotive activity is essentially continuous throughout the year with no significant seasonal component. Thus, typical operating day emissions for both line haul and switch locomotives are estimated by dividing the annual estimate by the number of days in a year.

The Denver ozone nonattainment area has Class I and Class III railroads; there are no Class II railroads.[(7), (8), (9)] Activity data for the ozone nonattainment have been obtained from each railroad company for 1993.[(10),(11),(12),(13),(14),(15),(16),(17),(18)] If some or all of the 1993 data are not available for a railroad which was active during 1993, activity data are estimated from 1990 levels.

Eight railroad companies have been identified with activity in the Denver nonattainment area. Five are Class I railroads: 1) Burlington Northern Railroad; 2) Atchison, Topeka, and Santa Fe Railway Co.; 3) Union Pacific Railroad Co.; 4) Southern Pacific (includes former Denver Rio Grande Western activity); 5) AMTRAK. Two are Class III railroads: 1) Denver Railway; 2) Denver Rock Island; and, 3) Great Western Railway of Colorado. Denver Railway was operated by Great Western Railway Company of Colorado under an ICC directed service order from January through September 1993 under the name Platte Valley Railway. In September 1993, Denver Railway became the Denver Rock Island Railroad. AMTRAK activity is based on number of trips per year on each of three routes.

All activity data are for 1993 with the exception of switch locomotive activity for Southern Pacific(SP). While SP provided line haul activity for 1993, it is not clear if the line haul data included switch locomotive activity. SP's representative was notified that the Division would assume the Denver Rio Grande Western's (DRGW) 1990 switch locomotive activity is representative of 1993 SP switch activity unless other data were received.[(19)] As of September 28, 1995 no response had been received. Thus, it has been assumed that 1990 DRGW switch activity is representative of 1993 SP switch activity.

4.2.5 Projection Methodology

A ratio from EPA=s Non-Road model was used to project 1993 emission to 2006 and 2013. The Non-Road model was used to account for both growth in activity levels and reductions due to new regulations. The six county railroad emission for NO_x and VOC in 1993 as estimated by the Non-Road model is 0.09 tpsd and 0.03 tpsd, respectively. The Non-Road Model estimated VOC and NO_x emissions for 2006 are 0.08 tpsd, and, 0.02 tpsd. The ratio of 2006 to 1993 for VOC and NO_x is 0.89 and 0.67.

The Non-Road Model estimated VOC and NO_x emissions for 2013 are 0.06 tpsd and 0.01 tpsd, respectively. The resultant 2013 to 1993 VOC and NOx ratios are 0.67 and 0.33.

4.2.6 Conclusion

Table 4.2.6-1 presents a summary of railroad locomotive emission rates for the Denver ozone nonattainment area. As shown in Table 4.2.6-1, it is estimated the NO_x emissions will be reduced from 3.7 tpsd in 1993 to 1.2 tpsd in 2013 due to new locomotive engine standards. VOC emissions are estimated to decrease from 0.3 tpsd in 1993 to 0.1 tpsd in 2013.

Table 4.2.6-1 Estimation of Emissions from Railroad Locomotives in the Nonattainment Area

Pollutant	1993 Annual Emissions (tpy)	1993 Summer Day Emissions (tpsd)	2006 Summer Day Emissions (tpsd)	2013 Summer Day Emissions (tpsd)
Nitrogen Oxides	1581	3.7	2.5	1.2
Hydrocarbons	106	0.3	0.3	0.1

1. "1993 Denver Ozone Inventory-Railroad Locomotives", CDPHE memorandum from Chuck Machovec to Kevin Briggs, August 29, 1995.
2. *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, U. S. EPA, Office of Mobile Sources, EPA-450/4-81-026d (Revised), July 1992.
3. *Transport Statistics in the United States -1993: Railroad Companies and Motor Carriers Subject to the Interstate Commerce Act*, Interstate Commerce Commission, Office of Economic & Environmental Analysis, 1993.
4. "Inventory Information on Class I Railroads," CDPHE memorandum from P. Woodford to C. Machovec, April 4, 1995.
5. *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, U. S. EPA, Office of Mobile Sources, EPA-450/4-81-026d (Revised), July 1992, pp. 213-214.
6. Douglas A. Skoog, Principles of Instrumental Analysis, Saunders College Publishing, Third Edition, 1985, pp. 767-768.
7. *Colorado - State Rail Plan 1991 Update*, Colorado Department of Transportation, Division of Transportation Development, in cooperation with the Federal Railroad Commission, May 1992.
8. "Inventory information on Class I, II, and III Railroads," CDPHE memorandum from Phyllis Woodford to C. Machovec, April 17, 1995.
9. "Class I and III Railroad Contact(s) - Update," CDPHE memorandum from P. Woodford to C. Machovec, May 2, 1995.
10. Letter from Ben Barnes, AMTRAK, to Phyllis Woodford, CDPHE, May 1995.
11. "Locomotive emissions in Colorado," letter from Mark Stehly, Atchison, Topeka, and Santa Fe Railway Co., to C. Machovec, CDPHE, June 28, 1995.
12. "Burlington Northern rail operation for 1993 around the Denver area," letter from Henry Stopplecamp, Burlington Northern Railroad, to C. Machovec, CDPHE, June 9, 1995.
13. Letter from Elizabeth Hill, Burlington Northern, to C. Machovec, CDPHE, June 13, 1995.
14. Letter from Dennis Arfmann concerning Southern Pacific GTM, Holme Roberts & Owen, to C. Machovec, CDPHE, July 25, 1995.
15. Personal Communication between Lonnie Morgan, Denver Rock Island Railroad, and C. Machovec, CDPHE, May 31, 1995.
16. Letter from John W. Schultz, Union Pacific, to C. Machovec, CDPHE, June 23, 1995.
17. Facsimile from Ken Longe, Union Pacific Public Relations, to P. Woodford, CDPHE, July 25, 1995.
18. Letter from D. L. Lafferty, Great Western Railway of Colorado, to C. Machovec, CDPHE, July 6, 1995.
19. Letter concerning "Denver Railroad Activity Data for Southern Pacific" from Chuck Machovec, CDPHE, to Dennis L. Arfmann, Holme Roberts & Owen, August 28, 1995.

4.3 OTHER NON-ROAD ENGINES AND VEHICLES

4.3.1 Abstract

The Environmental Protection Agency was directed by the 1990 Clean Air Act Amendments [Section 213(a)] to conduct a study of non-road engines and vehicles. Results of that study for the Denver ozone nonattainment area was used, as the basis, to estimate emissions for 1993, 2006, and 2013. The "Other Non-road Engines and Vehicles" category includes a diverse collection of equipment ranging from lawn mowers and chain saws, to recreational equipment, to farm equipment and construction machinery.

4.3.2 Introduction

The "Other Non-road Engines and Vehicles" category includes a diverse collection of equipment ranging from lawn mowers and chain saws, to recreational equipment, to farm equipment and construction machinery. The EPA conducted a study (completed in November 1991) of emissions from non-road engines and vehicles(1) to determine whether emissions from such sources cause, or significantly contribute to air pollution that may be reasonably anticipated to endanger public health or welfare.

4.3.3 Emission Inventory Methods

As part of the above study, EPA considered more than 80 different types of equipment. To facilitate analysis and reporting, EPA grouped the equipment types into the 10 equipment categories listed below:

- Lawn and Garden Equipment,
- Agricultural Equipment,
- Logging Equipment,
- Light Commercial Equipment,
- Industrial Equipment,
- Construction Equipment,
- Airport Service Equipment,
- Recreational Equipment,
- Recreational Marine Equipment, and
- Commercial Marine Vessels.[4]

Two emission inventories were developed for the first nine categories for 24 ozone and CO nonattainment areas across the country.

The EPA then contracted with Energy and Environmental Analysis, Inc., (EEA) to update the non-road equipment and vehicle emission inventories based on the 1991 EPA-designated nonattainment boundaries for CO and ozone exceedance areas. These areas include the original 24 areas from the original non-road study and an additional nine areas. The 33 nonattainment areas all have had an inventory, designated as "Inventory A," prepared for them, based on commercially and publicly available data. In addition to Inventory A, the original 24 areas have been provided with two more inventories. The second inventory, designated as "Inventory B," is based on confidential, industry-supplied sales and other data that are not publicly available. The second inventory provided EPA with a cross-check for the first inventory, and the results agreed reasonably well. The third inventory is an average of both inventories and is designated "Inventory (A+B)/2." Thus, for the original 24 inventory areas, inventory preparers use Inventory (A+B)/2, and for the

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ue to the lack of major inland water ways, the category of Commercial Marine Vessels is negatively declared.

remaining 9 inventory areas, only Inventory A is provided, and only Inventory A can be used. For the Denver ozone precursor gas inventory, the "A+B/2" inventory was used.

The following is a brief description of the procedures that were followed by the EPA in preparing the non-road emissions data that are being used for this inventory.

To construct the EPA non-road inventory, several factors were estimated: (1) equipment populations in the given nonattainment area; (2) annual hours of use of each type of equipment, adjusted for geographic region and for the season of interest for each pollutant studied; (3) average rated horsepower of each type of equipment; (4) typical load factor for each type of equipment; and (5) an emission factor for each of the 79 categories of equipment.

In developing emissions inventories for non-road engines and vehicles, the EPA used the following formula to

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calculate emissions for most of the 79 non-road categories:

where:

M_i	=	mass of emissions of i^{th} pollutant during inventory period
N	=	source population
HRS	=	annual hours of use
HP	=	average rated horsepower
LF	=	typical load factor
EF_i	=	average emissions of i^{th} pollutant per unit of use (e.g., emission factor grams per horsepower-hour)

The product of the annual hours of use, the average rated horsepower, and the load factor is referred to as the per-source usage rate. The product of the equipment population and the per-source usage rate is referred to as the activity level and is estimated in units of horsepower-hours. By multiplying the seasonally adjusted activity levels by the appropriate emission factor, emission estimates for an ozone season day were developed for each category of non-road equipment and vehicles in the EPA-prepared inventories.

As outlined in an April 27, 1992, memorandum[(2)] from EPA to all EPA Regional Offices, the first option for States developing non-road engine and vehicle emission inventories is to simply use the inventory prepared by EPA for the particular nonattainment area for which an inventory is being developed. This option was selected for the counties in the Denver CMSA. The ozone precursor emission estimates for the ozone season from inventory "A+B/2" for the Denver CMSA ozone nonattainment counties were taken directly from the EPA-supplied inventory for the Denver CMSA.

4.3.4 Results

The Denver ozone nonattainment emissions estimates from non-road engines and vehicles are from the OMS spreadsheets for the Denver CMSA. Table 4.3.4-1 presents a summary of the 1990 emission inventory from the EPA developed inventory. Emissions from 1990 were then projected to 1993 and 2010 for the ozone maintenance inventories.

Table 4.3.4-1 Summary of Non-Road Engine and Vehicle Emissions by Equipment Categories

EQUIPMENT CATEGORIES	1990 VOC (tpsd)	1990 NOx (tpsd)	1993 VOC (tpsd)	1993 NOx (tpsd)	2006 VOC (tpsd)	2006 NOx (tpsd)	2013 VOC (tpsd)	2013 NOx (tpsd)
LAWN AND GARDEN EQUIPMENT	27.26	0.58	28.00	0.65	14.35	0.7	14.98	0.73
AIRPORT SERVICE EQUIPMENT	0.42	4.38	0.71	4.22	0.61	3.21	0.56	2.58

Table 4.3.4-1 Summary of Non-Road Engine and Vehicle Emissions by Equipment Categories

EQUIPMENT CATEGORIES	1990 VOC (tpsd)	1990 NOx (tpsd)	1993 VOC (tpsd)	1993 NOx (tpsd)	2006 VOC (tpsd)	2006 NOx (tpsd)	2013 VOC (tpsd)	2013 NOx (tpsd)
RECREATIONAL VEHICLE	2.52	0.02	2.61	0.02	3.16	0.02	3.46	0.01
RECREATIONAL VESSELS	7.05	1.01	7.16	1.01	7.37	1.18	7.05	1.35
LIGHT COMMERCIAL EQUIPMENT	7.38	0.99	7.67	1.05	5.04	1.15	4.86	1.04
INDUSTRIAL EQUIPMENT	2.01	4.44	2.04	4.51	1.59	3.64	1.55	3.15
CONSTRUCTION EQUIPMENT	6.40	39.27	6.49	38.50	3.84	28.50	2.87	19.97
AGRICULTURAL EQUIPMENT	0.93	4.30	0.87	4.26	0.51	3.43	0.41	2.75
LOGGING EQUIPMENT	0.11	0.00	0.11	0.00	0.08	0.00	0.06	0.00
TOTALS	**54.37**	**54.68**	**55.66**	**54.23**	**36.53**	**41.83**	**35.78**	**31.57**

tpsd = tons per summer day

4.3.5 Projection Methodology

Non-road emissions for 1990 have been projected to 1993, 2006, and 2010 using ratios derived from EPA=s Non-Road Model to proportion 1990 emissions to 1993, 2006 and 2013. Table 4.3.5-1 presents the ratios used to project 1990 emissions to 1993, 2006 and 2013.

Non-road emission projections for 2006 and 2013 include court-ordered non-road standards(3) and estimated growth in equipment population. Projected non-road equipment emission estimates were made by multiplying the estimated 1990 emissions from the NEVES inventory by the ratio of projected emissions (i.e. 1993, 2006, 2013) from the Non-Road Model by the 1990 Non-Road Model estimated emissions. This process was performed for each equipment category. No credits were taken for 1993 emission projections because none of the court-ordered non-road standards had taken effect until after 1994.

Table 4.3.5-1 Projection Ratios Used to Project Non-Road Emissions to Future Years

Equipment Category	Ratio - 1990 to 1993		Ratio - 1990 to 2006		Ratio - 1990 to 2013	
	VOC	NOx	VOC	NOx	VOC	NOx
Lawn and Garden Equipment	1.03	1.12	0.53	1.21	0.55	1.25
Airport Service Equipment	1.00	0.96	0.86	0.73	0.79	0.59
Recreational Vehicles	1.04	1.00	1.25	1.00	1.37	0.71
Recreational Vessels	1.02	1.00	1.05	1.17	1.00	1.33
Light Commercial Equipment	1.04	1.06	0.68	1.06	0.66	1.05
Industrial Equipment	1.01	1.02	0.79	0.82	0.77	0.71
Construction Equipment	1.01	0.98	0.60	0.73	0.45	0.51

Agricultural Equipment	0.93	0.99	0.55	0.8	0.44	0.64
Logging Equipment	1.00	1.00	0.75	0.67	0.50	0.44

4.3.6 Temporal Factors

The EPA inventory for non-road vehicles contains emissions for both winter and summer, therefore, no seasonal temporal factors are applied to this source category.

4.3.7 Assumptions

It is assumed that the EPA non-road inventory (A+B/2) is accurate for the Denver ozone nonattainment area. No adjustments have been made to EPA's non-road inventory for the Denver CMSA.

4.3.8 Conclusions

A 1990 EPA developed non-road emission inventory was projected to 1993, 2006, and 2013 for the Denver ozone precursor gas inventory. The total inventory from miscellaneous non-road vehicles and engines for 1993 is estimated to be 55.7 tpsd of VOCs and 54.27 tpsd of NOx. Due to phased in standards for non-road vehicles and engines, these emissions will be reduced to 36.5 tpsd of VOCs and 41.8 tpsd of NOx by 2006. By 2013, non-road emissions will be further reduced to 35.8 tpsd of VOC and 31.6 tpsd of NOx. By 2006 and 2013 anticipated growth in equipment usage will be more than offset by decreased emission rates.

5.0 AREA SOURCES

An area source is defined as a stationary or non-road source that are either too small individually and/or too numerous to be included in the point source inventory, but may contribute collectively to ozone formation. The area source inventory was developed using guidance from the EPA document, *Procedure for the Preparation of Emission Inventories for Precursors of Ozone, Volume 1* (EPA 450/4-91-014). Following are the source categories that make up the area source inventory:

- Gasoline transfers
- Dry cleaners
- Surface coating
- Graphic arts
- Pesticide application
- Commercial/Consumer solvent use
- Publicly owned treatment works (POTWs)
- Treatment, storage, and disposal facilities (TSDFs)
- Landfills
- Leaking underground storage tanks (LUSTs)
- Bakeries
- Natural Gas
- Breweries, Wineries, and Distilleries
- Tank Truck, Rail Car, and Drum Cleaning
- Forest Fires/Prescribed Burns
- Structural Fires

5.1 GASOLINE DISTRIBUTION LOSSES

5.1.1 Abstract

The transportation of gasoline involve many distinct points of transfer, each of which represents a potential source of VOC evaporative losses. Gasoline is first conveyed to bulk terminals. From the bulk terminals, the gasoline is then transferred, by tankers, to local gas stations and distribution centers. From underground storage tanks, the gasoline is then transferred to individual gas tanks on motor vehicles. EPA methodologies and emission factors were used to estimate VOC emissions from gasoline transfer. Depending on the point of transfer, emissions from gasoline transfer may be either area or point sources.

5.1.2 Introduction

Gasoline distribution losses due to evaporation can occur during the dispensing of gasoline at bulk stations, tank truck transit, tanks truck unloading at gas stations, tank breathing losses, displacement and spillage. Those operations generally inventoried as area sources are gasoline dispensing outlets and gasoline tank trucks in transit. Bulk terminals and gasoline bulk plants, which are intermediate distribution points between refineries and outlets, are usually inventoried as point sources. Most gasoline dispensing outlets emit less than 10 tons of VOC per year and therefore are generally inventoried using area source methods. VOC emissions from gasoline dispensing outlets result from vapor losses during tank truck unloading into underground storage tanks, vehicle fueling, and underground storage tank breathing.

5.1.3 Estimated Gasoline Distribution

To estimate the emissions from gasoline transfers, the volume of gasoline has to first be estimated. Statewide figures of gasoline distributed were obtained from the Colorado Department of Revenue(1) and the U.S. Department of Energy(2). Neither source was able to provide gasoline consumption figures for the nonattainment area. In order to estimate the nonattainment area consumption, the statewide consumption of gasoline was proportioned to the nonattainment area based on population. Table 5.1.3-1 presents a summary of gasoline consumption.

