



Maricopa County

Air Quality Department

2011 Periodic Emissions Inventory for Ozone Precursors

for the
Maricopa County, Arizona, Eight-Hour Ozone Nonattainment Area

February 2014

Foreword

Maricopa County Air Quality Department released a draft version of this document, its 2011 emission inventory of ozone precursors, for a 30-day public review period on January 22, 2014. (The department's news release to announce the availability of the draft report, which outlines the schedule for public review and comment, is contained in Appendix D, along with a copy of the department's calendar item providing details on the workshop). The department held a public workshop on February 14, 2014 to discuss the draft inventory. No formal comments were received during the 30-day public review period.

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2011 Periodic Emissions Inventory for Ozone Precursors for the Maricopa County, Arizona Eight-Hour Ozone Nonattainment Area

February 2014

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Appendices

Appendix A Instructions for Reporting 2011 Annual Air Pollution Emissions

Appendix B Rule Effectiveness Studies

B.1 Introduction

B.2 Calculating Rule Effectiveness Rates for Title V Facilities and Non-Title V Facilities

B.3 References

Appendix C MOVES2010b Local Input Data and RunSpecs

MOVES2010b RunSpec Summary (Maricopa County, December 2011)

MOVES2010b RunSpec (Maricopa County, December 2011)

MOVES2010b Local Input Data (Maricopa County, December 2011)

Appendix D Public Comment Period Documentation

1. Introduction

1.1 Overview

This 2011 periodic ozone emissions inventory was developed to meet requirements set forth in Title I of the Clean Air Act Amendments of 1990 (CAAA). The CAAA require development of a baseline emissions inventory and periodic revisions for areas that fail to meet the National Ambient Air Quality Standards (NAAQS). A portion of Maricopa County is classified as nonattainment for the eight-hour ozone standard.

This inventory includes emission estimates for three ozone precursors: volatile organic compounds (VOCs), carbon monoxide (CO) and nitrogen oxides (NO_x). VOC is defined by Maricopa County's Rule 100 as "any organic compound, which participates in atmospheric photochemical reactions, except the non-precursor organic compounds". The inventory provides emission estimates from point, area, nonroad mobile, onroad mobile, and biogenic sources. Note that totals shown in tables may not equal the sum of individual values due to independent rounding.

1.2 Agencies responsible for the emissions inventory

Maricopa County Air Quality Department (MCAQD) has primary responsibility for preparing and submitting the 2011 Periodic Emissions Inventory for Ozone Precursors for Maricopa County. Point, area, and some nonroad mobile source emission estimates were prepared by MCAQD. The Maricopa Association of Governments (MAG) prepared the emission estimates for onroad mobile, biogenic, and the majority of nonroad mobile sources. Table 1.2-1 lists those responsible for inventory preparation and quality assurance/quality control activities, which are described in the respective chapters.

Table 1.2-1. Chapter authors and QA/QC contacts for this report.

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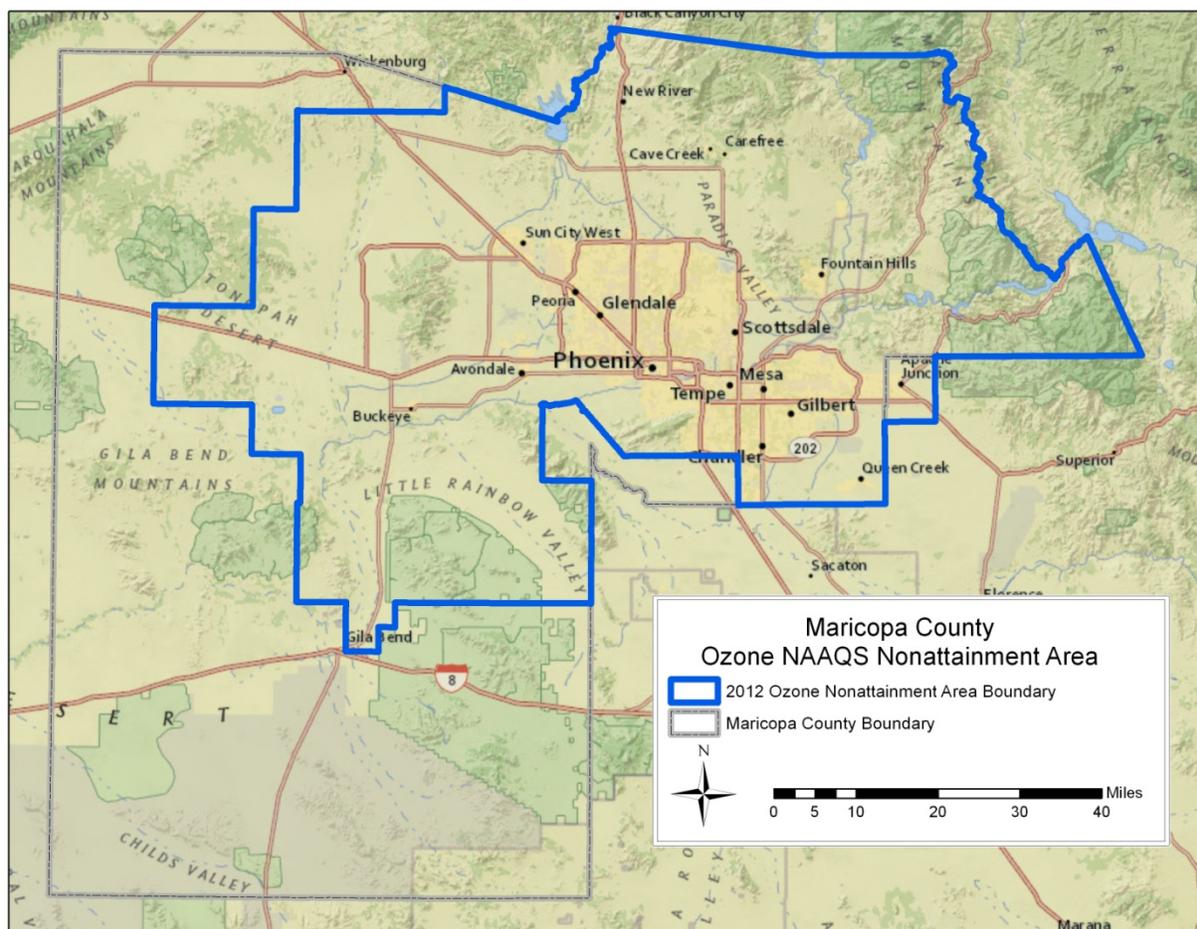
1.3 Temporal scope

Annual and ozone season-day emissions were estimated for the year 2011, for Maricopa County and the Maricopa County eight-hour ozone nonattainment area (NAA). The three-month peak ozone season for the Maricopa County nonattainment area has been defined as July 1 through September 30, based on the 1981–1991 pattern of ozone exceedances.