Table 5.1.3-1 Estimation of Nonattainment Area Fuel Consumption for 1993

Item	Annual	Summer
Statewide fuel consumption (kgal)	1636602	449827
State population	3551000	3551000
Emission inventory domain population	1919407	1919407
Population ratio	0.54	0.54
Estimated nonattainment area fuel consumption (kgal)	883765	242907
Estimated gallonage of gasoline through Metro bulk stations from AIRS (kgal)	19694600	

5.1.4 Emission Factors Used for Gasoline Distribution

Table 5.1.4-1 presents a summary of the emission factors used to estimate VOC emissions from gasoline distribution[3].

Table 5.1.4-1 Emission Factors for Gasoline Distribution

Activity	Emission Factors
Transport (lbs VOC/kgal)	0.12
Breathing (lbs VOC/kgal)	1.00
Displacement (lbs VOC/kgal)	11.00
Spillage (lbs VOC/kgal)	0.70

5.1.5 Estimated Emissions from Gasoline Distribution

The following sections describe the methodologies used to estimate the evaporative losses from gasoline during transfer at the various transfer points. In general, emissions from gasoline transfer can be either point or area sources.

- Bulk terminals

Emissions at bulk terminals are included as point sources within the Colorado AIRS database[4]. Since emissions from bulk stations are included in the point source inventory, no area source estimations of emissions are calculated.

- Trucks in transit

VOC emissions for trucks in transit are estimated using the estimated amount of gasoline transferred within the nonattainment area. An emission factor of 0.12 lbs/kgal of gasoline is multiplied by the annual and seasonal totals of gasoline distributed at bulk stations within the nonattainment area. Because some of the gas from bulk stations are transported out of the nonattainment area, the amount of gas dispensed at gas stations is smaller than the amount of gas distributed at bulk stations. For truck transit emission calculations, the amount of gas distributed at bulk stations is used to estimate emissions from trucks in transit.

As seen in Table 5.1.3-1, for 1993 the gallonage distributed at bulk station from AIRS (1,969,466 kgal) is greater than the statewide amount of gasoline consumed (1,636,602) kgal. Given this inconsistency, the statewide total amount of gasoline consumed is used to estimate the evaporative losses due to tankers in transit. By multiplication, the estimated VOC emissions from trucks in transit is 98.2 tpy, or, 0.3 tpsd in 1993. The emission rate from gasoline transfers is estimated to be 0.4 tpsd in 2006 and 0.5 tpsd in 2013 using population as a surrogate for emission growth.

- Breathing losses

VOC emissions due to breathing losses from tanks are estimated by multiplying the amount of gasoline distributed in the nonattainment area (1,636,602 kgal per year or 449,827 kgal per summer) by the emission factor for breathing losses of 1.0 lbs/kgal. This results in a total VOC breathing loss emission rate of 425.93 tpy, or, 1.27 tpsd.

The AIRS data base also contains point source emissions from breathing losses. Within the nonattainment area, the point source inventory contains 208.2 tpy (0.63 tpsd) of emissions from breathing losses. The area source emission inventory is estimated by subtracting the point source emissions from the total nonattainment area emissions from breathing losses. By subtraction, the area source VOC emission inventory from breathing losses is 217.73 tpy, or, 0.64 tpsd. Using population as a surrogate for growth, 2006 and 2013 VOC emissions from breathing losses are estimated to be 0.85 tpsd and 0.94 tpsd, respectively.

- Displacement and spillage

Emissions due to filling of gas tanks on motor vehicles and spillage are estimated by MOBILE5A. These emission are presented in within the totals presented in Section 3, "On-Road Mobile Sources", in Table 3.1-1.

5.1.6 Projection Methodology

Population estimates for 1993, 2006, and 2013 are used to proportion 1993 area source emissions from tankers in transit and breathing losses. In 1993, the estimated population within the inventory domain is 1,919,407 people. By 2006, population is estimated to grow to 2,562,039 people. Between 1993 and 2006, population is expected to grow by a factor of 1.33. In 2013, the nonattainment area population is projected to be 2,821,543. The resulting growth factor is 1.47. These growth factors are multiplied by the 1993 emissions estimates for area source breathing losses and transport.

5.1.7 Temporal Factors

Statewide estimates of monthly gasoline distributions are presented in the DOE document, "Petroleum Marketing Annual". The distribution of gasoline sales for the peak ozone season (June through August) is taken from these figures and is incorporated into the summer emission rates.

5.1.8 Assumptions

The following assumptions are made in the estimation of gasoline distribution losses:

1.) All emissions at bulk stations are include in the AIRS database;

2.) Emissions due to displacement and spillage from motor vehicle refueling are included in the MOBILE5A emission factors;

5.1.9 Sample Calculations

Tables 5.1.9-1 and 5.1.9-10 present sample calculations for VOC emissions from evaporative losses due to gasoline transport and tank breathing losses. Emission calculations for bulk terminals are included in the documentation for point sources. Calculations for displacement and spillage from motor vehicle refueling are included in the mobile source category.

Table 5.1.9-1 Sample Calculation for Tankers in Transit

Item	Value	Units
Gallonage throughput from bulk stations	1969466	kgal
Days/year	365	days
Daily Gallonage	5395.80	kgal/day
Transit emission factor	0.12	lbs/kgal
Transit emission rate	647.50	lbs/day
Transit emission rate	0.32	tpsd
2006/1993 Population Ratio	1.33	
Projected 2006 emissions	0.4	tpsd
2013/1993 Population Ratio	1.47	

Projected 2006 emissions	0.5	tpsd

Table 5.1.9-2 Sample Calculation for Breathing Losses

Item	Value	Units
Summer (June-Aug) fuel consumption	234138	kgal/summer
Days in peak ozone season	92	days
Summer day fuel consumption	2544.98	kgal/day
Breathing loss emission factor	1.00	lbs/kgal
Breathing loss emission rate	2544.98	lbs/day
Breathing loss emission factor	1.27	tpsd
Breathing loss from AIRS database	0.63	tpsd
Area source emissions	0.64	tpsd
2006/1993 population ratio	1.33	
Projected 2006 emissions	0.85	tpsd
2013/1993 population ratio	1.47	
Projected 2010 emissions	0.94	tpsd

5.1.10 Conclusion

Area Source VOC emissions from the transport of gasoline and breathing losses are estimated to be 526.13 tpy, or, 0.96 tpsd in 1993. By 2006 and 2013, area source emissions from gasoline transport are expected to grow to 1.2 tpsd and 1.4 tpsd based on growth in population.

5.2 DRY CLEANING

5.2.1 Introduction

Perchloroethylene (PERC) which is the primary solvent used in dry cleaning is not longer considered to be a photoreactive species[(1)] as a precursor for ozone formation. For this emission inventory, it is assumed that there are no reactive VOC species from dry cleaning as an area source. However, those dry cleaners reported as point sources in the point source inventory are still contained in the point source inventory as a conservative estimate to account for those facilities that use other solvents in for their dry cleaning processes.

Endnotes

1. *Dry Cleaning-Final Report*, Emission Inventory Improvement Program, U.S. Environmental Protection Agency (OAQPS), May 1996.

5.3 DEGREASING

5.3.1 Abstract

The methodologies and emission factors used to estimate volatile organic compounds (VOC) emissions for degreasing operations are estimated using EPA methods and emission factors. The majority of emissions from degreasing operations are calculated using area source methodologies. An emission factors of 4.3 lbs VOC/year/capita is used.

5.3.2 Introduction

Surface cleaning, or degreasing, includes the solvent cleaning or conditioning of metal surfaces and parts, fabricated plastics, electronic and electrical components and other nonporous substrates. These cleaning processes are designed to remove foreign material, such as oils, grease, waxes and moisture, usually in preparation for further treatment, such as painting, electroplating, galvanizing, anodizing or applying conversion coatings.

5.3.3 Degreasing Emission Inventory Methods

The AIRS emission inventory for Colorado contains degreasing operations down to one ton per year. However, at the one ton per year level, there are some facilities that may be missing from the AIRS data base because APENs may have not been submitted for all the smaller facilities. As a result, the degreasing emissions inventory is based on both area source and stationary source emission estimates. The methodology used to estimate degreasing emissions is described in the EPA document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*[1].

The area source emissions calculation for Denver was estimated using the following equation:

Area source VOC emissions for degreasing	=	Total region estimates of degreasing emissions	_	Regional point source inventory of degreasing emissions **(AIRS)**

5.3.4 Emission Factors

Table 5.3.4-1 gives recommended emission factors for degreasing operations on a per capita and per employee basis. The per capita factor (4.3 lbs/year/capita) was used in the Denver inventory to estimate degreasing emissions. The per capita factor was used for the Denver nonattainment area for two reasons. First, the per capita figure produces a more conservative estimate for the Denver area. Second, in some cases, the SIC codes for various plants on the Denver AIRS file do not match the SICs given in Table 5.3.4-1 for the per employee emission factor.

Table 5.3.4-1 Recommended Emission Factors for Surface Cleaning/Degreasing

	PER CAPITA FACTOR (lb/yr/person)		PER EMPLOYEE FACTOR (lb/yr/employee)		
SUBCATEGORY	VOC[a]	TOTAL ORGANICS	VOC[a]	TOTAL ORGANICS	SIC CODES
SURFACE CLEANING (Total):	4.3	7.2	87	144	25, 33-39, 417, 423, 551, 552, 554-556,753
COLD CLEANING:					
Automobile Repair	2.5	2.5	270	270	417, 423, 551, 552, 554-556, 753
Manufacturing	1.1	1.1	24	24	25, 33-39
VAPOR AND IN-LINE CLEANING:					
Electronics & Electrical	0.21	1.1	29	150	36
Other:	0.49	2.5	9.8	49	25, 33-39, 417, 423, 551, 552, 554-556, 753

[a]The VOC emission factors exclude some non-reactive organics.

5.3.5 Activity Factors

Table 5.3.5-1 presents the county level estimates of population and VOC emissions from degreasers for the nonattainment area. A small number of degreasers appear on the AIRS data base[(2)]. The total emissions on AIRS from degreasers is 91.56 tpy. A summary of the point source emissions appear in Table 5.3.5-1 as "point source emissions".

Also presented in Table 5.3.5-1 is the regional area population by county. To estimate total region wide emissions from degreasers, the population for each county was multiplied by the per capita emission rate of 4.3 lbs VOC/year/capita. This result was then converted to an annual emission rate in tons per year (tpy) and a typical summer day rate in tons per summer day (tpsd). From Table 5.3.5-1, the estimated total regional emissions from degreasers is 4130.2 tpy, annually, or, 13.23 tpsd.

To determine the area source emissions from degreasers, the point source degreaser emissions were subtracted from the regional total estimate of degreaser emissions. This results in an area source estimate of degreasers emissions at 4,038.43 tpy. As presented in Table 5.3.5-2, the typical summer day emission rate is 12.8 tpsd.

Table 5.3.5-1 Emissions Estimates from Degreasers

County	Point Source Emission Rates (TPY)	Point Source Emission Rates (TPSD)	1993 Population	Emis. Factor (lbs/yr/capita)	Regional Emission Rates (TPY)	Regional Emission Rates (TPSD)	Area Source Emission Rates (TPY)	Area Source Emission Rates (TPSD)

ADAMS	0.43	0.00	272860	4.3	586.65	1.88	586.22	1.9
ARAPAHOE	12.93	0.05	405525	4.3	871.88	2.79	858.95	2.7
BOULDER	13.03	0.05	231343	4.3	497.39	1.59	484.35	1.5
DENVER	42.87	0.19	484121	4.3	1040.86	3.34	997.99	3.2
DOUGLAS	0.00	0.00	77504	4.3	166.63	0.53	166.63	0.5
JEFFERSON	22.50	0.08	449672	4.3	966.79	3.10	944.29	3.0
TOTAL	**91.56**	**0.37**	**1919407**		**4126.7**	**13.21**	**4035.14**	**12.8**

5.3.6 Projection Methodology

To project emissions to future years, a ratio of population from the base year to the projected year is used. The ratio of population from 1993 to 2006 is 1.33. From 1993 to 2013, the population ratio is 1.47. In addition a control factor of 61% is applied to degreasers for 2006 and 2013 due to provisions contained in 58 FR 62566. By proportions, the 2006 and 2013 projected emission from degreasers are estimated to be 6.64 tpsd and 7.34 tpsd, respectively.

5.3.7 Temporal Factors

The document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*, Table 1, presents area source seasonal adjustment factors for various source categories. From this table, it is assumed that there is no seasonal variation in degreasing operations and that degreasers operate 6 days/week.

To convert annual emissions from tons per year (tpy) to tons per summer day (tpsd), the following formula is used:

$$\text{Emissions per typical summer day (tpsd)} = \frac{\text{Annual Emissions (tpy)} * \text{Seasonal Adjustment Factor}}{\text{\# Activity Days per Week} * 52 \text{ Weeks}}$$

The use of the above formula results in an annual average emission rate conversion factor to a typical summer day of 0.0032.

5.3.8 Sample Calculations

Table 5.3.8-1 presents a sample calculation used to estimate the total nonattainment area emissions from degreasers, as an area source. Both the base year and projected year estimation methods are presented in the table.

Table 5.3.8-1 Sample Calculations for Degreasers

ITEM	VALUE	UNITS
1993 Base year estimates		
Regional area population	1921025	people
Degreasing emission factor	4.3	lbs/year/capita
Regional estimate of emissions from degreasers	8,260,408	lbs/year
Annual regional emissions (tpy)	4130.2	tpy
Emissions from point sources (AIRS)	91.76	tpy
Estimated area sources emissions	4038.4	tpy
Seasonal scalar (6 days/wk, 52 wks/yr)	0.0032	no dimension
Summer emissions in tons per summer day (tpsd)	12.8	tpsd
PROJECTED 2006 EMISSIONS		
Population scalar to 2006	1.33	no dimension
Estimated emissions in 2006	17.0	tpsd
Control from 58 CFR 62566 (61% reduction)	6.64	tpsd
PROJECTED 2013 EMISSIONS		
Population scalar to 2013	1..47	no dimension
Estimated emissions in 2013	18.8	tpsd
Control from 58 FR 62566 (61% reduction)	7.34	tpsd

5.3.9 Conclusions

The 1993 area source VOC emissions from degreasers are estimated to be 12.8 tpsd. As a function of population growth and controls from NESHAP and MACT standards, area source VOC emissions from degreasers are estimated to be 6.6 tpsd by 2006, and, 7.3 tpsd by 2013.

Endnotes

1. *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, U.S. Environmental Protection Agency (OAQPS), May 1991.

2. Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency.

3. 58 FR 62566

5.4 SURFACE COATING

5.4.1 Abstract

The methodologies and emission factors used to estimate volatile organic compounds (VOC) emissions from nonindustrial surface coatings operations are estimated using EPA methods and emission factors. There are three nonindustrial surface coating subcategories which include architectural surface coating, traffic striping/marking, and automobile refinishing. Architectural surface coatings and traffic striping/marking are exclusively area sources. Emissions from automobile refinishing can be either point or area sources. To estimate area source emissions from automobile refinishing, a regional total estimate is first determined, then the point source emissions are subtracted out. Emission rates for architectural surface coatings and traffic paints are based on per capita emission factors of 4.6 lbs/year/capita and 0.5 lbs/year/capita, respectively. The regional estimate of emissions from automobile refinishing is based on the per employee emission factor of 3519 lbs/year/employee in SIC 7532.

5.4.2 Introduction

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.

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

Architectural coatings, also known as trade paints, are used primarily by homeowners and painting contractors. Architectural coatings include interior and exterior house and building paints as well as coatings for other surfaces, such as curbs and signs. The coatings are applied by spray, brush or roller and dry or cure at ambient conditions.

Automobile refinishing is the repainting of worn or damaged automobiles, light trucks and other vehicles. Coating of new cars is not included in this category but falls under industrial coating. In automobile refinishing, lacquers and enamels are usually applied with hand-operated spray guns. Because the vehicles contain heat-sensitive plastics and rubber, the coatings are dried or cured in low-temperature ovens or at ambient conditions.

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. All traffic paint emissions would be included in the area source inventory, since the emissions are not from any specific plant, but instead emanate from the roadways where markings are applied.

5.4.3 Surface Coating Inventory Methods

All industrial surface coating facilities emissions are assumed to be on the AIRS database since the State tracks emissions down to 1 tpy through the APEN process. Section 2 includes emissions from industrial surface coating facilities. There are both major (VOC>100 tpy) and minor (VOC<100 tpy) sources of industrial surface coating facilities.

The non-industrial surface coating emission inventory consists of emissions from architectural surface coatings, auto refinishing and traffic marking/striping. The methodologies used to estimate nonindustrial surface coating emissions are described in the EPA document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*[(1)]. Emissions from traffic paints and architectural coatings are estimated on a per capita basis based on the following formula:

Area source VOC emissions for traffic points/ architectural coatings (lbs/year)	=	Total regional population	x	Per capita emission factor (lbs/year/capita)

Since there are some automobile refinishing emissions on the AIRS database, the point source emissions must be subtracted out of the regional estimated emissions. Also, unlike architectural surface coatings and traffic paints, the regional estimate of VOC emissions for automobile refinishing is based on a per employee basis. The area source emissions calculation for Denver was estimated using the following equation:

Area source VOC emissions for automobile refinishing (lbs/year)	=	Total regional employment in SIC 7532	x	Per employee emission factor (lbs/year/employee)	-	Point Source Emission Rate For auto refinishing (scc 402016xx)

5.4.4 Emission Factors

Table 5.4.4-1 gives recommended emission factors for nonindustrial surface coatings on a per capita and per employee basis. For the Denver ozone precursor inventory, the per capita emission factor is used for architectural and traffic marking surface coatings. The per employee emission factor in Table 5.4.4-1 is used to estimate regional emissions from automobile refinishing.