1.4 Geographic scope

This inventory includes emission estimates for Maricopa County and for the Maricopa County eight-hour ozone nonattainment area. Maricopa County encompasses approximately 9,223 square miles of land area, while the Maricopa County eight-hour ozone nonattainment area is approximately 5,018 square miles or about 54 percent of the Maricopa County land area.¹ A portion of the southeastern boundary of the eight-hour ozone nonattainment area includes areas of Pinal County totaling 48 square miles or 0.96% of the nonattainment area. A map of Maricopa County and the eight-hour ozone nonattainment area is provided in Figure 1.4–1.

Figure 1.4–1. Map of Maricopa County and the eight-hour ozone nonattainment area.



1. In May 2012, EPA designated a new eight-hour ozone nonattainment area based on the 2008 eight-hour ozone NAAQS (77 FR 30088, May 12, 2012). The previous eight-hour ozone nonattainment area was based on the 1997 eight-hour ozone NAAQS. The 2012 nonattainment area boundary was used for this 2011 inventory, as it is expected to be used as a base-year inventory for a future state implementation plan.

1.5 Overview of local demographic and land use data

Many of the emissions estimates generated in this report were calculated using demographic and land use data provided by the Maricopa Association of Governments (MAG). These data were used to apportion and/or scale Maricopa County emissions estimates to the nonattainment area and vice versa. (For example, county-level emissions from residential natural gas usage in Maricopa County were apportioned to the nonattainment area using the ratio of total population in each area). Detailed explanations of how emission estimates were apportioned or scaled are presented in each of the following chapters, along with the data sources used.

1.5.1 Demographic profile

The demographic data provided by MAG included population, employment data, and single family/multi-family splits for calendar year 2011, for both Maricopa County and the eight-hour ozone nonattainment area. Table 1.5–1 provides an overview of the key demographic data used in this report. As noted throughout the text, these data are frequently used to derive estimates of activity or emissions within the eight-hour ozone nonattainment area from county-level calculations. It is important to note, however, that the nonattainment area includes a portion of Pinal County, AZ as shown in Figure 1.4–1. Thus in some cases (e.g., those source categories calculated based on total population), the multiplier used to derive nonattainment area estimates from County-level values may be greater than 1, and thus the resulting NAA emission totals are larger than the County-level estimates from which they are derived.

Table 1.5–1. Demographic profile of Maricopa County and the eight-hour ozone NAA.

Demographic variable	Maricopa County	8-hr ozone NAA	Percentage within 8-hr ozone NAA
Total resident population	3,843,370	3,873,528	100.78%
Total non-resident population	286,276	303,342	105.96%
Total population:	4,129,646	4,176,870	101.14%
Retail employment	414,477	415,672	100.29%
Office employment	320,536	320,189	99.89%
Industrial employment	374,338	372,731	99.57%
Public employment	240,952	241,429	100.20%
Other employment	261,769	258,963	98.93%
Construction	24,026	24,791	103.18%
Work at home	100,016	100,617	100.60%
Total employment:	1,736,114	1,734,392	99.90%
Single-family/multi-family household split:			
Single-family	77%	77%	
Multi-family	23%	23%	

1.5.2 Land use data

MAG provided draft 2010 land use data. The 2010 land use data was assumed to be representative of 2011. Table 1.5–2 presents a summary of the land use categories and acreage used to develop emission estimates for this inventory.

Table 1.5–2. Land use categories used to apportion emissions.

Land use category	Acreage within Maricopa County	Acreage within 8-hour ozone NAA	Percentage within 8-hour ozone NAA
General/active open space/golf course (e.g., parks)	210,159	211,297	100.54%
Passive/restricted open space, washes	2,614,870	1,188,251	45.44%
Lakes	12,525	12,525	100.00%
Agriculture	276,016	161,371	58.46%
Vacant (e.g., developable land)	2,045,587	911,304	44.55%

1.6 Emissions overview by source category

1.6.1 Point sources

The point source category includes those stationary sources that emit a significant amount of pollution into the air such as power plants, petroleum product storage and transfer facilities, and large industrial facilities. MCAQD utilizes the US EPA’s Annual Emissions Reporting Requirements (AERR) rule to define which stationary sources are listed as point sources. A detailed definition of a point source can be found in Section 2.1 of Chapter 2.

Table 1.6–1 summarizes annual and season-day emissions from point sources (including emission reduction credits) in Maricopa County and the eight-hour ozone nonattainment area, respectively. A detailed breakdown of emissions calculations for all point sources is contained in Chapter 2.

Table 1.6–1. Annual and season-day emissions from point sources.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO_x	CO	VOC	NO_x	CO
Maricopa County	768.54	1,754.12	1,078.48	4,908.3	15,407.1	9,715.8
8-hour ozone NAA	768.54	1,754.12	1,078.48	4,908.3	15,407.1	9,715.8

1.6.2 Area sources

Area sources are facilities or activities whose individual emissions do not qualify them as point sources. Area sources represent numerous facilities or activities that individually release small amounts of a given pollutant, but collectively they can release significant amounts of a pollutant. Emissions from stationary sources that were not identified as point sources in this report have been included in the area source inventory. Examples of area source categories include residential wood burning, commercial cooking, waste incineration and wildfires.

Tables 1.6–2 and 1.6–3 summarize annual and season-day emissions of the chief area source categories, for Maricopa County and the eight-hour ozone nonattainment area, respectively. A detailed breakdown of emissions calculations for each area source category is contained in Chapter 3.

Table 1.6–2. Annual and season-day emissions from area sources in Maricopa County.