Table 5.4.4-1 Recommended Emission Factors for Surface Coating

	VOC EMISSION FACTORS (lbs/year)[a]		COATING USAGE FACTORS (gal/year)		
SUBCATEGORY	PER CAPITA	PER EMPLOYEE	PER CAPITA	PER EMPLOYEE	SIC CODE(S)

Nonindustrial:					
Architectural	4.6	na	2.2	na	not applicable
Automobile refinishing	2.3	3,519	0.15	221	7532
Traffic markings	0.5	69[b]	0.16	22[b]	1721

[a] Assumes that 99 percent of the organic solvents used in surface coatings are classified as VOC.
[b] Lbs/Lane-mile painted.

5.4.5 Activity Factors for Automobile Refinishing

Table 5.4.5-1 presents the county level employment(2) and emissions for the nonattainment area from automobile refinishing. Some automobile refinishing shops appear on AIRS. A summary of those emissions appear in the Table 5.4.5-1 as "point source emission rates". Although the AIRS data base contains data for SIC 7532 at the point source level, the "proportioning up" (1) of emissions was not done because many of the SCC codes associated with the SIC 7532 codes were not automobile/light truck refinishing related (SCC code 402016xx).

The regional emission rate, which was calculated by multiplying the number of employees by the per employee emission rate, is also presented in Table 5.4.5-1. The area source emission rate from automobile refinishing is calculated by subtracting the point source emission rate from the regional estimate. It is estimated that the area source emissions from automobile refinishing is 2,742 tpy or 13.7 tpsd.

Table 5.4.5-1 1993 Base Year Emission Rates from Auto Refinishing

County	Point Source Emission Rates (tpy)	Point Source Emission Rates (tpsd)	Emp in SIC 7532	Emis. Factor (lbs/yr/ emp)	Regional Emission Rates (TPY)	Regional Emission Rates (TPSD)	Area Source Emission Rates (TPY)	Area Source Emission Rates (TPSD)
ADAMS	19.05	0.08	283	3519	497.94	1.89	478.89	2.39
ARAPAHOE	3.34	0.02	413	3519	726.67	2.76	723.33	3.62
BOULDER	1.74	0.01	145	3519	255.13	0.97	253.39	1.27
DENVER	19.58	0.11	363	3519	638.70	2.43	619.12	3.10
DOUGLAS	0.00	0.00	76	3519	133.72	0.51	133.72	0.67
JEFFERSON	38.09	0.14	325	3519	571.84	2.17	533.74	2.67
TOTALS	**81.80**	**0.35**	**1605**		**2824.00**	**10.73**	**2742.20**	**13.74**

5.4.6 Activity Factors for Architectural Coating

Table 5.4.6-1 presents county level population and VOC emissions from architectural coatings for the nonattainment area. The estimated 1993 base year VOC emissions from architectural coatings are estimated to be 4418.35 tpy or 15.74 tpsd. The summer emission rate includes a seasonal adjustment factor of 1.3. This factor is discuss in subsequent sections. For the 2006 and 2013 emission estimates, a control factor of 20% is applied per provision contained in 61FR32729.

Table 5.4.6-1 Emission Estimates for Architectural Surface Coating

County	1993 Population	Emission Factor (lbs/yr/ capita)	1993 Summer Emission Rate (tpsd)	2006 Population	2006 Summer Emission Rate (tpsd)	2013 Population	2013 Summer Emission Rate (tpsd)
ADAMS	272860	4.6	2.24	418655	2.74	494364	3.24
ARAPAHOE	405525	4.6	3.32	470512	3.08	488841	3.20
BOULDER	231343	4.6	1.90	309712	2.03	351159	2.30
DENVER	484121	4.6	3.97	522992	3.42	576935	3.78
DOUGLAS	77504	4.6	0.63	224095	1.47	273747	1.79
JEFFERSON	449672	4.6	3.68	616063	4.04	636497	4.17
TOTALS	**1921025**		**15.74**		**16.78**		**18.48**

5.4.7 Activity Factors for Traffic Marking/Striping

Table 5.4.7-1 presents county level population and VOC emissions from traffic marking and striping within the Denver ozone nonattainment area. The estimated 1993 base year VOC emissions from traffic marking/striping is estimated to be 480.26 tpy or 2.40 tpsd. Projected VOC emissions for 2006 and 2013 are 3.3 tpsd and 3.6 tpsd, respectively.

Table 5.4.7-1 Emission Estimates from Traffic Markings/Striping

COUNTY	1993 Population	Emission Factor (lbs/yr/ capita)	1993 Summer Emission Rate (tpsd)	2006 Population	2006 Summer Emission Rate (tpsd)	2013 Population	2013 Summer Emission Rate (tpsd)
ADAMS	272860	0.5	0.34	418665	0.53	494364	0.63
ARAPAHOE	405525	0.5	0.51	470512	0.60	488841	0.62
BOULDER	231343	0.5	0.29	309712	0.39	351159	0.44
DENVER	484121	0.5	0.61	522992	0.66	576935	0.73
DOUGLAS	77504	0.5	0.10	224095	0.28	273747	0.35
JEFFERSON	449672	0.5	0.56	616063	0.78	636497	0.81
TOTALS	1921025		2.40	2562039	3.25	2821543	3.58

5.4.8 Projection Methodology

To project automobile refinishing emissions to 2006 and 2013, a ratio of 2006 and 2013 to 1993 employment was established. This proportion was then multiplied by the 1993 estimated area source contribution of automobile refinishing. The 2006/1993 employment ratio was 1.49. Automobile refinishing emissions are further reduced after April 1, 1997 by NESHAP and MACT regulations contained in 61FR19005. It is estimated that these federal regulations will reduce automobile refinishing emissions by at least 37% over what they would have been after 1997. When multiplied by the 1993 VOC emission rate of 13.6 and by a 37% percent control, the 2006 emission rate is estimated to be 12.8 tpsd. The 2013/1993 employment ration was 1.62. When the 1993 VOC emission rate is multiplied by the 2013/1993 employment ratio, the projected emission rate becomes 14.0 tpsd.

Both the architectural surface coating and traffic marking/striping source categories used population as the surrogate for projecting emissions to 2006 and 2013. Emissions from these two source categories were estimated directly by multiplying the 2006 and 2013 population by the appropriate per capita emission factors presented in Table 5.4.4-1. In addition, emissions from architectural surface coating will be further reduced by provisions in 61CFR32729. It is anticipated that after 1997, VOC emissions from architectural surface coating will be reduced by 20% from these federally mandated provisions.

Table 5.4.6-1 presents estimated 2006 and 2013 emissions from architectural surface coating for the nonattainment area. It is estimated that VOC emissions from architectural surface coating will be 16.8 tpsd and 18.5 tpsd for 2006 and 2013, respectively.

Table 5.4.7-1 presents projected emissions from traffic paints for the years 2006 and 2013 The estimated VOC estimated emissions for 2006 and 2013 is 3.2 tpsd and 3.6 tpsd.

5.4.9 Temporal Factors

The document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*, presents area source seasonal adjustment factors for various source categories. Seasonal and daily activity factors are presented in this document for automobile refinishing and architectural surface coating. For traffic paints, it is assumed that traffic marking/striping are done 5 days per week and are applied 1.3 times more during the summer than the annual average.

To convert annual emissions from tons per year (tpy) to tons per summer day (tpsd), the following formula is used:

$$\text{Emissions per typical summer day (tpsd)} = \frac{\text{Annual Emissions (tpy)} * \text{Seasonal Adjustment Factor}}{\text{\# Activity Days per Week} * 52 \text{ Weeks}}$$

For automobile refinishing it is assumed that there is no seasonal variation and that most automobile refinishing shops operate five days per week. By substitution into the above equation, this results in a conversion factor from the annual rate (tpy) to the typical summer day rate (tpsd) of 0.0038. This factor is reflected in the typical summer day rates for 1993, 2006, and 2013 presented in Table 5.3.6-1.

It was assumed that architectural coatings are preferentially applied during the summer months. The summer seasonal scalar for architectural coatings is 1.3. It is assumed that architectural surface coatings are applied on any day of the week. The typical summer day rates presented in Table 5.4.7-1 reflect these temporal factors.

5.4.10 Assumptions

The following assumption(s) are made in the area source estimates for surface coatings:

1.) It is assumed that all industrial surface coating emissions are presented on AIRS as either major or minor sources.

5.4.11 Sample Calculations

Tables 5.4.11-1, 5.4.11-2, and 5.4.11-3 present sample calculations used to estimate area source emissions from architectural surface coatings, traffic marking/striping, and automobile refinishing, respectively. Both the base year and projected year estimation methods are presented in the table.

Table 5.4.11-1 Sample Calculations for Architectural Surface Coating Emissions

ITEM	VALUE	UNITS
1993 BASE YEAR ESTIMATES		
1993 Regional area population	1921025	people
Architectural surface coating emission factor	4.6	lbs/year/capita
Architectural surface coating emission rate	8836715	lbs/year
Annual estimated emission rate	4418.36	tons/year
Daily scalar (7 days/week, 52 weeks/year)	12.11	tons/day
Summer scalar=1.3	15.74	tpsd
2006 PROJECTED EMISSIONS		
2006 Regional area population	2562039	people
Architectural surface coating emission factor	4.6	lbs/year/capita
Architectural surface coating emission rate	11785379	lbs/year
Annual estimated emission rate	5892.7	tons/year
Daily scalar (7 days/week, 52 weeks/year)	16.1	tons/day
Summer scalar=1.3	21.0	tpsd
Reduction due to 61FR32729 (20% reduction)	16.8	tpsd
2013 PROJECTED EMISSIONS		
2013 Regional area population	2887671	people
Architectural surface coating emission factor	4.6	lbs/year/capita
Architectural surface coating emission rate	13283286	lbs/year
Annual estimated emission rate	6641.6	tons/year
Daily scalar (7 days/week, 52 weeks/year)	18.2	tons/day
Summer scalar=1.3	23.1	tpsd
Reduction due to 61FR32729 (20% reduction)	18.5	tpsd

Table 5.4.11-2 Sample Calculations for Emissions from Traffic Paints

ITEM	VALUE	UNITS
1993 BASE YEAR ESTIMATES		
Regional area population	1921025	people
Traffic marking/striping emission factor	0.5	lbs/year/capita
Traffic marking/striping emission rate	960512.5	lbs/year
Annual regional emissions	480.26	tons/year
Daily scalar (7 days/week, 52 weeks/year)	1.31	tons/day
Summer scalar=1.0	2.4	tons/summer day
2006 PROJECTED EMISSION		
Regional area population	2562039	people
Traffic marking/striping emission factor	0.5	lbs/year/capita
Traffic marking/striping coating emission rate	1281020	lbs/year
Annual regional emissions	640.5	tons/year
Daily scalar (7 days/week, 52 weeks/year)	1.75	tons/day
Summer scalar=1.85	3.3	tons/summer day
2013 PROJECTED EMISSION		
Regional area population	2821543	people
Traffic marking/striping emission factor	0.5	lbs/year/capita
Traffic marking/striping coating emission rate	1410772	lbs/year
Annual regional emissions	705.4	tons/year
Daily scalar (7 days/week, 52 weeks/year)	1.93	tons/day
Summer scalar=1.3	3.6	tons/summer day

Table 5.4.11-3 Sample Calculation for Automobile Refinishing Emissions

ITEM	VALUE	UNITS
1993 BASE YEAR ESTIMATES		
Regional Employment in SIC 7532	1605	employees
Auto refinishing emission factor	3519	lb/yr/emp
Regional emission rate	5647995	lbs/yr
Annual emissions (tpy)	2824.00	tpy
Emissions from point sources (scc 402016xx)	81.8	tpy
Area source estimate	2742.20	tpy
Daily scalar (5 days/week, 52 weeks/year)	0.0038	no dimensions
Summer scalar	1.3	No dimensions
Typical summer day emissions	13.7	tpsd
2006 PROJECTED EMISSIONS		
1993 Employment	1044681	employees
2006 Employment	1553625	employees
Ratio 2006 emp/1993 emp	1.49	
Estimated 2006 emissions	20.3	tpsd
Reduction due to 61FR19005 (37% reduction)	12.8	tpsd
2013 PROJECTED EMISSIONS		
1993 Employment	1044681	employees
2013 Employment	1697977	employees
Ratio 2013 emp/1993 emp	1.63	
Estimated 2013 emissions	22.2	tpsd
Reduction due to 61FR19005 (37% reduction)	14.0	tpsd

5.4.12 Conclusions

Table 5.4.12-1 presents a summary of the 1993, 2006 and 2013 area source VOC emission inventory from nonindustrial surface coating operations. The total estimated total emissions for the 1993 base year from nonindustrial surface coating operations is 30.7 tpsd. In 2006 and 2013, nonindustrial surface coating emissions are estimated to be 44.6 tpsd and 48.9 tpsd, respectively.

Table 5.4.12-1 Summary of Area Source Emissions from Nonindustrial Surface Coatings

Year	SUMMER DAY ARCHITECTURAL SURFACE COATS (TPSD)	SUMMER DAY TRAFFIC MARKING/STRIPIN G (TPSD)	SUMMER DAY AUTOMOBILE REFINISHING (TPSD)	TOTAL TYPICAL SUMMER DAY EMISSIONS FROM SURFACE COATING (TPSD)
SUMMARY OF EMISSIONS				
1993	15.7	2.4	12.6	30.7
2006	16.8	3.3	12.8	32.9
2013	18.5	3.6	14.0	36.1

Endnotes

1. *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, U.S. Environmental Protection Agency (OAQPS), May 1991.

2. *County Business Patterns 1992-Colorado*, CBP-92-7, U.S. Department of Commerce, Bureau of the Census, September 1994.

3. Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency.

4. *1993 TAZ Demographic Data Set*, Denver Regional Council of Governments, letter of transmittal, June 26, 1995.

5. *Economic Growth Analysis System: Reference Manual-Version 2.0*, EPA-600/R-94-139a, U.S. Environmental Protection Agency (ORD), August 1994.

6. *Procedures for Preparing Emissions Projections*, EPA-450/4-91-019, U.S. Environmental Protection Agency (OAQPS), July 1991

20. 61 FR 19005

21. 61 FR 32729

5.5 GRAPHIC ARTS

5.5.1 Abstract

The methodologies and emission factors used to estimate volatile organic compounds (VOC) emissions from graphic arts operations are estimated using EPA methods. Emissions from graphic arts may either be point sources or area sources. To estimate area source emissions from graphic arts, the point source emissions from the AIRS data base were subtracted from the total regional estimate of graphic art emissions. The regional estimate of graphic art emissions were estimated by the product of the regions population and a per capita emission factor. The EPA recommended emissions factor is 1.3 lbs/year/capita.

5.5.2 Introduction

Graphic arts includes operations that are involved in the printing of newspapers, magazines, books and other printed materials. The majority of solvent use in graphic arts operations is consumed in printing ink formulations. Lesser amounts of solvents are used in equipment cleaning and as a component in fountain solutions for dampening systems in lithographic printing.

5.5.3 Graphic Arts Inventory Method

The AIRS emission inventory[1] for Colorado contains some graphic arts facilities down to one ton per year. However, at the one ton per year level, there are some facilities that may be missing from the AIRS data base because APENs may have not been submitted for the smaller facilities. As a result, the graphic arts VOC emission inventory is based on both area source and stationary source emission estimates. The methodology used to estimate graphic arts emissions is described in the EPA document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*[2].

The area source emissions calculation for Denver was estimated using the following equation:

Area Source VOC Emissions for Graphic Arts (lb/year)	=	Total Region Population	x	Graphic Arts Emission Factor (lbs/year/capita)	-	Graphic Arts Point Source Emission Rates (from AIRS)

5.5.4 Emission Factors

Table 5.5.4-1 gives recommended emission factors for the graphic arts industry on a per capita basis for facilities with emissions less than 100 tons per year. Because of the number of captive graphic arts operations that are used in industries other than printing and publishing (SIC 27), a per employee factor is unreliable for calculating emissions.

Table 5.5.4-1 Recommended Emission Factors for Graphic Arts

	PER CAPITA FACTOR (lb/person/year)	PER EMPLOYEE FACTOR (lb/employee/year)	SIC CODES
Graphic arts, <100 tons/year	1.3	na	not applicable

5.5.5 Activity Factors

Table 5.5.5-1 presents the county level population[3] and VOC emissions from graphic arts for the nonattainment area. A summary of county wide emissions from minor point sources (<100 tpy) are presented in Table 5.5.5-1 as "point source emission rates".

Regional emission rates are estimated by the product of the population and the graphic arts emission factor (1.3 lbs/yr/capita). To estimate area source emissions from graphic arts, the minor point source emissions from AIRS was subtracted from the regional estimate of emissions. A scalar of 0.0032 was used to estimate typical summer day emissions which assumes that graphic arts facilities operate 6 days/week. Derivation of the typical summer day scalar is presented in a following section. The estimated 1993 base year area source emissions from graphic art facilities is 1,032.69 tpy, or, 3.2 tpsd.

Table 5.5.5-1 Emission Estimates from Graphic Arts

County	Point Source Emission Rate (TPY)	Point Source Emission Rate (TPSD)	1993 Population	Emission Factor (lbs/yr/ capita)	Regional Emission Rate (tpy)	Regional Emission Rate (tpsd)	Area Source Emission Rate (tpy)	Area Source Emis. Rate (tpsd)
ADAMS	20.13	0.06	272860	1.3	177.36	0.57	157.23	0.50
ARAPAHOE	13.32	0.04	405525	1.3	263.59	0.84	250.27	0.80
BOULDER	33.42	0.11	231343	1.3	150.37	0.48	116.95	0.37
DENVER	142.11	0.45	484121	1.3	314.68	1.01	172.57	0.55
DOUGLAS	1.00	0.00	77504	1.3	50.38	0.16	49.38	0.16
JEFFERSON	6.00	0.02	449672	1.3	292.29	0.94	286.29	0.92
TOTAL	**215.98**	**0.69**	**1921025**		**1248.67**	**4.00**	**1032.69**	**3.20**

5.5.6 Projection Methodology

To project emissions to future years, a ratio of population from the base year to the projected year is used. This ratio was then multiplied by the 1993 base year emissions. The population ratio between 2006 and 1993 is 1.33. By multiplication of the 1993 emission rate of 3.2 tpsd with the population ratio results in an estimated emission rate in 2006 of 4.26 tpsd. The 2013 to 1993 population ratio is 1.47. Using the 2013 to 1993 ratio, the projected emission rate for 2013 is 4.7 tpsd.

5.5.7 Temporal Factors

The document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*, presents area source seasonal adjustment factors for various source categories. From this document, it is assumed that there is no seasonal variation in graphic arts emissions and that these facilities operate 5 days/week. However, data on the AIRS file and personal observations would indicate that these facilities operate 6 days/week.

To convert annual emissions from tons per year (tpy) to tons per summer day (tpsd), the following formula is used:

$$\text{Emissions per typical summer day (tpsd)} = \frac{\text{Annual Emissions (tpy)} * \text{Seasonal Adjustment Factor}}{\text{\# Activity Days per Week} * \text{52 Weeks}}$$

The use of the above formula results in an annual average emission rate conversion factor to a typical summer day of 0.0032.

5.5.8 Assumptions

It was assumed that the EPA per capita emission factor is representative of the Denver-Boulder nonattainment area.

5.5.9 Sample Calculations

Table 5.5.9-1 presents a sample calculation used to estimate the total nonattainment area emissions from graphic arts, as an area source. Both the base year and projected year estimation methods are presented in the table.

Table 5.5.9-1 Sample Calculations for Graphic Arts

ITEM	VALUE	UNITS
1993 Base year estimates		
Regional area population	1921025	people
Graphic arts emission factor	1.3	lbs/yr/capita
Regional estimate of graphic art emissions	2497333	lbs/yr
Annual emission rate	1248.67	tpy
Point source emission rates	215.98	tpy
Estimated area source emissions	1032.69	tpy
Seasonal scalars (6 days/week, 52 weeks/year)	0.0032	no dimensions
Summer emissions in tons per summer day	3.2	tpsd
2006 Projected emissions		
Population scalar	1.33	no dimensions
Estimated Emission in 2006	4.3	
2013 Projected emissions		
Population scalar	1.47	no dimensions
Estimated emissions in 2010	4.7	tpsd

5.5.10 Conclusions

The estimated VOC emission rate from area sources of graphics arts is estimated to be 3.2 tpsd for 1993. By 2006 and 2013, this emission rate is expected to increase as a function of population growth to 4.3 tpsd and 4.7 tpsd, respective.

Endnotes

1. Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency.

2. *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, U.S. Environmental Protection Agency (OAQPS), May 1991.

3. *1993 TAZ Demographic Data Set*, Denver Regional Council of Governments, letter of transmittal, June 26, 1995.

5.6 PESTICIDES

5.6.1 Abstract

There are no EPA methods for estimating regional area emissions from pesticides. However, AP-42 offers some generalized data by which regional emission estimates can be made. AP-42 gives an agricultural application rate of 2 to 5 lbs per acre and that there are 0.09 lbs of VOC/pound of pesticide applied. An accurate estimate on the amount of pesticide applied within a given area is somewhat difficult to obtain. The Bureau of Census does publish an estimate of the amount of pesticides applied in their document, *Census of Agriculture*.

5.6.2 Introduction

Pesticides include any substance used to kill or retard the growth of insects, rodents, fungi, weeds or microorganisms. A number of substances are used as pesticides, including synthetic organics, petroleum solvents and inorganic compounds. Both the active and inert ingredients in pesticides evaporate and contribute to VOC emissions.

5.6.3 Pesticide Inventory Methods

There are no point source emissions attributed to pesticides. Therefore, all emissions from pesticides are area sources. There are two types of area sources that may use pesticides, agricultural and commercial/consumer. For consumer/commercial use of pesticides, it is assumed that each person uses 0.25 pounds of pesticide per year with a VOC content of 0.09 pounds per pound of pesticide used.

The EPA does not specify a method for estimating area wide VOC emissions from agricultural use of pesticides. However, AP42[2] does present some general data that is sufficient for estimating emissions from pesticides. In order to estimate emissions from pesticides, the number of acres that the pesticide is applied is first estimated. Then, from AP-42, it is assumed that 2 to 5 pounds of pesticide is applied per acre. For the Denver inventory, an average of 2 pounds of pesticide per acre is assumed to be applied. Of the pesticide applied, it is assumed that 0.09 lbs of VOC is emitted per pound of pesticide applied[1,4].

Area source VOC emissions from pesticides (lbs/year)	=	Acres pesticides applied to	x	2 lbs pesticide per acre	x	0.09 lbs of VOCs per lb of pesticide

5.6.4 Emission Factors

As described above, AP-42 gives a general emission factor of 0.09 lbs VOC emitted per pound of pesticide applied.

5.6.5 Activity Factors

Table 5.6.5-1 presents the number of acres that pesticides are applied, by county, within the nonattainment area. The amount of pesticides applied is estimated in the Bureau of Census document, *Census of Agriculture-1987*[3].

Table 5.6.5-1 Number of Acres Pesticides Applied to by County

Type of Pesticide Application	Adams	Arapahoe	Boulder	Denver	Douglas	Jefferson
Insecticides	139,046	15,130	23,044	14	139	253

Table 5.6.5-2 presents the estimated VOC emission rates from pesticide applications. In Table 5.6.5-2, the amount of pesticide applied was estimated as the product of the number of acres that pesticide was applied to, and, 2 lbs pesticide applied per acre. The amount of VOCs in the pesticide was then multiplied by 0.09 lbs VOC/lb of pesticide to estimate the emission rate.

The summer VOC emissions from pesticide applications include a seasonal factor of 1.3. The use of this factor is described below in the "Temporal Factor" section. From Table 5.6.5-2, it is estimated that VOC emissions from agricultural use of pesticides is 15.99 tpy, or, 0.06 tpsd.

Consumer/commercial use of pesticides are estimated by applying a per capita emission factor of 0.25 pound of pesticide per capita. Given that the population for the six county area is 1,921,025 people, this results in an estimated pesticide use rate of 480,256.3 pounds of pesticide used annually. Assuming that there are 0.09 lbs VOC per pound of fertilizer results in an annual VOC emission rate of 21.61 tpy VOC. Using the annual to summer conversion rate of 0.0036 results in a typical summer day emission rate of 0.08 tpsd for consumer/commercial pesticide use. The combined VOC emission rate from agricultural and consumer/commercial pesticide used is estimated at 0.14 tpsd.

Table 5.6.5-2 Estimated VOC Emissions from Pesticide Applications

County	Acres Pesticide Applied to	Amount of Pesticides Applied (lbs)	Amount of VOCs in the Applied Pesticide (lbs)	Annual VOC Emission Rate from VOCs (tpy)	Summer Day Emission Rate from VOCs (tpsd)
Six County Area	177,626	355,252	31,972.68	15.99	0.06

5.6.6 Projection Methodology

Pesticide emissions were projected to 2006 and 2013 as a function of population growth. Population is projected to grow by a factor of 1.33 between 1993 and 2006, and, 1.47 between 1993 and 2013. Using population growth as a surrogate for pesticide use yields a 2006 estimated VOC emission rate of 0.19 tpsd. The estimated VOC emission rate from pesticide use is expected to be 0.21 tpsd by 2013.

5.6.7 Temporal Factors

The document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*, presents area source seasonal adjustment factors for various source categories. From this document, it is assumed that there is 1.3 times as much pesticide applied in summer months and that there is no daily variation in pesticide applications. To convert annual emissions from tons per year (tpy) to tons per summer day (tpsd), the following formula is used:

$$\text{Emissions per typical summer day (tpsd)} = \frac{\text{Annual Emissions (tpy)} * \text{Seasonal Adjustment Factor}}{\text{\# Activity Days per Week} * \text{52 Weeks}}$$

The use of the above formula results in an annual average emission rate conversion factor to a typical summer day of 0.0036.

5.6.8 Assumptions

The following assumptions are made in the area source estimates for pesticides:

1) Pesticides are applied at a rate of 2.0 lbs/acre;
2) There are 0.09 pounds of VOC per pound of pesticide applied;
3) The USDA estimates on the number of acres that pesticides are applied, are accurate.

5.6.9 Sample Calculations

Table 5.6.9-1 presents a sample calculation used to estimate the total nonattainment area emissions from pesticides.

Table 5.6.9-1 Sample Calculation for Pesticide Emissions

ITEM	VALUE	UNITS
1993 BASE YEAR ESTIMATES		
Estimated acres that pesticides are used on	177,626	acres
Application rate of pesticide application	2.0	lbs/acre
Pounds of pesticide applied	355,252	lbs
Amount of VOCs in pesticides	0.09	lbs VOC/lb pesticide
Amount of VOCs emitted	31,972.68	Ibs/year
Annual VOC	15.99	tpy
Daily scalar (assume 7 day/week, 52 weeks/yr)	0.0027	no dim
Summer seasonal scalar	1.3	no dim
Summer day emissions	0.06	tpsd
Population	1,921,025	people
Application Rate	0.25	lbs/capita
Pound of pesticide applied	480,256.3	lbs/year
Amount of VOCs in pesticides	0.09	lbs VOC/lb pesticide
Amount of VOCs emitted	43,223	lbs VOC/year
Annual VOC	21.61	tpy
Summer day emissions (tpy*0.0036)	0.08	tpsd
Total Agricultural/consumer/commercial VOC emissions from pesticides	0.14	tpsd
2006/1993 growth factor	1.33	No dim
Estimated 2006 emissions	0.19	tpsd
2013/1993 growth factor	1.47	No dim
Estimated 2013 emissions	0.21	tpsd

5.6.10 Conclusions

It is estimated that the 1993 VOC emissions from pesticide application is 37.60 tpy, or, 0.14 tons per summer day over the nonattainment area. By 2010, it is expected that VOC emissions from pesticide use will grow to 0.18 tpsd as a function of population growth.

Endnotes

1. *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, U.S. Environmental Protection Agency (OAQPS), May 1991.

2. *Compilation of Air Pollutant Emission Factor*, Fourth Edition and Supplements, AP-42, U.S. Environmental Protection Agency, September 1985.

3. *Census of Agriculture-1987*, Volume 1: Geographic Area Series, Part 6, Colorado State and County Data, U.S. Department of Commerce, Bureau of the Census, June 1994.

4. *Procedures for Emission Inventory Preparation, Volume III, Area Sources*, EPA 450/4-81-026c, U.S. Environmental Protection Agency (OAQPS), September 1981.

5.7 COMMERCIAL/CONSUMER SOLVENT USE

5.7.1 Abstract

The methodologies and emissions factors used to estimate volatile organic compound (VOC) emissions from commercial/consumer solvent use are estimated using EPA methods. Emissions from commercial/consumer solvent use are exclusively area sources. To estimate emissions relative to commercial/consumer solvent use, a per capita emission factor is multiplied by the areas population to estimate an emission rate. The EPA recommended emissions factor of 6.3 lbs/year/capita was used for the VOC emission estimates.

5.7.2 Introduction

Some commercial/consumer products contain volatile organic compounds (VOC). The quantity and use practices of these products cannot easily be identified by questionnaires, surveys or other inventory procedures yielding locale-specific emissions estimates. The major organic materials comprising the commercial/consumer solvent use category are special naphthas, alcohols, carbonyls and various other organics.

5.7.3 Commercial/Consumer Solvent Use Inventory Methods

There are no point source emissions attributed to commercial/consumer solvent use. All emissions from commercial/consumer solvent use are area sources. The methodology used to estimate VOC emissions from commercial/consumer solvent use is described in the EPA document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*[1].

The area source emissions calculation for Denver was estimated using the following equation:

Area source VOC emissions for Comm/Cons. Solvent Use (lb/year)	=	Total regional population	x	Per capita..... emission factor (6.3 lbs/year/capita)

5.7.4 Emission Factors

An emission factor of 6.3 pounds per capita per year is recommended for estimating emissions from this category[(1)]. Table 5.7.4-1 presents a summary of the subcategories that comprise the commercial/consumer source category. Nonreactive species such as halogenates used in aerosols and other products are excluded from these emission factors.

Table 5.7.4-1 Emission Factor for Commercial/Consumer Solvent Use

Item	Emission Factor	Units
Household products	2.0	lbs/year/capita
Toiletries	1.4	lbs/year/capita
Aerosol products	0.8	lbs/year/capita
Rubbing compounds	0.6	lbs/year/capita
Windshield washing fluids	0.6	lbs/year/capita
Polishes and waxes	0.3	lbs/year/capita
Nonindustrial adhesives	0.3	lbs/year/capita
Space deodorants	0.2	lbs/year/capita
Moth control	0.1	lbs/year/capita
Laundry detergents and treatment	< 0.1	lbs/year/capita
TOTAL	**6.3**	**lbs/year/capita**

5.7.5 Activity Factors

Table 5.7.5-1 presents the county level population[(2)] and VOC emission rates from commercial/consumer solvent use. Emission rates were estimated by multiplying the population estimates by the per capita emission factor of 6.3 lbs/year/capita. The emission rates were then converted to an annual rate in tons per year (tpy) and a typical summer day rate in tons per summer day (tpsd). A conversion rate of 0.003205 was used to convert the annual emission rate into a typical summer day rate. Derivation of this conversion factor is described in a subsequent section. The estimated emission rate for VOCs from commercial/consumer solvent use for 1993 is 6,519.21 tpy, or, 20.89 tpsd. After 1997, a reduction rate of 20% is applied to the emissions estimates to account for the effects of provisions contained in 61CFR14532.

Table 5.7.5-1 VOC Emissions Estimates for Commercial/Consumer Solvent Use

County	1993 Population	Emission Factor (Lbs/yr/ capita)	1993 Annual Emission Rate (tpy)	1993 Summer Day Emission Rate (tpsd)	2006 Population	2006 Summer Day Emission Rate (tpsd	2013 Population	2013 Summer Day Emission Rate (tspd)
ADAMS	272860	6.3	859.51	2.75	418665	3.38	494364	3.98
ARAPAHOE	405525	6.3	1277.40	4.09	470512	3.79	488841	3.94
BOULDER	231343	6.3	728.73	2.34	309712	2.50	351159	2.83
DENVER	484121	6.3	1524.98	4.89	522992	4.22	576935	4.66
DOUGLAS	77504	6.3	244.14	0.78	224095	1.81	273747	2.21
JEFFERSON	449672	6.3	1416.47	4.54	616063	4.97	636497	5.14
TOTAL	**1923018**		**9437.46**	**19.36**	**2562039**	**20.67**	**2821543**	**22.76**

5.7.6 Projection Methodology

To project emissions to future years, population data for 2010[(2)] is used. The population data is then multiplied by the emission factor of 6.3 lbs/year/capita. Table 5.7.5-1 presents population estimates for 2006 and 2013 along with projected emission rates. The 2006 and 2013 emission rate from consumer/commercial solvent use is projected to be 20.7 tpsd and 22.8 tpsd, respectively.

5.7.7 Temporal Factors

The document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*, presents area source seasonal adjustment factors for various source categories. From this document, it is assumed that there is no seasonal variation in commercial/solvent use and that commercial solvent use occurs 6 days/week.

To convert annual emissions from tons per year (tpy) to tons per summer day (tpsd), the following formula is used:

$$\text{Emissions per typical summer day (tpsd)} = \frac{\text{Annual Emissions (tpy)} \times \text{Seasonal Adjustment Factor}}{\text{\# Activity Days per Week} \times \text{52 Weeks}}$$

The use of the above formula results in an annual average emission rate conversion factor to a typical summer day of 0.0032.

5.7.8 Assumptions

The following assumptions are made in the area source estimates for commercial/consumer solvent use:

1) The per capita emission factor from EPA is representative of the Denver area;

2) The per capita emission factor does not include: small cold cleaning degreasing operations; dry cleaning plants; auto refinishing shops; architectural surface coating applications; graphic arts plants; cutback asphalt paving applications; and agricultural and municipal pesticide applications. These categories must be inventoried by point or area source procedures, elsewhere, in the inventory;

3) The emission factor does include commercial/residential pesticide use;

4) The use of commercial/consumer solvents occur, on average, six days per week.

5.7.9 Sample Calculations

Table 5.7.9-1 presents a sample calculation used to estimate the total nonattainment area emissions from commercial/consumer solvent use. Both the base year and projected year estimation methods are presented in the table.

Table 5.7.9-1 Sample Calculations for Commercial/Consumer Solvent Use

ITEM	VALUE	UNITS
1993 BASE YEAR ESTIMATES		
Population	1919407	people
Commercial/consumer solvent emission factor	6.3	lbs/year/capita
Estimated emission rate	12092264	lbs/year
Estimated annual emission rate	6046.13	tpy
Seasonal scalars (6 days/week, 52 weeks/yr)	0.0032	no dimensions
Summer emissions in tons per summer day	19.35	tpsd
2006 Projected emissions		
Population	2562039	people
Commercial/consumer solvent emission factor	6.3	lbs/year/capita
Estimated emission rate	16140845	lbs/year
Estimated annual emission rate	8070.4	tpy
Seasonal scalars (6 days/week, 52 weeks/yr)	0.0032	no dimensions
Summer Emission in tons per summer day	25.8	tpsd
Reduction due to 61CFR14531(20% reduction)	20.6	tpsd
2013 Projected emissions		
Population	2821543	people
Commercial/consumer solvent emission factor	6.3	lbs/year/capita
Estimated emission rate	17775720	lbs/year
Estimated annual emission rate	8887.9	tpy
Seasonal scalars (6 days/week, 52 weeks/yr)	0.0032	no dimensions
Summer emissions in tons per summer day	28.4	tpsd
Reduction due to 61CFR14531(20% reduction)	22.7	tpsd

5.7.10 Conclusions

Table 5.7.9-1 presents the VOC emission rates for commercial/consumer use of solvents. In 1993, the estimated emission rate is 6,519.22 tpy, or, 20.89 tpsd within the nonattainment area. These emissions are expected to grow, as a function of population and federally mandated controls to 20.7 tpsd by the year 2006, and, 22.8 tpsd by the year 2013.