Source category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Fuel combustion	653.61	4,675.41	4,866.67	593.3	23,544.5	9,255.2
Industrial processes	2,284.00	263.41	585.79	17,516.5	1,489.5	3,396.2
Solvent use	28,153.45			167,043.9		
Storage/transport	5,176.39			28,577.9		
Waste treatment/disposal	115.61	56.21	193.56	842.6	320.7	1,227.1
Misc. area sources	271.58	166.54	4,765.93	13,982.3	6,680.5	281,693.1
All area sources:	36,654.65	5,161.56	10,411.95	228,556.4	32,035.2	295,571.5

Table 1.6–3. Annual and season-day emissions from area sources in the eight-hour ozone NAA.

Source category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Fuel combustion	659.63	4,670.68	4,898.99	593.0	23,483.5	9,235.4
Industrial processes	2,276.48	263.41	590.27	17,452.4	1,489.5	3,420.8
Solvent use	28,139.77			166,557.4		
Storage/transport	5,211.35			28,766.2		
Waste treatment/disposal	116.10	56.04	190.06	837.8	315.6	1,119.6
Misc. area sources	261.09	161.70	4,664.71	13,650.0	6,531.8	278,544.9
All area sources:	36,664.42	5,151.83	10,344.03	227,856.8	31,820.5	292,320.7

1.6.3 Nonroad mobile sources

Nonroad mobile sources include off-highway vehicles and engines that move or are moved within a 12-month period. Tables 1.6–4 and 1.6–5 summarize annual and season-day emissions from nonroad mobile sources, for Maricopa County and the eight-hour ozone nonattainment area, respectively. A detailed breakdown of emissions calculations for each source category is contained in Chapter 4.

Table 1.6–4. Annual and season-day emissions from nonroad mobile sources in Maricopa County.

Source category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Agricultural equipment	38.53	330.49	303.71	329.3	2,762.6	2,584.4
Airport GSE (+APU)	111.98	406.04	3,275.98	587.3	2,136.6	17,155.0
Commercial equipment	1,924.41	1,361.42	30,224.21	14,537.1	8,334.7	203,404.4
Construction & mining	1,881.88	12,937.30	14,396.92	13,116.9	87,972.9	99,942.8
Industrial equipment	341.25	1,839.35	7,140.99	2,212.6	11,763.4	46,138.5
Lawn & garden	4,913.96	866.64	54,798.41	51,990.4	6,998.4	523,235.5
Pleasure craft	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
Railway maintenance	1.94	8.55	16.48	14.2	59.0	117.8
Recreational equipment	1,518.97	66.10	6,373.46	17,804.4	679.3	74,424.8
Aircraft	1,719.33	2,588.82	11,781.38	8,451.0	12,548.2	65,325.4
Locomotives	77.60	1,406.08	245.74	425.2	7,704.5	1,346.5
All nonroad mobile sources:	13,060.24	21,907.35	129,806.94	120,995.4	142,956.4	1,060,413.4

Table 1.6–5. Annual and season-day emissions from nonroad mobile sources in the eight-hour ozone NAA.

Source category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Agricultural equipment	22.52	193.22	177.56	192.5	1,615.1	1,510.9
Airport GSE (+APU)	111.43	404.49	3,259.08	584.5	2,128.9	17,071.7
Commercial equipment	1,916.15	1,355.57	30,094.46	14,474.7	8,299.0	202,531.2
Construction & mining	1,941.80	13,349.23	14,855.32	13,534.5	90,774.0	103,125.0
Industrial equipment	339.78	1,831.45	7,110.33	2,203.1	11,712.9	45,940.4
Lawn & garden	4,970.15	876.55	55,425.05	52,584.9	7,078.4	529,218.9
Pleasure craft	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
Railway maintenance	1.96	8.64	16.67	14.4	59.7	119.1
Recreational equipment	684.30	29.78	2,871.27	8,020.9	306.0	33,528.7
Aircraft	1,705.43	2,585.98	11,719.36	8,385.8	12,535.3	64,993.6
Locomotives	50.15	901.12	153.29	274.8	4,937.7	839.9
All nonroad mobile sources:	12,274.06	21,632.59	126,932.05	111,797.1	141,443.8	1,025,617.7

1.6.4 Onroad mobile sources

Emissions from onroad mobile sources were calculated for Maricopa County and the eight-hour ozone nonattainment area. A detailed description of emissions calculations is contained in Chapter 5.

Table 1.6–6 summarizes annual and season-day emissions from onroad mobile sources in Maricopa County and the eight-hour ozone nonattainment area, respectively.

Table 1.6–6. Annual and season-day emissions from onroad mobile sources in Maricopa County and the eight-hour ozone NAA.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	24,556.85	60,269.94	235,088.25	150,603.7	319,470.2	1,378,165.5
8-hour ozone NAA	24,110.04	56,861.82	226,581.20	148,186.2	301,823.7	1,321,680.2

1.6.5 Biogenic sources

The biogenic source category includes emissions from all vegetation (e.g., crops, indigenous vegetation, landscaping, etc.) in Maricopa County and the eight-hour ozone nonattainment area. Emissions were estimated using the Model of Emissions of Gases and Aerosols from Nature (MEGAN). MEGAN is a state-of-the-art biogenic emissions model developed by the National Center for Atmospheric Research (NCAR). Some corrections and improvements were made in the latest version of MEGAN2.1. MEGAN2.1 was used to compute biogenic emissions in Maricopa County and the eight-hour ozone nonattainment area. Annual and season-day emissions from biogenic sources are shown in Table 1.6–7 for Maricopa County and the eight-hour ozone nonattainment area.

Table 1.6–7. Annual and season-day emissions from biogenic sources in Maricopa County and the eight-hour ozone NAA.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	79,714.87	779.52	11,548.84	895,860.0	9,199.0	122,186.2
8-hour ozone NAA	55,311.84	527.18	5,934.55	624,395.0	6,231.7	62,584.2

1.6.6 Summary of all source categories

Tables 1.6–8 and 1.6–9 provide summary totals of annual and season-day emissions from all emission sources in Maricopa County and the eight-hour ozone nonattainment area, respectively.

Table 1.6–8. Annual and season-day emissions from all sources in Maricopa County.