Endnotes

1. *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, U.S. Environmental Protection Agency (OAQPS), May 1991.

2. *1993 TAZ Demographic Data Set*, Denver Regional Council of Governments, letter of transmittal, June 26, 1995.

5.8 PUBLICLY OWNED TREATMENT WORKS/WASTE WATER TREATMENT

5.8.1 Abstract

VOCs are emitted from waste water collection, treatment, and storage systems through volatilization of organic compounds at the liquid surface. Emissions can occur by diffusive or convective mechanisms, or both. Diffusion occurs when organic concentrations at the water surface are much higher than ambient concentrations. The organics volatilize, or diffuse into the air, in an attempt to reach equilibrium between aqueous and vapor phases. Convection occurs when air flows over the water surface, sweeping organic vapors from the water surface into the air. The rate of volatilization relates directly to the speed of the air flow over the water surface.

To estimate VOC emissions from Publicly Owned Treatment Works (POTWs) in the Denver area, a comparison of emissions from AIRS and approximate area source emissions were estimated. It was found that all POTW emission rates are accounted for on AIRS as point sources.

5.8.2 Introduction

Many different industries generate waste water streams that contain organic compounds. Nearly all of these streams undergo collection, contaminant treatment, and/or storage operations before they are finally discharged into either a receiving body of water or a publicly owned waste water treatment plant (POTW) for further treatment. During some of these operations, the waste water is open to the atmosphere, and volatile organic compounds (VOC) may be emitted from the waste water into the air.

Industrial waste water sent to POTWs may be treated or untreated and may contain VOCs. POTWs may also treat waste water from residential, institutional, and commercial facilities; from infiltration (water that enters the sewer system from the ground); and/or storm water runoff. These types of waste water generally do not contain VOCs. A POTW usually consists of a collection system, primary settling, biotreatment, secondary settling, and disinfection processes.

5.8.3 Publicly Owned Treatment Works Emission Inventory Methods

The AIRS emission inventory for Colorado contains all the emissions from POTWs. This was determined by contacting the individual waste water treatment districts in the area for their estimated daily influent rates(1). These rates were then multiplied by 1.1 lbs VOC/gallon of waste water(2). This rate was then compared to the total emissions on AIRS(3). The emission rate on AIRS was greater than the area source estimation method, therefore, it was assumed that all emissions from POTWs are point sources.

5.8.4 Emission Factors

VOCs are emitted from waste water collection, treatment, and storage systems through volatilization of organic compounds at the liquid surface. Emissions can occur by diffusive or convective mechanisms, or both. Diffusion occurs when organic concentrations at the water surface are much higher than ambient concentrations. The organics volatilize, or diffuse into the air, in an attempt to reach equilibrium between aqueous and vapor phases. Convection occurs when air flows over the water surface, sweeping organic vapors from the water surface into the air. The rate of volatilization relates directly to the speed of the air flow over the water surface.

The EPA document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*, contains a generalized emission factor for POTWs of 1.1 lb VOC/gallon of industrial waste water.

5.8.5 Activity Factors

Table 5.8.5-1 presents a summary of POTW emissions from AIRS. As a comparison Table 5.8.5-2 presents area source emission estimates for POTWs using information obtained from the various waste water districts. Tables 5.8.5-1 and 5.8.5-2 demonstrate that the area source estimates of VOC emissions from POTWs is smaller than those on AIRS, therefore, it is assumed that all POTW emissions are accounted for on AIRS.

The area source emission rate in tons per year was estimated by taking the daily influent rate (mgd) times 365 days per year to estimate how many million gallons per year are processed by the various POTWs. This annual influent rate is then multiplied by the emission rate of 1.1×10^{-4} lbs VOC/gallon of influent. This result was then converted to an emission rate in tons VOC/year.

5.8.6 Conclusion

All emissions from POTWs for the Denver ozone nonattainment area are on the AIRS data base, therefore, there are no estimated area source emissions. The point source VOC emissions for POTWs is 55.51 tpy.

Table 5.8.5-1 Summary of POTW Emissions from AIRS

Point ID	POTW Name	Influent (mgy)	Emission Rate (tpy)
0010097	METRO WASTE WATER RECLAMATION DISTRICT	120305	25.14
0010154	NORTHGLENN WATER TREATMENT PLANT	1260	0.69
0010864	BRIGHTON WASTE WATER TREATMENT PLANT	639	1.00
0130057	BOULDER WASTE WATER TREATMENT PLANT	676	27.35
0130063	LONGMONT - WASTE WATER TREATMENT PLANT	7272	1.32
TOTALS		**130152**	**55.51**

mgy= Million Gallons of influent per year
tpy= Tons VOC per year

Table 5.8.5-2 Area Source Emission Estimates from POTWs

POTW Name	Area Source Influent Rate (mgd)	Area Source Emission Rate (tpy)
METROPOLITAN WASTE WATER DISTRICT	140.0	7.70
LITTLETON/ENGLEWOOD WASTE WATER TREATMENT	23.1	1.27
PLUM CREEK WASTE WATER AUTHORITY-CASTLE ROCK	1.2	0.07
BOULDER WASTE WATER UTILITY	17.2	0.95
SAND CREEK RECLAMATION FACILITY	2.5	0.14
TOTAL	**184.0**	**10.12**

mgd= Million Gallons of influent per day
tpy= Tons VOC per day

Endnotes

1) Woodford, Phyllis, CDPHE internal memorandum, *POTW Flow Rate Data*, May 17, 1995.

2) *Procedure 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, U.S. Environmental Protection Agency (OAQPS), May 1991.

3) Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency.

5.9 TREATMENT, STORAGE, OR DISPOSAL FACILITIES

5.9.1 Abstract

A comparison of treatment, storage, or disposal facilities (TSDFs) from EPA's RCRIS data base was made with those facilities on the AIRS data base. This comparison revealed that the majority of the TSDF emissions are accounted for as point sources on AIRS. Since there are no large unaccounted for surface impoundments, it is assumed that area source emissions (those emissions not on AIRS) from TSDFs are very small or negligible.

5.9.2 Introduction

A treatment, storage, or disposal facility (TSDF), according to 40 CFR 260.10, is a facility that performs one or more of the following functions:

Treatment--Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize it, or render it non-hazardous or less hazardous, or to recover it, make it safer to transport, store or dispose of, or amenable for recovery, storage or volume reduction.

Storage--The holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed, or stored elsewhere.

Disposal--The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste into or on any land or water so that the waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

5.9.3 TSDF Inventory Conclusions

Table 5.9.3-1 presents a listing of treatment, storage, or disposal facilities within the nonattainment area from EPA's Resource Conservation and Recovery Information System (RCRIS)[(1)]. This listing was then compared to facilities on the Colorado AIRS data base[(2)]. The comparison revealed that most all of the TSD facilities are on AIRS. Since the Colorado AIRS database contains facilities down to 1 tpy, it is assumed that emissions from those TSDFs not on AIRS have very small or no emissions. As seen in Table 5.9.3-1, most the facilities not on AIRS would store their wastes in totally enclosed drums or tank storage facilities. Except for the Rocky Flats Plant and the Chemical Handling Corporation (both on AIRS) there are no large aerated/non-aerated surface impoundments within the nonattainment area. Therefore, area source emissions from TSDFs are expected to be very small or negligible.

Table 5.9.3-1 Listing of Reported RCRA Treatment, Storage or Disposal Facilities (TSDF)

FACILITY NAME	COUNTY	TYPE OF STORAGE/PROCESSES	ON AIRS?
AEERCO	Jefferson	Container storage, Tank storage, Tank	No

Table 5.9.3-1 Listing of Reported RCRA Treatment, Storage or Disposal Facilities (TSDF)

FACILITY NAME	COUNTY	TYPE OF STORAGE/PROCESSES	ON AIRS?
		treatment	
ASARCO	Denver	Land disposal	Yes
Broderick Investments CO	Adams	Land disposal	Yes
Chemical Handling Corp	Boulder	Container storage, Tank storage, Tank treatment, Surface impoundment treatment	Yes
TOTAL Refining (Colorado Refining)	Adams	Land disposal	Yes
Conoco INC	Adams	Storage	Yes
Coors Brewing CO	Adams	Storage	Yes
Denver-Arapahoe Chem Waste Process	Arapahoe	Disposal, Storage	Yes
ECOVA	Jefferson	Incineration	Yes
Ensign-Bickford Co.	Douglas	Storage	No
Great Western Inorganics	Jefferson	Disposal	Yes
Highway 36 Land Development Corp	Adams	Disposal, Storage	Yes
International Business Machines Inc	Boulder	Container storage, Tank storage	Yes
Koppers	Denver	Storage, Disposal	Yes
MAI/Approved Oil Service Inc	Adams	Disposal	No
Martin Marietta Astronautics	Jefferson	Disposal, Storage	Yes
Molycorp	Douglas	Disposal	Yes
OEA Inc	Denver	Disposal, Storage	Yes
Oil & Solvent Process CO (OSCO)	Adams	Container storage, Tank storage, Tank treatment, Other treatment	No
Protex Industries	Denver	Disposal	No
Ramp Industries	Denver	Disposal	Yes
Remelt metals Inc.	Arapahoe	Disposal	No
Rocky Flats Plant	Jefferson	Container storage, Surface impoundment treatment	Yes
Rocky Mountain Arsenal	Adams	Disposal, Storage	Yes
Safety-Kleen (Denver)	Denver	Container storage, Tank storage	Yes
Safety-Kleen (Commerce City)	Adams	Container storage, Tank storage	Yes
Safety-Kleen (Englewood)	Arapahoe	Container storage, Tank storage	Yes

Table 5.9.3-1 Listing of Reported RCRA Treatment, Storage or Disposal Facilities (TSDF)

FACILITY NAME	COUNTY	TYPE OF STORAGE/PROCESSES	ON AIRS?
Syntex Chemicals	Boulder	Container storage	Yes
Syntex Cleanup Project (Lyons)	Boulder	Container storage	Yes
Thoro Products Inc	Jefferson	Container storage, Tank storage, Tank treatment	No
University of Colorado	Boulder	Container storage	Yes

Endnotes

5.10 LANDFILLS

5.10.1 Abstract

Landfill emissions are produced from volatilization, chemical reaction and decomposition of liquid and solid compounds into other chemical species. EPA's Landfill Air Emissions Estimation Model was used to calculate emissions from landfills. In addition, Radian Corporation was contracted by EPA to recommend default values for some of the input variables to the landfill model when doing SIP work.

5.10.2 Introduction

VOC emissions are produced from municipal solid waste (MSW) landfills by three mechanisms: volatilization, chemical reaction and biological decomposition of liquid and solid compounds into other chemical species. Factors affecting volatilization include: partial pressure of the constituent; constituent concentration at the liquid-air interface; temperature; and confining pressure. Chemical reactions are also affected by temperature, as well as: waste composition; moisture content; and the practice of separate disposal areas for different waste types. Factors affecting biological decomposition are: nutrient and oxygen availability; refuse composition; age of the landfill; moisture content; temperature; pH; and waste that is toxic to bacteria.

5.10.3 Landfill Inventory Methods

The Landfill Air Emissions Estimation Model(1)(2) (hereafter, referred to as the "Landfill Emissions Model") was used to estimate Non-methane Organic Carbon (NMOC) emissions from landfills. Inputs into the model include estimated yearly refuse in place, NMOC concentration, methane generation constant (k), and the potential methane generation capacity (L_o). Model default values for percent methane and carbon dioxide were also used.

Radian Corporation was contracted by EPA to recommend values for the concentration of NMOC, k, and L_o(3). The Radian suggested value for N concentration is 880 parts per million (ppm) as hexane. Values for NMOC concentration can range from a minimum of 105 ppm to 12588 ppm. The value of 880 ppm is a median value over the data set that Radian used. For (k), Radian suggests using a value of 0.02/yr for dry climates. A value of 4411 cubic feet is used for the L_o variable. The Radian suggested values for NMOC, k, and L_o were used for all existing and closed landfills in the Denver nonattainment area for inventory modeling purposes.

5.10.4 Activity Factors

Estimations of amount of refuse in place for inactive landfills were derived from historical documents(4)(5)(6)(7)(8). The annual disposal rate for each inactive landfill was determined by dividing the total amount of refuse in place at the time of closure by the number of years the landfill was open. For active landfills, reports from the Colorado Hazardous Materials and Waste Management Division were used(9). Estimations on the amount of refused placed in landfills per year is then entered into the Landfill Emissions Model.

Table 5.10.4-1 presents a summary of landfill emissions for 1993 from the various active and inactive landfills.

5.10.5 Projection Methodology

Although the Landfill Emissions Model is capable of predicting NMOC concentrations well into the future for an individual landfill, it is not able to calculate emissions from future activity without knowledge of how much refuge is going to be placed in solid waste landfills. In projecting emissions out to 2013, existing landfills are likely to be filled up and new sites established. Given these uncertainties, landfill emissions from the current 1993 levels were grown to 2006 and 2013 using population as a surrogate. By 2006 and 2013, landfill emissions are projected to be 2.81 tpsd and 2.10 tpsd, respectively.

5.10.6 Temporal Factors

The Landfill Emissions Model does not provide for input regarding variables such as temperature, humidity, or other conditions that may effect seasonal or daily emissions. It is assumed that landfill emissions are uniformly distributed on a daily basis[10].

5.10.7 Assumptions

The following assumptions are made in regards to estimating emissions from landfills:

1) The recommended values for NMOC, k, and L_o from the Radian memo are representative of all landfills in the Denver nonattainment area;

2) Future emissions grow as a function of population rather than the model predicted values for existing landfills.

5.10.8 Sample Calculations

Calculations for emissions from landfills are self contained in the Landfill Emissions Model. Since the calculations are self contained in the EPA model, no sample calculations are provided here.

Table 5.10.4-1 1993 Estimated Emissions Rates for Nonattainment Area Landfills

LANDFILL NAME	VOC Emission Rate (tpy)	VOC Emission Rate (tpsd)
TOWER ROAD	168.50	0.46

LANDFILL INC	23.58	0.06
BRIGHTON BLVD	7.40	0.02
48TH AND HOLLY	43.95	0.12
WESTERN PAVING	1.49	0.00
WESTERN PAVING EXPERIMENTAL	0.67	0.00
ADAMS COUNTY	7.38	0.02
PROPERTY IMPROVEMENTS	7.38	0.02
DADS (LOWRY)	39.75	0.11
MILE HIGH	13.47	0.04
MARSHAL (1965-1970)	0.00	0.00
MARSHAL (1970-1983)	17.20	0.05
MARSHAL (1964-1980)	11.01	0.03
MARSHAL (1983-1987)	18.99	0.05
COUNTY LINE (1964-1980)	157.48	0.43
COUNTY LINE (1980-1987)	82.96	0.23
BFI-RPS	44.29	0.12
JEFFERSON COUNTY	36.96	0.10
56TH AND FENTON	9.99	0.03
1ST AND AMES	0.25	0.00
46TH AND HARLAN	0.19	0.00
82ND AND INDIANA	15.20	0.04
FAIRGROUNDS	1.88	0.01
ROONEY	60.84	0.17
TOTAL	**770.78**	**2.11**

5.10.9 Conclusions

The estimated emissions from inactive and active landfills within the nonattainment area are estimated to be 2.11 tpsd. These emissions are expected to grow as a function of population to 2.81 tpsd by 2006, and, 3.10 tpsd by 2013.

Endnotes

5.11 LEAKING UNDERGROUND STORAGE TANKS

5.11.1 Abstract

The methodologies and emission factors used to estimate VOC emissions from leaking underground storage tanks (LUSTs) are described in a Radian Corporation memo dated May 5, 1992. Emission estimation methodologies for this category are not included in AP-42[1]. Emissions from LUSTs are estimated by identifying the number of leaking underground storage tank remediations that were initiated during the base year ozone season, and, then, applying an emission factor of 28 lbs VOC/day per event.

5.11.2 Introduction

Leaking underground storage tanks, typically, do not become quantifiable sources of volatile organic compounds (VOC) until excavation and remediation efforts are conducted. Remediation can be accomplished by various methods, including soil venting, air stripping of VOC in water, soil aeration, product recovery and carbon adsorption. Each of these methods accounts for initial and final contaminant levels. The common practice for LUST excavations is to remove the leaking tank and surrounding soil. The contaminated soil is then either piled or spread out to allow the organic compounds to volatilize.

5.11.3 Leaking Underground Storage Tank Emission Inventory Methods

The EPA document, *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone*[2], suggests that site-specific data be compiled for each remediation activity as the basis for estimating emissions from LUSTs. Given the large number of LUST sites and the lack of a reliable database, emission estimations from LUSTs within the Denver nonattainment area is prohibitively time consuming. In addition, it is estimated that emissions from LUSTs are small compared to the overall VOC emission inventory.

Radian Corporation, through EPA Contract No. 69-DO-0125, was contracted to: 1) present a simple approach for estimating VOC emissions from remediations of LUST sites; 2) provide a recommended default emission rate for use where data is limited, and; 3) provide a set of default emission rates covering common ranges of soil excavation and gasoline contamination levels at LUST sites[3].

The LUST emission inventory for the Denver ozone nonattainment area followed the recommended procedures and emission factors described in the Radian memo. The two step process is:

1.) Identify the number of leaking underground storage tank remediations that were initiated during the base year ozone season;

2.) Use an emission factor of 28 lbs VOC/day per event to estimate daily ozone season emissions.

These two steps can be presented in a numerical equation as follows:

$$\text{LUST Emissions (lbs VOC)} = \frac{\text{Number of remediation}}{\text{ozone season}} \times \frac{\text{28 lbs VOC}}{\text{remediation-day}}$$

5.11.4 Emission Factors

For remediation sites with unknown quantities of soil moved, the Radian memo recommends a default emission factor of 28 lbs VOC/remediation-day.

5.11.5 Activity Factors

The Colorado Department of Labor and Employment, Oil Inspection Division was contacted concerning the number of tank removal excavations planned. The Oil Inspection Division indicated that there were 751 excavations, statewide, during 1993[(4)]. The Oil Inspection Division could not supply the number of excavations done within the nonattainment area.

The statewide number of excavations was proportioned down based on the total state population and the nonattainment area population. The Bureau of Census indicates that the total state population for 1993 is 3,551,000 people[(5)]. The total number of people in the Denver ozone emission inventory domain is 1,947,312 people[(6)]. This results in a ratio of 0.548. This ratio was multiplied by the statewide number of excavations (751 excavations) to estimate a nonattainment area number of excavations. The estimated number of nonattainment area excavations is 411.8.

Since the Radian suggested emission factor is defined as pounds of VOCs per remediation-day, the number of "remediation-days" were also estimated. As a conservative estimate, the number of days in the peak ozone season from June through August, or 92 days, was used as the average number of days it takes to excavate a site. Ninety-two days was then multiplied by the number of excavations in the nonattainment area (411.8 excavations) to approximate an area wide number of "remediation-days" of 37,889.

The number of "remediation-days" was then multiplied by the emission factor of 28 lbs VOC/remediation-day. This results in an annual total of 530 tons VOC per year, or, 1.4 tons/summer day.

5.11.6 Projection Methodology

Because of the large uncertainties in estimating emissions from LUSTs and the lack of data to project LUST emissions to the future, the base year emission estimates are used for the projected years.

5.11.7 Temporal Factors

The existing databases by which to distribute LUST emissions on a seasonal basis are inadequate. Further, since LUST emissions result from the volatilization of organics compounds from excavated soil, ambient temperature also plays a role in the amount of emissions. The Radian emission factor does not consider temperature. Given the limitation of the method and emission factor for LUSTs, the annual emission rate was simply divided by 365 days/year to estimate the summer day emissions.

5.11.8 Assumptions

Several noteworthy assumptions are made in order to estimate emissions from LUSTs. These assumptions include:

1.) The emission factor of 28 tons VOC/remediation-day, which is the midpoint of the Radian emission factors, is representative of LUST sites in the Denver nonattainment area;

2.) It was assumed that the emission factor intrinsically includes other factors such as volatilization efficiency. For instance, during a hot, peak ozone day, the efficiency of evaporation is much better than a cold winter day;

3.) It was assumed that each excavation takes 92 days. As noted, this is a conservative estimate;

4.) Due to the lack of a solid LUST database concerning the number of LUST sites that were actually excavated, the date the LUST sites were excavated, the method of remediation, and the size of the excavations, the emission estimates are approximate.

5.11.9 Sample Calculations

Table 5.11.9-1 presents a sample calculation used to estimate the total nonattainment area emissions from leaking underground storage tanks.

Table 5.11.9-1 Sample Calculations for Leaking Underground Storage Tanks

ITEM	VALUE	UNITS
Statewide number of LUSTs with plans	751	excavations
Statewide population for 1993	3551000	people
Inventory Domain Population	1947312	people
Population Ratio	0.55	
Denver nonattainment area # of LUSTs	411.84	excavations
Number of days/excavation	92	days
Number of "Excavation Days"	37888.96	excavation days
Lust site emission factor	28	lbs VOC/excavation-day
Annual emission rate	530.45	tpy
Summer day emission rate	1.44	tpsd

5.11.10 Conclusions

It is estimated that VOC emissions from LUST excavations are 530.45 tpy, or, 1.44 tpsd. Because of the lack of suitable LUST databases and the apparent small contribution the LUST category has to the overall VOC inventory, these emission estimates are approximate.

5.12 BAKERIES

5.12.1 Abstract

The methodologies and emission factors used to estimate bakery emissions are described in a Radian Corporation memo dated April 24, 1992, entitled, "VOC Emissions from Bakeries". The methodology described in this memo is, first, to estimate the number of bakery employees (SICs 2051 and 546). Then, as described in the Radian memo, a per employee emission factor is applied. The per employee emission factor is 0.11 tons/year/employee.

5.12.2 Introduction

Bakeries emit volatile organic compounds (VOC), primarily ethanol, formed by yeast fermentation of bread or dough, during the baking process. The ethanol is, usually, emitted through a vent with other combustion product gases.

5.12.3 Bakery Inventory Methods

The AIRS data base contains only one bakery that is included in the point source inventory. Given only one data point, it was not appropriate to scale up the inventory. Therefore, emissions from bakeries are, for the most part, estimated as area sources. The following general equation, was used to estimate emissions from bakeries:

Area source VOC emissions for SIC 2051 & 546 (Ton/year)	=	Total region employment in SIC 2051 & 546	x	Per employee emission factor (lb/yr/employee)

5.12.4 Emission Factors

Table 5.12.4-1 presents a per capita and per employee emission factor for bakeries. The EPA document, *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone*[1], recommends using either AP-42[2] emission factors or American Institute of Baking (AIB) methods to determine emission rates from bakeries. Both methods require an estimate of bread production. Given the difficulty of estimating bread production from in-store and neighborhood bakeries, EPA contracted (EPA Contract No. 68-D0-0125) to Radian Corporation to develop a national average emission factor for bakeries.

Table 5.12.4-1 presents the per capita and per employee emission factor developed from the EPA contract[3]. The bakery VOC emission inventory for Denver is based on the per employee emission factor of 0.11 tons/year/employee.

Table 5.12.4-1 Recommended Emission Factors for Bakeries

Categories	Per Capita Factor (lbs/year/capita)	Per Employee Factor (tons/year/emp)	SIC Codes
Bakeries, <100 tpy	0.31	0.11	2051, 546

5.12.5 Activity Factors

Table 5.12.5-1 presents the county level employment and emissions for the inventory area for bakeries. The county level employment figures come from the Bureau of Census document, *County Business Patterns*[(4)]. To determine the number of employees that are not accounted for in the AIRS data base, the number of employees for SIC 2051 and 546 were, first, added together.

The number of bakery employees were then multiplied by the per employee emission factor (0.11 tons/yr/emp) to estimate the VOC emission rate for employees. The 1993 estimated annual emission rate for bakeries is 367.18 tpy. The typical summer day emissions is estimated to be 1.18 tpsd. It is assumed that bakeries operate 6 days a week. The conversion factor of 0.00321 was used to convert an annual emission rate to a typical summer day emission rate.

Table 5.12.5-1 Summary of VOC Emissions from Bakeries for 1993

County	Regional Employment in SIC 2051	Regional Employees in SIC 546	Total employees	Area source emission factor (tons/year/emp)	Annual Area source emission rate (tpy)	Seasonal Area Source Emission Rate (tpsd)
Adams	528	179	707	0.11	77.77	0.25
Arapahoe	0	274	274	0.11	30.14	0.10
Boulder	175	227	402	0.11	44.22	0.14
Denver	925	685	1610	0.11	177.10	0.57
Douglas	0	0	0	0.11	0.00	0.00
Jefferson	0	345	345	0.11	37.95	0.12
Totals	**1628**	**1710**	**3338**		**367.18**	**1.18**

5.12.6 Projection Methodology

There are no specified methods to project bakery emission into the future from either the Radian/EPA paper[3] nor the EPA document, *Procedures for Preparing Emissions Projections*[4]. For the Denver inventory, the change in employment from 1993 to 2006 and 2013 were used as surrogates. For the Denver inventory domain, the ratio between the employment in 1993 to 2006 is 1.49. The ratio of employees from 1993 to 2013 is 1.63. These ratios are multiplied by the 1993 emission rates to project emissions to future years. Using employment as the growth surrogate, the 2006 and 2013 emissions from bakeries are expected to grow to 1.6 tpsd and 1.8 tpsd, respectively.

5.12.7 Temporal Factors

Neither the EPA document, *"Procedure for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"*[1] nor the Radian/EPA document[3] contain temporal factors to be used for seasonal and daily scalars. It was assumed that bakeries operate 6 days per week. This results in an annual to typical summer day conversion factor of 0.00321.

5.12.8 Assumptions

The following assumptions are made in the area source estimates for bakeries:

1) It is assumed that the employee based emission factor derived by Radian/EPA is typical for the Denver area;

2) All bakery employees are included in SICs 2051 and 546. In reality, the in-house bakers for large grocery store chains may be under different SICs.

5.12.9 Sample Calculations

Table 5.12.9-1 presents a sample calculation used to estimate the total nonattainment area emissions from bakeries, as an area source. Both the base year and projected year estimation methods are presented in the table.

5.12.10 Conclusions

The nonattainment area VOC emissions from bakeries are estimated to be 367.18 tpy, or, 1.2 tpsd for the 1993 base year inventory. As a function of employment growth, these emissions are estimated to increase to 1.6 tpsd by 2006, and, 1.8 tpsd by 2013.

Table 5.12.9-1 Sample Calculations for Bakeries

ITEM	VALUE	UNITS
1993 Base year estimates		
Regional employment in SIC 2051 and 546	3338	employees
Bakery per employee emission factor	0.11	tons/yr/emp
Annual voc emissions from bakeries	367.18	tpy
Summer day emissions from bakeries	1.2	tpsd
Projected 2006 Emission		
Ratio 2006/1993 employment (1553625/1044681)	1.49	no dimensions
Estimated 2006 emissions	1.6	tpsd
Projected 2013 Emissions		
Ratio 2006/1993 employment (1697977/1044681)	1.63	tpsd
Estimated emissions in 2010	1.8	tpsd

Endnotes

1. *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, U.S. Environmental Protection Agency (OAQPS), May 1991.

2. *Compilation of Air Pollutant Emission Factor*, Fourth Edition and Supplements, AP-42, U.S. Environmental Protection Agency, September 1985.

3. *VOC Emissions from Bakeries*, memorandum from Lucy Adams to SIP Inventory Preparers and EPA Regions, April 24, 1992.

4. *County Business Patterns 1992-Colorado*, CBP-92-7, U.S. Department of Commerce, Bureau of the Census, September 1994.

5. Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency.

5.13 RESIDENTIAL/COMMERCIAL NATURAL GAS COMBUSTION

5.13.1 Abstract

Emissions from natural gas combustion are computed by applying a natural gas emission factor to the amount of natural gas used in the modeling domain. Natural gas emissions from residential and commercial usage is a function of gas usage per household or per employee. All industrial emissions, due to the combustion of natural gas, are assumed to be reflected in the stationary source inventory.

5.13.2 Introduction

Natural gas is widely used in the Denver nonattainment area for residential and commercial space/water heating. Nitrogen Oxides (NO_x) are the major pollutants of concern during the combustion of natural gas. Natural gas consists of a high percentage of methane and varying amounts of ethane, propane, butane and other inert gases.

5.13.3 Natural Gas Emission Inventory Methods

For industrial sources using natural gas as a fuel, most emissions are contained on the AIRS database for Colorado. Estimates of natural gas emissions for commercial and residential space/water heating are estimated as area sources. Emissions for natural gas combustion are calculated by obtained gas use data from local suppliers and applying appropriate residential and commercial emission factors.

Natural Gas		Daily Gas Usage		Natural Gas
Emission Rate	=	(MCF Gas)	x	Emission Factor
(tpy)				(lbs/MCF Gas)

5.13.4 Emission Factors

Table 5.13.4-1 gives recommended emission factors for the combustion of natural gas by residential and commercial users[(1)].

Table 5.13.4-1 Emission Factors for Natural Gas Use

Boiler type	NO_X (L.S./MCF)	VOC (L.S./MCF)
Residential	100	5.3
Commercial	100	5.3

5.13.5 Activity Factors

Monthly natural gas usage data for 1993, the number of residential customers, and the number of commercial customers were obtained from the Public Service Company of Colorado (PSCo)(2). Natural gas use rate per household or per business are also published as statewide averages by the Department of Energy(3). Although PSCo supplies the vast majority of the natural gas within the nonattainment area, it does not supply all of the natural gas. PSCo does not supply natural gas to portions of southern Douglas and Jefferson counties, eastern Adams and Arapahoe Counties and western portions of Boulder County. For this reason, gas usage rates on a per household and per commercial customer basis are calculated from the PSCo data.

Based on the PSCo data, the average household used 102,500 cubic feet of gas in 1993. During the peak ozone season (June through August), the average household used 9.76×10^{-5} MCF/HH per peak ozone day. On a typical summer day, the area wide gas use by all residential customers is 77 MCF/day.

From the PSCo data, the average gas use rate is 634,430 cubic feet/commercial customer. During the peak ozone season, the average commercial customer uses 7.32×10^{-4} MCF/commercial customer per day.

Since DRCOG only supplies the number of employees within the nonattainment area and not the number of establishments, the number of commercial establishments had to be determined. The number of employees per establishment were estimated by taking the statewide number of employees divided by the number of establishments. From the County Business Patterns(4), the statewide number of employees is 1,332,239 and the number of establishments is 103,959. The estimated number of employees per establishment is 12.82. The number of commercial establishment in the inventory domain is approximately 61,895.

The number of establishments were then multiplied by the annual and typical summer day gas use rates. During a typical summer day, commercial establishments consume 59.6 MCF of natural gas.

Emission rates were determined by multiplying the natural gas use rates by the natural gas emission factors presented in Table 5.13.4-1. The total NO_x emission rate from natural gas for 1993 is estimated to be 6.84 tpsd. The total VOC emission rate is determined to be 0.36 tpsd.

5.13.6 Projection Methodology

DRCOG estimations of households and employees for 2006 and 2013 are used to estimate natural gas emissions for future years. It is assumed that the gas use rate for households and commercial establishments will be the same through 2013. It is estimated that the total NO_x emission rate for 2006 and 2013 is 9.7 tpsd and 10.8 tpsd, respectively. The total VOC emission rate is projected to be 0.51 tpsd in 2006 and 0.57 tpsd in 2013.

5.13.7 Temporal Factors

Summer emission rates are determined by actual PSCo gas use data. Monthly summer data for the high ozone season (June-August) is divided by 92 days/summer to estimate a typical summer day.

5.13.8 Assumptions

The following assumptions are made in estimating emissions from natural gas:

1.) Natural gas use rates for 1993 are the same as for future years. In reality, gas use rates are dependent on yearly swings in heating and cooling degree days;

2.) Commercial natural gas use is mostly due to office building and retail space heating;

3.) All gas fired boilers and natural gas fuels are included in the point source natural gas inventory.

5.13.9 Sample Calculations

Table 5.13.9-1 present sample calculations for natural gas use. The sample calculation is for the entire Denver ozone inventory domain during a typical summer day.

Table 5.13.9-1 Sample Calculations for Natural Gas Use in 1993

DESCRIPTION	VALUE	UNITS
Residential Calculations		
Number of households	786783	households
Summer day average gas use rate for households	0.000098	mcf/hh/day
Total household natural gas used	77.1	mcf/day
NOx emission factor	100	lbs NOx/mcf
Summer day NOx emission rate	7710.5	lbs/day
Summer day NOx emission rate	3.86	tpsd
VOC emission factor	5.3	lbs VOC/mcf
Summer day VOC emission rate	408.7	lbs/day
Summer day VOC emission rate	0.20	tpsd
Commercial business calculations		
Number of employees	1044681	employees
Number of employees/business	12.82	employees/business
Estimated number of businesses in the inventory domain	81488.4	businesses
Summer day gas use for commercial businesses	0.000732	mcf/bus/yr
Summer day gas usage by commercial establishments	59.65	mcf/yr
Summer day NOx emission factor	100.00	lbs NOx/mcf
Estimated NOx emission rate	5965	lbs/day
Estimated NOx emission rate	3.142.98	tpsd
VOC emission factor	5.3	lbs/mcf
Summer Day VOC emission rate	316.14	lbs VOC/day
Summer Day VOC emission rate	0.16	tpsd
Combined NOx household and commercial business emission rate	6.84	tpsd NOx
Combined VOC household and commercial business emission rate	0.36	tpsd VOC

5.13.10 Conclusions

Total NOx emissions for the inventory domain from natural gas used by households and commercial businesses in 1993 is estimated to be 6.84 tpsd. Total VOC emissions are estimated to be 0.36 tpsd. By 2006, NO_x emissions are expected to increase to 9.7 tpsd and VOC emission are expected to also increase to 0.51 tpsd. Emissions from natural gas in 2013 are expected to be 10.8 tpsd for NO_x and 0.57 tpsd for VOC..

5.14 BREWERIES, WINERIES AND DISTILLERIES

5.14.1 Abstract

VOC emissions from brewery and distillery bioprocesses are mostly included in the point source inventory for Denver. There is one large brewery within the nonattainment area and two plants with "distillery like" processes. An estimate of VOC emissions from small/micro breweries are included as area sources, however, these emissions are very small compared to the rest of the inventory. There are little or no emissions from wineries in the nonattainment area.

5.14.2 Introduction

Breweries, emit VOC (including ethanol, ethyl acetate, myrcene and some other higher alcohols) from the various brewing process steps. Emissions vary depending on brewery size and process. There both large and small breweries in the Denver ozone nonattainment area.

Ethanol emissions from wineries result from entrainment of ethanol by carbon dioxide during the fermentation process. Although this is the primary source of ethanol emissions in the wine production process, other emissions occur whenever wine is exposed to air, such as in transferring or racking, blending and storage for aging purposes. Due to the lack of wineries in the nonattainment area, emissions from wineries are negatively declared.

Ethanol emissions are the largest component of the VOC emitted from distilleries. Distilleries produce both grain alcohol for industrial and fuel purposes, and distilled spirits such as whiskey and brandy for consumption purposes. The starting processes for whiskey and brandy are analogous to beer and wine production, respectively. In addition to these initial processes, distilled spirits manufacturing involves both distilling and aging steps for various fermented products. As a result, the emissions points in the distilled spirits manufacturing process are likely to be the same as in breweries and wineries, with the aging process as an additional source of emissions. The Denver ozone nonattainment area contains "distillery like" processes at one of its large breweries and a sake plant near Golden. Both processes are included as point sources on AIRS. Any emissions from distilleries not on AIRS are expected to be very small, therefore, no area source estimates are made for distilleries.

5.14.3 Small Brewery Emission Inventories

VOC emissions due to bioprocesses at breweries are inventoried as both point source and area sources. VOC emissions due to bioprocesses from largest brewery in the nonattainment area, Coors Brewery, is a point source on the Colorado AIRS database(1). A per facility emission factor for small breweries is estimated to be 0.13 tons VOC/year/facility(2).