Section	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
POINT SOURCES:	768.54	1,754.12	1,078.48	4,908.3	15,407.1	9,715.8
AREA SOURCES:						
<i>Fuel combustion:</i>						
Industrial distillate oil: Boilers	0.61	60.87	15.22	3.9	390.2	97.5
Industrial distillate oil: Engines	0.00	1,838.26	395.65	0.0	11,783.7	2,536.2
Industrial natural gas	36.99	730.94	455.30	217.8	4,303.8	2,680.8
Comm./inst. distillate oil: Boilers	0.00	0.12	0.03	0.0	0.8	0.2
Comm./inst. distillate oil: Engines	0.00	3.72	0.80	0.0	23.8	5.1
Comm./inst. natural gas	54.48	1,080.73	662.84	252.0	4,998.0	3,065.4
Residential distillate oil	0.01	0.35	0.10	0.0	0.0	0.0
Residential natural gas	49.81	851.32	362.26	119.6	2,044.2	869.9
Residential LPG	2.00	51.35	14.56	0.0	0.0	0.0
Residential wood combustion	509.7	57.72	2,959.91	0.0	0.0	0.0
Residential kerosene	0.00	0.03	0.01	0.0	0.0	0.0
All Fuel Combustion	653.61	4,675.41	4,866.67	593.3	23,544.5	9,255.2
<i>Industrial Processes:</i>						
Chemical manufacturing	77.42			599.0		
Commercial cooking	149.33		392.60	820.5		2,157.1
Bakeries	78.18			547.8		
Secondary metal production	41.01	15.02	98.36	306.4	107.9	697.4
Rubber/plastic product mfg.	1,766.75			14,171.0		
Electrical equipment mfg.	122.80	23.47	2.98	746.2	135.8	16.4
Industrial processes, NEC	48.51	224.92	91.84	325.6	1,245.8	525.2
All Industrial Processes	2,284.00	263.41	585.79	17,516.5	1,489.5	3,396.2
<i>Solvent Use:</i>						
Architectural coatings	4,976.22			30,622.9		
Auto refinishing	1,333.26			10,255.9		
Traffic markings	179.60			1,823.6		
Factory finished wood	137.72			1,396.7		
Wood furniture	416.56			3,434.7		
Aircraft surface coating	65.84			473.1		
Miscellaneous surface coating	316.38			2,450.5		
Degreasing	217.55			1,451.4		
Dry cleaning	23.15			178.1		
Graphics arts	290.98			2,225.7		
Miscellaneous industrial solvent use	721.85			5,126.6		
Consumer and commercial products	17,406.46			95,377.9		
Cutback asphalt	835.84			4,567.4		
Emulsified asphalt	866.06			4,732.6		
Roofing asphalt	3.04			23.4		
Agricultural pesticides	362.93			2,903.4		
All Solvent Use	28,153.45			167,043.9		

Table 1.6–8. Annual and season-day emissions from all sources in Maricopa County (continued).

Section	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NOx	CO	VOC	NOx	CO
<i>Storage/Transport:</i>						
Residential portable gas cans	2,935.09			16,126.8		
Commercial portable gas cans	564.43			3,101.2		
Bulk plants	120.91			659.3		
Gas stations Stage I: Submerged fill	85.08			528.7		
Gas stations Stage I: Bal. submerged fill	229.60			1,426.8		
Gas stations Stage II	0.00			0.0		
Underground tanks: Breathing/emptying	777.00			4,138.6		
Airports: aviation gasoline Stage I	347.57			1,904.5		
Airports: aviation gasoline Stage II	18.04			98.8		
Truck: gasoline (tank trucks in transit)	50.82			315.8		
Pipeline gasoline	17.32			94.5		
Volatile organic liquids storage/transport	30.54			182.7		
All Storage/Transport	5,176.39			28,577.9		
<i>Waste Treatment/Disposal:</i>						
On-site incineration	0.17	3.31	0.79	1.1	21.4	5.3
Open burning: Land clearing debris	0.67	0.30	6.30	20.5	9.1	193.8
Landfills	36.59	30.40	108.55	200.7	167.4	596.4
Publicly owned treatment works	75.02			577.1		
Leaking underground storage tanks	1.05			32.3		
Other waste	2.12	22.19	77.93	10.9	122.8	431.4
All Waste Treatment/Disposal	115.61	56.21	193.56	842.6	320.7	1,227.1
<i>Miscellaneous Area Sources:</i>						
Agricultural field burning	26.14	11.62	246.85	804.2	357.4	7,595.5
Structure fires	14.78	1.88	80.63	72.4	9.2	395.2
Aircraft engine testing	4.72	46.36	16.16	26.1	259.3	91.2
Vehicle fires	9.27	1.16	36.23	50.8	6.4	198.5
Crematories	1.18	11.19	2.23	51.1	88.5	17.3
Accidental releases	0.45	0.00	0.00	2.1	0.0	0.0
Hospitals	8.57			52.3		
Wildfires	206.08	93.95	4,379.29	12,794.0	5,832.6	271,872.2
Prescribed fires	0.39	0.38	4.54	129.2	127.1	1,523.2
All Misc. Area Sources	271.58	166.54	4,765.93	13,982.3	6,680.5	281,693.1
ALL AREA SOURCES	36,654.65	5,161.56	10,411.95	228,556.4	32,035.2	295,571.5
NONROAD MOBILE SOURCES:						
Agricultural equipment	38.53	330.49	303.71	329.3	2,762.6	2,584.4
Airport GSE (+APU)	111.98	406.04	3,275.98	587.3	2,136.6	17,155.0
Commercial equipment	1,924.41	1,361.42	30,224.21	14,537.1	8,334.7	203,404.4
Construction & mining equipment	1,881.88	12,937.30	14,396.92	13,116.9	87,972.9	99,942.8
Industrial equipment	341.25	1,839.35	7,140.99	2,212.6	11,763.4	46,138.5
Lawn and garden equipment	4,913.96	866.64	54,798.41	51,990.4	6,998.4	523,235.5
Pleasure craft	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
Railway maintenance equipment	1.94	8.55	16.48	14.2	59.0	117.8
Recreational equipment	1,518.97	66.10	6,373.46	17,804.4	679.3	74,424.8
Aircraft	1,719.33	2,588.82	11,781.38	8,451.0	12,548.2	65,325.4
Locomotives	77.60	1,406.08	245.74	425.2	7,704.6	1,346.5
ALL NONROAD MOBILE	13,060.24	21,907.35	129,806.94	120,995.4	142,956.4	1,060,413.4
ONROAD MOBILE SOURCES	24,556.85	60,269.94	235,088.25	150,603.7	319,470.2	1,378,165.5
BIOGENIC SOURCES	79,714.87	779.52	11,548.84	895,860.0	9,199.0	122,186.2
TOTAL, ALL SOURCE CATEGORIES	154,755.15	89,872.48	387,934.46	1,400,923.9	519,067.9	2,866,052.4

Table 1.6–9. Annual and season-day emissions from all sources in the eight-hour ozone nonattainment area.