From the US West Phone Directory, there are eleven small/micro breweries in the nonattainment area(3). By multiplication, VOC emissions from small/micro breweries are estimated to be 1.43 tpy or 0.004 tpsd.

5.15 TANK TRUCK, RAIL CAR, AND DRUM CLEANING

5.15.1 Abstract

Barge, tank, tank truck, rail car and drum cleaning may result in emissions of VOC, NO_x and PM_{10}. Emissions types and levels depend on the commodity transported, the cleaning agent and the management of chemical residues. Large scale cleaning operations involving rail cars, tank trucks and drums are contained in the AIRS data base as point sources. Emissions from smaller operations are expected to be very small.

5.15.2 Introduction

Barges, tanks, tank trucks, rail cars and drums are used to transport a broad range of different commodities. Rail tank cars and most tank trucks and drums are in dedicated service (carrying one commodity only) and, unless contaminated, are cleaned only prior to repair or testing. Non-dedicated tank trucks and drums are cleaned after every trip. Cleaning agents include water, steam, detergents, bases, acids and solvents.

Barge, tank, tank truck, rail car and drum cleaning may result in emissions of VOC, NO_x and PM_{10}. Emissions types and levels depend on the commodity transported, the cleaning agent and the management of chemical residues. Emissions associated with the chemical residue depend on the compound and the quantity remaining in the container. They may be affected both by viscosity (which affects the quantity remaining inside the container after unloading) and vapor pressure (which affects the quantity that evaporates). Emissions associated with cleaning agents used to clean the receptacles depend primarily on the type of agent used, quantity, ambient temperature and recovery method. The process may be further characterized by location, vehicle or container type, and commodity or waste transported.

5.15.3 Inventory Methods

This section contains descriptions of general operations for tank and drum cleaning, and, the emissions from the various source categories.

- Barge Cleaning

The Level II checklist[1] requires estimates for emissions from the cleaning of barges. Since there are no large waterways or bodies of water within the nonattainment area, this source category is negatively declared.

- Rail Tank Cars

Most tank car cleaning is conducted at shipping and receiving terminals, where the wastes go to the manufacturers' treatment systems. Some tank car cleaning is done at service stations operated by tank car owners/lessors. These installations clean waste of a wide variety of commodities, many of which require special cleaning methods. There are no large scale tank car cleaning facilities in the nonattainment area, therefore, this source category is negatively declared or represented elsewhere on the AIRS point source inventory.

- Tank Trucks

Interior washing is carried out at many tank truck dispatch terminals. Cleaning agents include water, steam, detergents, bases, acids, and solvents, which are applied with hand-held pressure wands or by rotating spray nozzles. Detergent, acidic, or basic solutions are usually used until spent and then sent to treatment facilities. Tank truck cleaning emissions are on the AIRS(2) file as point sources. Point source emissions from tank truck cleaning are 5.8 tpy, or, 0.02 tpsd.

- Drums

Both 30 and 55 drums are used to ship a vast variety of commodities, with organic chemicals (including solvents) accounting for 50 percent. The remaining 50 percent includes inorganic chemicals, asphaltic materials, elastomeric materials, printing inks, paints, food additives, fuel oils, and other products. Drums used to carry materials that are difficult to clean are burned out, either in a furnace or in the open. Tighthead drums that have carried materials that are easy to clean are steamed or washed with base. Steam cleaning is done by inserting a nozzle into the drum, with vapors going to the atmosphere. Base washing is done by tumbling the drum with a charge of hot caustic solution and some pieces of chain.

The Colorado AIRS database contains points down to 1 tpy. Any large scale drum cleaning activities would be contained on the AIRS database. In addition, AP-42(3) only contains emission factors for drums that are burned out. VOC emissions from burned out drums are negligible. There are no general emission factors for drums that are steamed cleaned or washed out with base. Solution or caustic washing yields negligible air emissions, because the drum is closed during the wash cycle. Emissions from drum cleaning operations not on AIRS are expected to be small.

5.15.4 Conclusion

Large scale operations involving rail tank cars, tank trucks, and drums appear on the AIRS data base for facilities down to 1 tpy. VOC and NO_x emissions from any sources not on AIRS are expected to be very small compared to the rest of the inventory.

5.17 FOREST FIRES AND PRESCRIBED BURNS

5.17.1 Abstract

Emissions from forest fires and prescribed burns are generally calculated by taking the area consumed by fire and applying a fuel loading factor to approximate the mass of fuel consumed. The mass of fuel consumed is then multiplied by appropriate EPA emission factors from AP-42. For forest fires, the amount of land consumed by fire was estimated by contacting various agencies. The number, location and size of prescribed fires are from the State's permit data base.

5.17.2 Introduction

A wildfire is a large-scale natural combustion process that consumes various ages, sizes, and types of flora growing outdoors in a geographical area. Consequently, wildfires are potential sources of large amounts of air pollutants that should be considered when trying to relate emissions to air quality. The size and intensity, even the occurrence, of a wildfire depend directly on such variables as meteorological conditions, the species of vegetation involved and their moisture content, and the weight of consumable fuel per acre (available fuel loading). The complete combustion of wildland fuels (forests, grasslands, wetlands) require a heat flux (temperature gradient), adequate oxygen supply, and sufficient burning time. The size and quantity of wildland fuels, meteorological conditions, and topographic features interact to modify the burning behavior as the fire spreads, and the wildfire will attain different degrees of combustion efficiency during its lifetime.

Prescribed burning is a land treatment, used under controlled conditions, to accomplish natural resource management objectives. Prescribed fires are conducted within the limits of a fire plan and prescription that describes both the acceptable range of weather, moisture, fuel, and fire behavior parameters, and the ignition method to achieve the desired effects. Smoke from prescribed fires is a complex mixture of carbon, tars, liquids, and different gases. The major pollutants from wildland burning are particulate, carbon monoxide, and volatile organics. Nitrogen oxides are emitted at rates of from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of sulfur oxides are negligible.

5.17.3 Inventory Methods

Emissions for forest fires and prescribed burns are calculated using somewhat similar methods. The mass of fuel burned is estimated by taking the volume or land area consumed by fire and applying a fuel loading factor. The fuel loading factor is in the units of mass per area. By multiplication, the area or volume of fuel consumed times the fuel loading factor results in the mass of material burned. An emission factor, in mass of pollutant per mass of fuel burned, is applied resulting in an emission rate.

5.17.4 Emission Factors

Table 5.17.4-1 present the emission factors used to prepare the wildfire and prescribed burning emission inventories. To convert the forest fire emission factor units from kg/hect to g/kg, the forest fire emission factors were multiplied by the fuel loading of 40 Mg/hectare. These emission factors are from AP-42[1]

Table 5.17.4-1 Emission Factors for Wildfire and Prescribed Burning for Ozone Precursor Gases

POLLUTANT	FOREST FIRES (Kg/hect)	PRESCRIBED BURNS (g/kg)
NO_X	36	2.5
VOC	215	3.2

5.17.5 Activity Factors

The following sections describe the activity factors and the resulting emissions from forest fires and prescribed burns.

- Forest Fires

Forest fires in certain rural areas can produce very large, short term emissions. The general practice is to suppress all fires. Although the Denver ozone nonattainment area is mostly urban, areas on the west side of Boulder and Jefferson Counties and portions of Douglas County have forested areas in them. To see if these areas had any forest fires in 1993, the Bureau of Land Management (BLM), Colorado State Forest Service (CSFS), the National Park Service (NPS), and the United States Forest Service (USFS) were all contacted to see if there were any forest fires in these areas during 1993[(2)]. The USFS data base contained 31.7 acres (12.83 hectares) that were burned during 1993 within the nonattainment area. There were no other forest fires reported by the other organizations within the nonattainment area for 1993.

Determining tons of growth burned per acre ("fuel loading") is equally important. AP-42 presents both fuel loading and emission factors for wildfires. From AP-42, Table 13.1.1, the Rocky Mountain-Intermountain fuel loading of 40 Mg/hectare was used. By multiplying the number of hectares burned by the fuel loading, the total mass of material burned can be determined. The total mass burned is 513.20 Mg (12.83 hectares X 40 Mg/hectare = 513.20 Mg).

VOC and NO_x emissions were estimated by multiplying the fuel consumed (513.20 Mg) by the appropriate emission factors. The estimated VOC emission rate is 3.04 tpy (513.20 Mg X 5.375 Kg VOC/Mg = 3.04 tons VOC/year). Given that the peak ozone season from June through August contains 92 days, the average daily VOC emissions from forest fires is 0.0331 tpsd. Similarly, the estimated NO_x emission rate is 0.479 tpy, or, 0.0052 tpsd.

- Prescribed Burns

Information on prescribed burns within the nonattainment area come from the State's permit records for prescribed burns. Table 5.17-5-1 presents a summary of those prescribed burns in the nonattainment area with permits and those prescribed burns that actually occurred. Since the state's permit database only contains particulate and CO estimated emissions, VOC and NO_x emissions are based on the proportioning of the emission factors in Table 5.17.5-1. The CO emission factor for prescribed burns is 83.4 g/kg. Using the proportional method, NO_x and VOC emissions are estimated to be 0.02 tpsd and 0.03 tpsd, respectively.

Table 5.17.5-1 Permits and Burn Dates for Prescribed Burns Within the Denver Nonattainment Area

Burn_Name	County	Date of Application	Beginning Date	Estimated NOx (tons)	Estimated VOC (tons)	Estimated CO (tons)
Sugar Creek Timber Sale	Douglas	03-Feb-93		0.0	0.0	0.0
Polhemus Prescribed Fire	Douglas	03-Feb-93		0.0	0.0	0.0
Dakan Mtn Timber Sale	Douglas	03-Feb-93		0.0	0.0	0.0
Indian Creek	Douglas	04-Feb-93	26-Mar-93	0.008	0.010	0.27
Northrup/Metberry	Douglas, Teller	03-Feb-93		0.0	0.0	0.0
Buck Gulch Fuelwood	Jefferson	03-Feb-93	15-Nov-93	0.020	0.026	0.68
Wigwam	Jefferson	03-Feb-93	15-Nov-93	0.074	0.095	2.47
Ridgeline	Jefferson	02-Sep-93	29-Oct-93	0.071	0.091	2.37
[unnamed]	Jefferson	02-Sep-93		0.0	0.0	0.0
Fillius Park	Jefferson	02-Dec-93	10-Feb-93	0.280	0.359	9.35
Black Mountain	Jefferson	08-Feb-93		0.0	0.0	0.0
Maxwell	Jefferson	09-Sep-93		0.0	0.0	0.0
Cub Creek	Jefferson	09-Sep-93		0.0	0.0	0.0
Middle Pen	Jefferson	09-Sep-93		0.0	0.0	0.0
Bowers Pile Burn	Jefferson	30-Sep-93		0.0	0.0	0.0
Brush Creek	Jefferson	03-Feb-93		0.0	0.0	0.0
Dead Pine	Jefferson	04-Feb-93		0.0	0.0	0.0
Buffalo Baldy	Jefferson	04-Feb-93	15-Nov-93	0.048	0.062	1.60
Waterton Wildlife Management	Jefferson, Douglas	26-Jan-93	08-Mar-93	7.391	9.461	246.57
Annual Total				**7.893**	**10.103**	**263.31**
Daily Total				**0.02**	**0.03**	**0.72**

5.17.6 Projection Methodology

Since there is no way of knowing how many forest fires or prescribed burns there will be in the year 2010, the emissions were kept at 1993 levels.

5.17.7 Conclusions

Table 5.17.7-1 presents a summary of ozone precursor gas emissions from forest fires and prescribed burns within the nonattainment area. As shown in Table 5.17.7-1, the total summer day emissions from forest fires and prescribed burns are 0.05 tpsd NO_x and 0.03 tpsd of VOC. Compared to the rest of the NO_x and VOC emission inventories, these emissions are very small and comprise less than 1% of either inventory.

Table 5.17.7-1 Summary of Emissions from Forest Fires and Prescribed Burns

Activity	NO_x Emission Rate (tpsd)	VOC Emission Rate (tpsd)
Forest Fires	0.03	0.01
Prescribed Burns	0.02	0.03
Total	**0.05**	**0.04**

Endnotes

5.18 DOMESTIC FIRES

5.18.1 Abstract

Domestic fires comprise of structural, automobile, refuse, and other fires. Emissions from domestic fires are estimated using EPA emission factors and fuel loadings. Statewide activity data on the number of fires is obtained from the Colorado Department of Public Safety, Division of Fire Safety. Based on the EPA emission factors and fuel loading, and the number of fires, a statewide per capita emission factor is developed for VOC and NO_x. **The derived per capita emission factors are then multiplied by the inventory domain population to get the emission rates.**

5.18.2 Introduction

The Level II checklist from the EPA document, "Quality Review Guidelines for 1990 Base Year Emission Inventories"(1) recommends that structural fires be looked at as a possible source category for precursor gases of ozone. For the Denver inventory, statewide data is also available for automobile, refuse and other domestic fires. Forest fires, prescribed burns, and other wild land fires are presented in a separate section to this document.

5.18.3 Domestic Fire Inventory Methods

A per capita emission factor was developed using the statewide number of fires from the Colorado Division of Fire Safety's 1993 database along with EPA fuel loading and emission factors. The precursor gas emission rate inventory is then calculated using the inventory domain population and the derived per capita emission factors for VOC and NO_x.

5.18.4 Emission Factors

Emission factors for fires come from AP-42(2) and the EPA document, "Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone"(3). Table 5.18.4-1 presents a summary of the emission factors used in preparing the domestic fire inventory for Denver.

Table 5.18.4-1 Emission Factors for Domestic Fires

FIRE TYPE	VOC EMISSION FACTOR (lbs/ton)	NO_x EMISSION FACTOR (lbs/ton)
Structural	11	1.4
Vehicle	32	4.0
Refuse	30	6.0
Other	11	1.4

5.18.5 Activity Factors

The statewide number of fires were obtained from the Colorado Department of Safety[(4)]. The estimated fuel loading per fire comes from AP-42[(5)]. The total amount of fuel consumed by fires, statewide, are estimated by taking the number of fires and multiplying them by the fuel loading. A summary of the number of fires, fuel loading, fuel consumed, and statewide emission rates are presented in Table 5.18.5-1.

Table 5.18.5-1 Statewide Fuel Consumption by Domestic Fires in 1993

Type of Fire	Number of Fires	Fuel Loading (tons/fire)	Statewide Fuel Consumed by Fires (tons/year)	Statewide Annual Emission Rate for NO_x (tpy)	Statewide Annual Emission Rate for VOC (tpy)	Statewide Summer day Emission Rate for NO_x (tpsd)	Statewide Summer day Emission Rate for VOC (tpsd)
Structural	5388	6.8	36625	25.64	201.44	0.07	0.55
Vehicle	3315	0.2	663	1.33	10.61	0.00	0.03
Refuse	3643	1.0	3643	10.93	54.65	0.03	0.15
Other	2264	1.0	2264	1.58	12.45	0.00	0.03
Total	**14608**		**43195**	**39.48**	**279.14**	**0.11**	**0.76**

To estimate a statewide per capita emission factor for domestic fires, the total statewide emission rate for all types of fires were added together and, then, divided by the 1993 state population. In 1993, there were 3,551,000 people living in Colorado. The derived per capita emission factor and the estimated inventory area emission rate from domestic fires are presented in Table 5.18.5-2. Also included in Table 5.18.5-2 are the NO_x and VOC emission rates for the nonattainment area.

The emission rate for domestic fires within the nonattaiment area was estimated by multiplying the inventory domain population (2,069,592 people) times the per capita emission factors. The estimated VOC emission rate from domestic fires within the inventory domain is 163 tpy, or, 0.45 tpsd. The NO_x emission rate for 1993 is estimated to be 23 tpy, or, 0.06 tpsd.

Table 5.18.5-2 Per Capita Emission Factors and Nonattainment Emission Rates for Domestic Fires

Pollutant	Annual Emission Factor (lbs/ 1000 people/ year)	Summer Day Emission Factor (lbs/ 1000 people/ year)	Annual Emission Rate (tpy)	Summer Day Emission Rate (tpsd)
VOC	158	0.43	162.7	0.45
NO_x	22	0.06	23.0	0.06

5.18.6 Projection Methodology

Population for 2006 and 2013 within the inventory domain was multiplied by the per capita emission factors given in Table 5.18.5-2. By 2006, VOC emissions from domestic fires are expected to grow to 0.56 tpsd, and, by 2013 to 0.61 tpsd. In 2006, NO_x emissions are estimated to grow to 0.6 tpsd. The VOC emission rate in 2013 from domestic fires are expected to be 0.08 tpsd.

5.18.7 Temporal Factors

The EPA document, "Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone", presents temporal factors for the various ozone source categories. For structural fires, the temporal factor is uniform. For the Denver domestic fire source category, it is assumed that emissions are evenly distributed on a daily basis.

5.18.8 Assumptions

The following assumptions are made for domestic fire emission inventory:

1.) Although the Colorado Department of Public Safety's fire database only contains 88% of the fire districts within the state, the assumption is made that most (100%) of the larger fire districts are within the Denver metro area and no adjustments have been made to the number of fires statewide;

2.) Fuel loadings for structural fires and automobile fires are fairly high and are applicable if whole structures or cars catch on fire. The majority of structural fires consume portions of structures and not all car fires consume the whole car. However, given that domestic fires is a very small source category compared with other categories, the conservatism is kept for the Denver ozone inventory.

5.18.9 Conclusions

NO_x emissions from domestic fires for 1993, 2006, and 2013 are estimated to be 0.06 tpsd, 0.06 tpsd and 0.08 tpsd, respectively. VOC emissions are expected to be 0.45 tpsd in 1993 and grow as a function of population to 0.56 tpsd by 2006, and, 0.61 tpsd in 2013. Compared to the overall NO_x and VOC emission inventories, domestic fires only account for less than 0.2% of either of the precursor gas inventory.