Section	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
POINT SOURCES:	768.54	1,754.12	1,078.48	4,908.3	15,407.1	9,715.8
AREA SOURCES:						
<i>Fuel combustion:</i>						
Industrial distillate oil: Boilers	0.61	60.61	15.15	3.9	388.5	97.1
Industrial distillate oil: Engines	0.00	1,830.35	393.95	0.0	11,733.0	2,525.3
Industrial natural gas	36.83	727.80	453.34	216.9	4,285.3	2,669.3
Comm./inst. distillate oil: Boilers	0.00	0.12	0.03	0.0	0.8	0.2
Comm./inst. distillate oil: Engines	0.00	3.70	0.80	0.0	23.7	5.1
Comm./inst. natural gas	54.42	1,079.44	662.05	251.7	4,992.0	3,061.7
Residential distillate oil	0.01	0.35	0.10	0.0	0.0	0.0
Residential natural gas	50.20	857.96	365.09	120.5	2,060.1	876.7
Residential LPG	2.02	51.93	14.73	0.0	0.0	0.0
Residential wood combustion	515.53	58.38	2,993.75	0.0	0.0	0.0
Residential kerosene	0.00	0.03	0.01	0.0	0.0	0.0
All Fuel Combustion:	659.63	4,670.68	4,898.99	593.0	23,483.5	9,235.4
<i>Industrial processes:</i>						
Chemical manufacturing	77.09			596.5		
Commercial cooking	151.03		397.07	829.8		2,181.7
Bakeries	77.85			545.4		
Secondary metal production	41.01	15.02	98.36	306.4	107.9	697.4
Rubber/plastic product manufacturing	1,759.15			14,110.1		
Electrical equipment manufacturing	122.80	23.47	2.98	746.2	135.8	16.4
Industrial processes, NEC	47.55	224.92	91.84	318.0	1,245.8	525.2
All Industrial Processes:	2,276.48	263.41	590.27	17,452.4	1,489.5	3,420.8
<i>Solvent use:</i>						
Architectural coatings	5,033.13			30,973.1		
Auto refinishing	1,327.53			10,211.8		
Traffic markings	171.12			1,737.5		
Factory finished wood	137.12			1,390.7		
Wood furniture	414.77			3,419.9		
Aircraft surface coating	65.84			473.1		
Miscellaneous surface coating	315.02			2,440.0		
Degreasing	216.62			1,445.1		
Dry cleaning	23.42			180.1		
Graphics arts	289.73			2,216.1		
Miscellaneous industrial solvent use	718.75			5,104.6		
Consumer and commercial products	17,605.51			96,468.5		
Cutback asphalt	788.72			4,309.9		
Emulsified asphalt	817.24			4,465.8		
Roofing asphalt	3.08			23.7		
Agricultural pesticides	212.18			1,697.5		
All Solvent Use:	28,139.77			166,557.4		

Table 1.6–9. Annual and season-day emissions from all sources in the eight-hour ozone nonattainment area (continued).

Section	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NOx	CO	VOC	NOx	CO
Storage/transport:						
Residential portable gas cans	2,968.67			16,311.39		
Commercial portable gas cans	570.89			3,136.73		
Bulk plants	120.91			659.3		
Gas stations Stage I: Submerged fill	85.08			528.7		
Gas stations Stage I: Bal. submerged fill	229.60			1,426.8		
Gas stations Stage II	0.00			0.0		
Underground tanks: Breathing/emptying	777.00			4,138.6		
Airports: Aviation gasoline Stage I	344.41			1,887.2		
Airports: Aviation gasoline Stage II	17.87			97.9		
Truck: Gasoline (tank trucks in transit)	50.82			315.8		
Pipeline gasoline	17.32			94.5		
Volatile organic liquids storage/transport	28.80			169.3		
All Storage/Transport:	5,211.35			28,766.2		
Waste treatment/disposal:						
On-site incineration	0.17	3.31	0.79	1.1	21.4	5.3
Open Burning: Land clearing debris	0.30	0.13	2.81	9.1	4.1	86.4
Landfills	36.59	30.40	108.55	200.7	167.4	596.4
Publicly owned treatment works	75.88			583.7		
Leaking underground storage tanks	1.05			32.3		
Other waste	2.12	22.19	77.93	10.9	122.8	431.4
All Waste Treatment/Disposal:	116.10	56.04	190.06	837.8	315.6	1,119.6
Misc. area sources:						
Agricultural field burning	15.28	6.79	144.32	470.2	209.0	4,440.7
Structure fires	14.95	1.90	81.55	73.3	9.3	399.7
Aircraft engine testing	4.72	46.36	16.16	26.1	259.3	91.2
Vehicle fires	9.38	1.17	36.64	51.4	6.4	200.8
Crematories	1.18	11.14	2.22	50.9	88.1	17.2
Accidental releases	0.45	0.00	0.00	2.1	0.0	0.0
Hospitals	8.66			52.9		
Wildfires	206.08	93.95	4,379.28	12,794.0	5,832.6	271,872.2
Prescribed fires	0.39	0.38	4.54	129.2	127.1	1,523.2
All Misc. Area Sources	261.09	161.70	4,664.71	13,650.0	6,531.8	278,544.9
ALL AREA SOURCES:	36,664.42	5,151.83	10,344.03	227,856.8	31,820.5	292,320.7
NONROAD MOBILE SOURCES:						
Agricultural equipment	22.52	193.22	177.56	192.5	1,615.1	1,510.9
Airport ground support equipment (+APU)	111.43	404.49	3,259.08	584.5	2,128.9	17,071.7
Commercial equipment	1,916.15	1,355.57	30,094.46	14,474.7	8,299.0	202,531.2
Construction & mining equipment	1,941.80	13,349.23	14,855.32	13,534.5	90,774.0	103,125.0
Industrial equipment	339.78	1,831.45	7,110.33	2,203.1	11,712.9	45,940.4
Lawn and garden equipment	4,970.15	876.55	55,425.05	52,584.9	7,078.4	529,218.9
Pleasure craft	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
Railway maintenance equipment	1.96	8.64	16.67	14.4	59.7	119.1
Recreational equipment	684.30	29.78	2,871.27	8,020.9	306.0	33,528.7
Aircraft	1,705.43	2,585.98	11,719.36	8,385.8	12,535.3	64,993.6
Locomotives	50.15	901.12	153.29	274.8	4,937.7	839.9
ALL NONROAD MOBILE SOURCES:	12,274.06	21,632.59	126,932.05	111,797.1	141,443.8	1,025,617.7
ONROAD MOBILE SOURCES:	24,110.04	56,861.82	226,581.20	148,186.2	301,823.7	1,321,680.2
BIOGENIC SOURCES:	55,311.84	527.18	5,934.55	624,395.0	6,231.7	62,584.2
TOTAL, ALL SOURCE CATEGORIES:	129,128.91	85,927.54	370,870.31	1,117,143.4	496,726.7	2,711,918.6

2. Point Sources

2.1 Introduction and scope

This inventory of ozone precursors (VOC, NO_x, and CO) is one of two 2011 emissions inventory reports being prepared to meet US EPA reporting requirements. This inventory has been developed concurrently with a similar inventory for PM₁₀ and related pollutants (PM_{2.5}, NO_x, SO_x, and NH₃) as part of Maricopa County's requirements under the respective SIPs.

In addition to preparing a periodic emissions inventory for the eight-hour ozone nonattainment area (NAA) as a commitment under the current ozone State Implementation Plan (SIP), the federal Air Emission Reporting Requirements (AERR) rule requires that state and local agencies prepare emissions estimates on a county basis, and submit data electronically to the US EPA for inclusion in the National Emissions Inventory (NEI) for 2011.

In order to provide consistency among all these inventories, it was decided to standardize the definition of a “point source” by adopting the designation of point sources as outlined in the AERR:

We are basing the requirement for point source format reporting on whether the source is major under 40 CFR part 70 for the pollutants for which reporting is required, i.e., CO, VOC, NO_x, SO₂, PM_{2.5}, PM₁₀, lead and NH₃ but without regard to emissions of HAPs... [T]his approach will result in a more stable universe of reporting point sources, which in turn will facilitate elimination of overlaps and gaps in estimating point source emissions, as compared to nonpoint source emissions. Under this requirement, states will know well in advance of the start of the inventory year which sources will need to be reported. (US EPA, 2008)

This chapter contains several tables that provide information on point source emissions. Table 2.2–1 provides an alphabetical listing of all point sources and their location. Table 2.4–1 shows the annual and ozone season-day emissions of VOC, NO_x, and CO for those point sources which reported emissions of one or more of these pollutants in 2011. Table 2.5–1 lists emission reduction credits for the area, while Table 2.6–1 summarizes point source emission totals for both Maricopa County and the eight-hour ozone nonattainment area. Note that the totals shown in tables may not equal the sum of individual values due to independent rounding.

2.2 Identification of point sources

The Maricopa County Air Quality Department (MCAQD) identified point sources within Maricopa County through its electronic permit system database, EMS, and the 2011 annual emissions reports submitted to the department. A total of 18 stationary sources were identified as point sources using the definition described in Section 2.1. While the Arizona Department of Environmental Quality (ADEQ) retains permitting authority for a limited number of industrial source categories in Maricopa County, no ADEQ-permitted facilities are considered point sources, and are addressed instead as area sources.

Table 2.2–1 contains an alphabetical listing of all point sources, including a unique business identification number, NAICS industry classification code, business name, and physical address.

Table 2.2–1. Name and location of all point sources in Maricopa County.

ID #	NAICS	Business name	Address	City	ZIP
3313	221112	APS West Phoenix Power Plant	4606 W Hadley St	Phoenix	85043
43063	221112	Arlington Valley LLC	39027 W Elliot Rd	Arlington	85322
127771	331111	CMC Steel Fabricators Inc	11444 E Germann Rd	Mesa	85212
44439	221112	Gila River Power Station	1250 E Watermelon Rd	Gila Bend	85337
3300	92811	Luke AFB – 56th Fighter Wing	14002 W Marauder St	Glendale	85309
44186	221112	Mesquite Generating Station	37625 W Elliot Rd	Arlington	85322
43530	221112	New Harquahala Generating Co	2530 N 491st Ave	Tonopah	85354
20706	32614	New Wincup Holdings Inc	7980 W Buckeye Rd	Phoenix	85043
1879	562212	Northwest Regional Landfill	19401 W Deer Valley Rd	Surprise	85387
1331	337122	Oak Canyon Manufacturing Inc	3021 N 29th Dr	Phoenix	85017
52382	221112	Ocotillo Power Plant	1500 E University Dr	Tempe	85281
42956	221112	Redhawk Generating Facility	11600 S 363rd Ave	Arlington	85322
303	332431	Rexam Beverage Can Company	211 N 51st Ave	Phoenix	85043
3315	221112	Santan Generating Station	1005 S Val Vista Rd	Gilbert	85296
4175	424710	SFPP LP Phoenix Terminal	49 N 53rd Ave	Phoenix	85043
3316	221112	SRP Agua Fria Generating Station	7302 W Northern Ave	Glendale	85303
3317	221112	SRP Kyrene Generating Station	7005 S Kyrene Rd	Tempe	85283
1210	337122	Trendwood Inc	2402 S 15th Ave	Phoenix	85007

2.3 Procedures for estimating emissions from point sources

Annual and season-day emission estimates were determined from annual source emissions reports, MCAQD investigation reports, permit files and logs, or telephone contacts with sources. For most of the sources, material balance methods were used for determining emissions. Emissions were estimated using the emission factors from AP-42, source tests, engineering calculations, or manufacturers' specifications.

MCAQD distributes annual emissions survey forms to nearly all facilities for which MCAQD has issued an operating permit. Facilities are required to report detailed information on stacks, control devices, operating schedules, and process-level information concerning their annual activities. (See Appendix A for a copy of the instructions to complete the emissions inventory.) These instructions include examples and explanations on how to complete the annual emissions reporting forms that facilities must submit to MCAQD.