6.1 BIOGENIC EMISSIONS

6.1.1 Abstract

Emission estimates have been developed by EPA using the updated PC-based model, PC-Biogenic Emissions Inventory System (PC-BEIS2). PC-BEIS2 is used to estimate biogenic non-methane hydrocarbon emissions from biogenic sources. The model estimates area-wide emissions on an hourly basis for one typical ozone day.

The PC-BEIS2 model requires input for each county, defining the location (Federal Information Procedures System (FIPS) code, latitude and longitude), time (day-month-year for a typical high ozone day), and meteorology (temperature and cloud cover). The documentation for the PC-BEIS2 model defines the procedure for the selection of the modeling day. The modeled day is a typical high ozone day.

6.1.2 Introduction

The EPA model, PC-Biogenic Emissions Inventory System (PC-BEIS2 Version 1) was used to estimate biogenic non-methane hydrocarbon emissions from biogenic sources. The model estimates area-wide emissions on an hourly basis for one typical ozone day.

The PC-BEIS2 model requires input for each county, defining the location, Federal Information Procedures System (FIPS) code, latitude, longitude, time, temperature, and cloud cover. The selection of these parameters are greatly simplified for some high ozone areas by EPA's Emission Inventory Branch. However, for the Denver Ozone nonattainment area, the Emission Inventory Branch did not create a meteorological file, therefore, one had to be developed.

6.1.3 Biogenic Emission Inventory Methods

The Personal Computer version of the Biogenic Emissions Inventory System (PC-BEIS2) was developed by the EPA to allow users to estimate hourly emissions of biogenic non-methane hydrocarbon emissions on a county-wide basis. Emission rates depend on land use, leaf biomass, and emission rates for various vegetative types. PC-BEIS2 also includes adjustments to temperature and sunlight. A simplified leaf energy balance module is included in the model to allow for more refined calculations of leaf temperature and sunlight through forest canopies. A description of the PC-BEIS2 model is contained in the EPA document, *User's Guide to the Personal Computer Version of the Biogenic Emissions Inventory System (PC-BEIS2)*[1].

Emission rates depend on land use, emission factors, temperature and solar radiation. A simple canopy model is used to adjust photosynthetically active solar radiation at five vertical levels in the forest canopy. Leaf temperature and photosynthetically active solar radiation derived from ambient conditions above the forest canopy are then used to drive empirical equations to estimate genus level emission rates of biogenic volatile organic compounds vertically through canopies. Emission rates from vegetation other than forests are expressed as biogenic volatile organic compound carbon mass per unit land area, with a constant peak growing season biomass assumed. Light and temperature corrections are applied, but no canopy model is used for non-forested areas.

- Derivation of Meteorological Input for PC-BEIS2

A typical high ozone day, hourly meteorological data set was developed for input into PC-BEIS2 for Denver. The EPA document, *User's Guide to the Personal Computer Version of the Biogenic Emission Inventory System (PC-BEIS2),* suggests a method for determining the typical high ozone day. This method was slightly modified in the case of Denver to provide a longer period of record. Following are the steps used to develop the Denver specific typical high ozone day meteorological data set:

- The top sixteen days with the highest hourly ozone readings over the most recent seven years of monitored data were selected for the database to work from. The PC-BEIS2 guide suggests that the most recent three years of data and the top 10 concentrations be used.

- Using Stapleton International Airport data, the maximum daily temperatures from highest to lowest were ranked for the top sixteen days;

- The eighth highest day (one permitted exceedance per year for seven years) was selected based upon maximum daily temperature;

- Use hourly meteorological data (cloud cover, relative humidity, wind speed, and temperature) for this day as model input.

The use of seven years of ozone data was used to eliminate the notion that the meteorology for the past three years may not have been favorable for high ozone concentrations. Since seven years of data is used, the eighth highest temperature was selected given that the ozone standard may be exceeded once per year. Table 6.1.3-1 presents a ranked listing of the sixteen high ozone days. Table 6.1.3-2 presents a ranking of temperatures for those sixteen high ozone days.

As shown in Table 6.1.3-2, the June 22, 1992 and August 4, 1987 tie for the eighth highest temperature. Since both days had the same temperature, the day with the lowest mean wind speed was chosen. The mean wind speed for June 22 and August 4 was 3.2 m/s and 4.2 m/s, respectively. Based on the lower wind speed, the meteorology from June 22, 1992 was used as the typical high ozone day. Table 6.1.3-3 presents the hourly meteorological variables for June 22, 1992. Table 6.1.3-3 presents those meteorological variables that effect biogenic emissions which include cloud cover, relative humidity, wind speed and temperature.

June 22, 1992 has other favorable features. First, this day occurred within the last three years and has the second highest ozone concentration over the past three years. Therefore, the methodology described previously actually produced conditions that were more conservative than if the methodology described in the PC-BEIS2 manual was followed. Second, the value (0.123 ppm) recorded on this day is close, but slightly less than the 1 hour ozone standard of 0.125 ppm. June 22, 1992 is representative of a day that maintains the ozone standard but is very close to the standard.

Table 6.1.3-1 Ranking of the Top Sixteen Ozone Concentrations 1987-1993

Monitor	Date	Concentration (ppm)
Highland*	24-Jul-87	0.145
Arvada	04-Aug-87	0.136
Highland	10-Jun-88	0.136
Boulder	7-Jul-89	0.130
Carriage**	02-Jul-93	0.128
Arvada	04-Jun-88	0.125
Carriage***	18-Aug-88	0.124
Highland	26-Jul-88	0.123
Carriage	22-Jun-92	0.123
Englewood	18-Aug-88	0.123
Englewood	23-Aug-88	0.122
Boulder	24-Aug-88	0.122
Boulder	06-Jun-87	0.121
Carriage	26-May-90	0.120
CAMP	30-Jun-90	0.120
Boulder	22-Aug-88	0.120
	Duplicate days	
Carriage	*24-Jul-87	0.137
Boulder	**02-Jul-93	0.128
Englewood	***18-Aug-88	0.123

Table 6.1.3-2 Ranking of the Top Sixteen Ozone Concentrations by Temperature

MONITOR	DATA	CONC. (PPM)	HIGH TEMPERATURE (^{O}F)
CAMP	30-Jun-90	0.120	102
Boulder	7-Jul-89	0.130	102
Highland	24-Jul-87	0.145	96
Carriage	02-Jul-93	0.128	95
Englewood	23-Aug-88	0.122	91
Boulder	06-Jun-87	0.121	89
Arvada	04-Jun-88	0.125	88
Carriage	22-Jun-92	0.123	87
Arvada	04-Aug-87	0.136	87
Highland	10-Jun-88	0.136	86
Highland	26-Jul-88	0.123	86
Boulder	22-Aug-88	0.120	85
Carriage	18-Aug-88	0.124	82
Englewood	18-Aug-88	0.123	82
Boulder	24-Aug-88	0.122	82
Carriage	26-May-90	0.120	77

Table 6.1.3-3 Meteorology for June 22, 1992

HOUR	SKY COVER (%)	HUMIDITY (%)	WIND SPEED (M/S)	TEMPERATURE (^oC)
1	20	56	3.08	16.12
2	10	59	3.08	15.56
3	10	62	2.57	15.00
4	40	68	2.57	13.89
5	60	75	2.57	13.89
6	80	83	3.08	13.34
7	80	79	4.11	15.56
8	60	74	3.60	17.23
9	20	68	2.06	18.89
10	20	62	2.57	21.12
11	20	55	1.54	22.78
12	20	47	0.00	25.56
13	10	43	3.08	26.67
14	30	38	4.63	27.23
15	50	32	2.06	27.79
16	50	31	4.11	29.45
17	50	30	3.60	30.01
18	70	28	5.14	30.01
19	90	33	5.65	26.67
20	90	38	4.11	25.01
21	100	45	3.60	22.78
22	90	53	2.57	21.12
23	60	62	3.08	19.45
24	20	73	4.11	16.67
mean	**48**	**54**	**3.19**	**21.32**

6.1.4 Emission Factors

The emission factors used for estimation of biogenic emissions are self contained in the PC-BEIS2 model. These emission factors are documented in the PC-BEIS2 users guide[(1)].

6.1.5 Activity Factors

Table 6.1.5-1 presents a summary of the PC-BEIS2 model results for the six county non-attainment area. The PC-BEIS2 model produces both VOC emissions from vegetation and NO_x emissions from microbial activity in soils. The results presented in Table 6.1.4-1 are for a typical high ozone day. In order to estimate annual biogenic emissions, it is assumed that vegetative growth occurs mostly during the ozone season (March 1 through September 30). The typical high ozone day is multiplied by the number of days in the ozone season (214 days) to get the annual average. As seen in Table 6.1.4-1, the estimated biogenic emissions for a typical high ozone day is 211.18 tpsd.

Table 6.1.4-1 Summary of PC-BEIS2 Biogenic Emission Estimates

County	Total VOCs (tpsd)	Total NO_x (tpsd)	Annual Total VOCs (tpy)	Annual Total NO_x (tpy)
Adams	5.32	1.73	1138.49	369.64
Arapahoe	3.08	0.74	658.11	158.30
Boulder	74.73	0.52	15993.05	110.49
Denver	2.00	0.07	428.67	14.49
Douglas	64.81	0.42	13869.57	91.70
Jefferson	61.24	0.20	13105.53	42.41
Total	**211.18**	**3.68**	**45193.42**	**787.03**

6.1.6 Projection Methodology

It is assumed that there will not be any large changes to vegetation types through 2015, therefore, biogenic emissions for 2010 are assumed to be the same as the base year.

6.1.7 Temporal Factors

PC-BEIS2 produces emissions for one typical high ozone day. To estimate annual emissions, it is assumed that the majority of the biogenic emissions occur during the growing season. It is assumed that the growing season coincides with the ozone season (March 1 through September 30). The typical ozone day is multiplied by the number of days in the ozone season to get the annual emissions from biogenic sources.

6.1.8 Sample Calculations

PC-BEIS2 is supported by EPA, therefore, no sample calculations are presented here.

6.1.9 Conclusions

The PC-BEIS2 model was used to estimate biogenic emissions for the six county nonattainment area. The PC-BEIS2 model also calculates nitrogen oxide (NO) emissions from microbial activity. VOC biogenic emissions from the nonattainment area are estimated to be 45,193.42 tpy, or, 211.18 tpsd. Nitrogen oxide emissions from microbial activity is estimated to be 787.03 tpy, or, 3.68 tpsd.

Endnotes

1) *User's Guide to the Personal Computer Version of the Biogenic Emissions Inventory System (PC-BEIS2)*, U.S. Environmental Protection Agency (OAQPS), June 1995.

2) *Annual Summary of Local Climatic Data-1993; Stapleton International Airport*, NOAA-National Climatic Data Center, 1993.

7.1 SOURCE CATEGORIES WITH NEGATIVE DECLARATION

7.1.1 Asphalt Paving

The two types of asphalt paving used for road paving and repair are cutback asphalt and emulsified asphalt. Colorado Regulation 7, Section XI(1), generally excludes the use of cutback asphalt in the nonattainment area during the ozone season. For the purposes of the ozone inventory, the use of cutback asphalt is negatively declared.

Emulsified asphalt is a type of liquefied road surfacing material that is used in the same applications as cutback asphalt. However, instead of blending asphalt cement with petroleum distillates as in cutback asphalt, emulsified asphalt uses a blend of water with an emulsifier, which is generically referred to as "soap". The blend media consists of 94 to 98 percent water and 2 to 6 percent soaps.

The Colorado Department of Transportation (CDOT) was contacted to see if their "soaps", or their consultant's "soaps" generally contain any petroleum distillates. CDOT indicates that their emulsifiers did not contain any petroleum distillates(2). Due to the lack of petroleum distillates in blending emulsified asphalt, VOC emissions are expected to be very small or negligible.

7.1.2 Synthetic Organic Chemical Storage Tanks

The synthetic organic chemical (SOC) industries manufacture organic chemicals for various uses in the industrial, commercial and other sectors. SOCs are stored in tanks by both manufacturers and end-users. Manufacturers may concentrate around particularly industrialized areas or where base chemicals are more readily available, while end-users may be more concentrated in industrialized and populated areas. When placed in storage tanks, these chemicals may be a source of VOC emissions due to breathing losses (standing losses) and working losses (withdrawal losses).

There are no synthetic organic chemical storage manufacturers in the nonattainment area. The number of end-users, and the amount of SOCs consumed is fairly difficult to estimate, however, it is felt that emissions from SOCs are small. Therefore, VOC emissions from synthetic organic chemicals are negatively declared.

7.1.3 Catastrophic/Accidental Releases

Sources in the catastrophic/accidental release category represent unplanned, unintentional emissions releases associated with evaporation or combustion of material. Source categories include rail car, tank truck and industrial accidents; natural gas well blowouts; and oil spills. Although there are occasions when rail cars, tank trucks etc. are involve in accidents, these events do not have any effects on high ozone days. Given the exceptional and periodic nature of catastrophic/accidental releases, this source category has a negative declaration for the Denver Ozone SIP.

7.1.4 Orchard Heaters

In areas where frost threatens, orchard heaters may be used in cold portions of the growing season. In Colorado, the majority of the fruit production occurs on the western slope in Mesa and Delta Counties[3]. There are no large scale orchards in the nonattainment area where orchard heaters may be used. In addition, the high ozone days in the region are typified by very warm temperatures when frost is unlikely to occur.

7.1.5 Aircraft/Rocket Engine Firing And Testing

EPA suggests that this category is intended to quantify emissions from "significant re-work facilities" or "major civilian or military installations" where engine testing may create significant emissions[4].

According to the Federal Aviation Administration, there are no commercial aircraft manufacturing facilities in eastern Colorado that perform engine firing and/or testing. No major civilian or military rocket or aircraft engine firing/or testing facilities are known to exist in the nonattainment area. Although minor aircraft engine testing occurs in association with aircraft maintenance facilities, emissions from routine maintenance are negligible.

7.1.6 Open Burning And Detonation

Residential open burning is banned by various local ordinances throughout the Denver nonattainment area. Commercial and industrial open burning are covered by Colorado Air Quality Regulation No. 1[5] which requires permits for open burning. All commercial and industrial sources are assumed to be on the AIRS database for Colorado. In addition, the Division limits permitted burning to daylight hours and hours with good dispersion through meteorological forecasts. These forecasts are broadcasted through the Division's hotline.

Agricultural burning of weeds along fence lines and ditches occur during the early spring and late fall. The period of when agricultural burning occurs generally falls outside the high ozone months of June through August.

7.1.7 Incineration

Solid waste may consist of any discarded solid materials from industrial, commercial/institutional, or residential sources. The materials may be combustible or noncombustible and are often burned to reduce bulk, unless direct burial is either available or practical. On-site incineration is the confined burning of waste leaves, landscape refuse, or other refuse or rubbish.

Residential incineration is banned by various local ordinances through the Denver nonattainment area. It is assumed that all emissions from industrial and commercial/institutional incineration is on the Colorado AIRS file because of permitting requirements.

7.1.8 Wood Burning

Residential wood burning includes the burning of wood in devices such as stoves and fireplaces. Due to the warm ambient temperatures associated with typical high ozone days, it is assumed that residential wood burning is nil, therefore, the source category is excluded from the ozone emission inventory.

7.1.9 Residential Fuel Oil And Coal Use

The use of fuel oil and coal to heat space and water is extremely small within the nonattainment area. The use of fuel oil and coal during peak ozone days, which characteristically happen on very hot summer days, would even be more minimal than during the winter months. Therefore, these source categories are excluded from the ozone precursor gas inventory.

7.1.10 Firefighting Training

The two firefighter training academies within the nonattainment area were contacted about their level of activity during the high ozone season(6). During 1993, most of the firefighting training was outside of the peak ozone season (June through August). In addition, the amount of fuel consumed and the resulting emissions are very small and negligible in the overall NO_x and VOC emission inventories.

Endnotes

7.2 UNINVENTORIED SOURCE CATEGORIES

7.2.1 Charcoal Grilling

There are no emission factors in AP-42[1], the CHIEF Bulletin Board or emission inventory preparation documents[2] by which to calculate emissions from charcoal grills. In addition, a review of both the Level I and II review checklists for both CO and ozone[3] reveal that a charcoal grilling inventory is required only for CO. The CO Level II check list has a category "Charcoal Grilling" in the review checklist (question 2.4.1). The Ozone Level II checklist does not list charcoal grilling as a source category. Given the lack of an emission factor, activity factors, and no apparent requirement to include charcoal grilling in the inventory, charcoal grilling was not inventoried.

7.2.2 Restaurant Charbroilers

Emissions from restaurant charbroilers include carbon dioxide, water vapor, and organic vapors. Although charbroiler emission inventories are not required as part of the Ozone Level II checklist, emissions from charbroilers are generally uncontrolled. EPA does not provide any guidance on preparing restaurant charbroiler emission inventories nor are there any emission factors in AP-42.

1. *1993 APEN Instructions for: Hazardous Air Pollutants and Criteria Pollutants,* Colorado Department of Public Health and Environment-Air Pollution Control Division, September 1993.

1. *Procedures for Preparing Emission Projections*, EPA-450/4-91-019, U.S. Environmental Protection Agency (OAQPS), July 1991.

1. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone: Volume 2, Emission Inventory Requirements for Photochemical Air Quality Simulation Models*, U.S. Environmental Protection Agency (OAQPS), November 1992.

1. *Economic Growth Analysis System: Reference Manual Version 2.0*, EPA-600/4-94-139a, U.S. Environmental Protection Agency (ORD), Augus 1994.

1. Thomas D. Getz letter sent to major NO_x and VOC emitters requesting information on future activity, CDPHE-APCD, September 20, 1995.

1. "Emissions from Aircraft", pp. 137 - 199. In Procedures for Emission Inventory Preparation: Volume IV: Mobile Sources. [EPA Pub. No. EP 450/4-81-026d (Revised)], US Environmental Protection Agency, Office of Mobile Sources, Emission Planning and Strategy Division, Ann Arbor, MI, and Office of Air Quality Planning and Standards, Technical Support Division, Research Triangle Park, NC, 1992.

2. "Category FAQ Sheet with attached Aircraft Summary Sheet", CDPHE internal document from Rob Osterburg, October 19, 1995.

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