After a facility has submitted an annual emissions report to MCAQD, emissions inventory staff check all reports for missing and questionable data, and check the accuracy and reasonableness of all emissions calculations with AP-42, the Factor Information and REtrieval (*webFIRE*) software, and other EPA documentation. Control efficiencies are determined by source tests when available, or by AP-42 factors, engineering calculations, or manufacturers' specifications. MCAQD has conducted annual emissions surveys for permitted facilities since 1988, and the department's database system, EMS, contains numerous automated quality assurance/quality control checks for data input and processing.

2.3.1 Application of rule effectiveness

Rule effectiveness reflects the actual ability of a regulatory program to achieve the emission reductions required by regulation. The concept of applying rule effectiveness in a SIP emissions inventory has evolved from the observation that regulatory programs may be less than 100 percent effective for some source categories. Rule effectiveness (“RE”) is applied to those sources affected by a regulation and for which emissions are determined by means of emission factors and control efficiency estimates.

For processes that claimed emissions reductions through the use of a control device, RE calculations were performed separately for Title V and non-Title V sources. Overall RE values of 91.81% (for Title V processes) and 87.81% (for non-Title V processes) were calculated.

Appendix B contains further details on the methods and data used in computing the above RE rates.

2.4 Detailed overview of point source emissions

Table 2.4–1 provides a summary of annual and season-day emissions from all point sources. All point sources are located within the eight-hour ozone nonattainment area, therefore, county and nonattainment area emissions are equal. Sources for which rule effectiveness has been applied are noted. Values of “0.00” and “0.0” for annual and daily emissions denote a value below the level of significance (0.005 tons/yr and 0.05 lbs/day, respectively).

Table 2.4–1. Annual and season-day point source emissions, by facility.

ID #	Business name		Annual emissions (tons/yr)			Ozone season day (lbs/day)		
			VOC	NO _x	CO	VOC	NO _x	CO
3313	APS West Phoenix Power Plant	*	28.43	596.56	80.92	163.6	4,162.0	422.6
43063	Arlington Valley LLC		0.52	38.68	24.12	8.7	605.4	377.5
127771	CMC Steel Fabricators Inc	*	23.63	34.05	455.94	226.7	318.6	4,376.6
44439	Gila River Power Station		10.40	194.22	53.43	93.9	1,777.7	501.0
3300	Luke AFB – 56th Fighter Wing	*	8.07	10.04	5.36	53.1	52.2	22.5
44186	Mesquite Generating Station	*	22.53	192.49	22.99	134.0	1,146.1	137.2
43530	New Harquahala Generating Co	*	15.50	23.24	35.24	169.0	251.0	386.3
20706	New Wincup Holdings Inc		125.98	11.82	2.10	684.0	65.1	12.9
1879	Northwest Regional Landfill		2.47	9.74	5.18	13.6	53.5	28.5
1331	Oak Canyon Manufacturing Inc		62.86			483.5		
52382	Ocotillo Power Plant		4.79	82.96	15.54	51.1	1,087.8	203.7
42956	Redhawk Generating Facility		5.61	150.82	168.87	26.6	813.2	890.8
303	Rexam Beverage Can Company		99.49	4.35	3.65	481.1	21.0	17.7
3315	Santan Generating Station	*	8.78	257.77	150.24	87.7	2,817.6	1,648.7
4175	SFPP LP Phoenix Terminal		101.15	4.89	5.53	556.6	36.2	47.4
3316	SRP Agua Fria Generating Station	*	1.88	104.92	25.55	32.2	1,900.1	481.8
3317	SRP Kyrene Generating Station		3.16	27.77	8.51	25.2	245.8	76.9
1210	Trendwood Inc		128.59			989.1		
TOTAL:			653.84	1,744.32	1,063.18	4,279.8	15,353.4	9,632.0

* = Facility for which rule effectiveness has been applied.

2.5 Emission reduction credits

A major source or major modification planned in a nonattainment area must obtain emissions reductions as a condition for approval. These emissions reductions, generally obtained from

existing sources located in the vicinity of a proposed source, must offset the emissions increase from the new source or modification. The obvious purpose of acquiring offsetting emissions decreases is to allow an area to move towards attainment of the national ambient air quality standards while still allowing some industrial growth.

In order for these emission reductions to be available in the future for offsetting, they must be: 1) explicitly included and quantified as growth in projection-year inventories required in rate of progress plans or attainment demonstrations that were based on 1990 actual inventories, and 2) meet the requirements outlined in MCAQD Rule 240 (Permit Requirements for New Major Sources and Major Modification to Existing Major Sources).

Table 2.5–1 provides a list of emission reduction credits for VOC, NO_x, and CO.

Table 2.5–1. Emission reduction credits as of December 31, 2011.

ID	Facility/ Owner	Reduction Date	Emission reduction credits (tons/yr)		
			VOC	NO _x	CO
1151	Freescale Semiconductor, Inc.	3/1/2004	17.1	9.8	15.3
	Grey K Envl Fund, NYC	12/11/2006	80.0		
	Woodstuff Mfg	11/30/2007	17.6		
TOTAL:			114.7	9.8	15.3

2.6 Summary of point source emissions

Table 2.6–1 provides a summary of point source emissions for Maricopa County and the eight-hour ozone nonattainment area, including emission reduction credits.

Table 2.6–1. Annual and season-day point source emissions (including emission reduction credits).

Geographic Area	Annual (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	768.54	1,754.12	1,078.48	4,908.3	15,407.1	9,715.8
8-hr ozone NAA	768.54	1,754.12	1,078.48	4,908.3	15,407.1	9,715.8

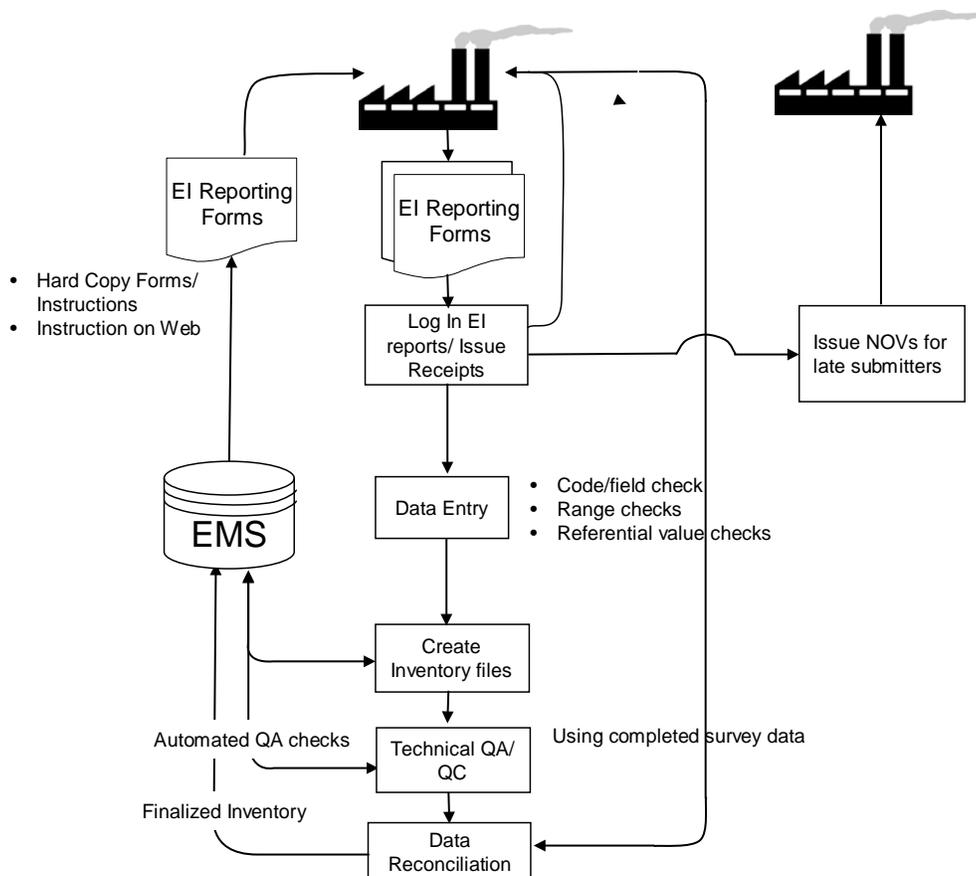
2.7 Quality assurance/quality control procedures

2.7.1 Emission survey preparation and data collection

The MCAQD's Emissions Inventory (EI) Unit annually collects point source criteria pollutant emission data from sources in the county. MCAQD annually reviews EPA guidance, documents from the Emissions inventory Improvement Program (EIIP), and other source materials to ensure that the most current emission factors and emission calculation methods are used for each year's survey. Each January, the EI Unit prepares a pre-populated hard copy of the preceding year's submissions and mails reporting forms to permitted sources, along with detailed instructions for completing the forms. (A copy of these instructions is included as Appendix A). The EI Unit asks sources to verify and update the data. The EI Unit also holds numerous workshops each spring to assist businesses in completing EI forms.

The general data flow for data collection and inventory preparation is shown in Figure 2.7–1.

Figure 2.7–1. Data flow for annual point source emissions inventory reporting.



2.7.2 Submission processing

Submitted EI reports are logged in as they are received, and receipts are issued for emissions fees paid. The data are input “as received” into the department's data base. During data entry, a variety of automated quality control (QC) checks are performed, including:

- pull-down menus to minimize data entry errors (e.g., city, pollutant, emission factor unit, etc.)
- mandatory data field requirement checks (e.g., a warning screen appears if a user tries to save an emission record with a missing emission factor).
- range checks (e.g., were valid SCC, Tier, SIC, and NAICS codes entered?)
- referential value checks (e.g., emission factor units, annual throughput units)
- automatic formatting of date, time, telephone number fields, etc.

Automated quality assurance (QA) checks on the report that has been entered include the following:

- Comparing reported emission factors to SCC reference lists
- Comparing reported emission factors to material name reference list

- Checking the report for calculation errors. This includes annual throughput, emission factors, unit conversion factors (e.g., BTU to therms), capture efficiency, primary / secondary control device efficiency, and any offsite recycling credits claimed.
- Checking the report for completeness of required data.

When data entry is complete, an electronic version of the original data is preserved separately to document changes made during the technical review and QA/QC process.

When errors are flagged, the businesses are contacted and correct information is obtained and input to the EMS. Outstanding reporting issues are documented. Confidential business information (CBI) is identified by a checkbox on the form, and these data elements are flagged during data entry and are not transmitted to the EPA.

To prepare the inventory for submittal to the National Emissions Inventory (NEI), the EI Unit has developed a series of MS-Access queries to extract data from EMS; and to append or convert codes, units of measure, etc., in order to create staging tables that adhere to the EPA's Consolidated Emissions Reporting Schema (CERS). These tables are then converted to XML files using EPA's Bridge conversion tool for submittal to the EPA's Emissions inventory System (EIS).

2.7.3 Analysis of annual point source emissions data for this inventory

Two air quality planners checked inventory accuracy and reasonableness, and assured that all point sources had been identified and that the methodology applied to calculate emissions was appropriate and that the calculations were correct. Other reasonableness checks were conducted by recalculating emissions using methods other than those used to make the initial emissions calculations and then comparing results. QA was conducted by checking all emissions reports submitted to MCAQD for the year 2011 for missing and questionable data and by checking the accuracy and reasonableness of all emissions calculations made for such reports. Notes concerning follow-up calls and corrections to calculations were documented on each 2011 annual emissions report.

The QA point source coordinator reviewed and checked calculations, identified errors, and performed completeness, reasonableness and accuracy checks.

2.8 References

US EPA, 2008. Air Emissions Reporting Requirements: Final Rule. 73 Fed. Reg. 76539.
Available at: http://www.epa.gov/ttn/chief/aerr/final_published_aerr.pdf.

3. Area Sources

3.1 Scope and methodology

This chapter considers all stationary sources which are too small or too numerous to be treated as point sources. US EPA guidance documents, including “Introduction to Area Source Inventory Development” (US EPA, 2001a) as well as permit and emissions data in the MCAQD’s Environmental Management System (EMS) database, and previous SIP inventories, were evaluated to develop the list of area source categories for inclusion. Some source categories were deemed “insignificant” because there are no large production facilities and/or very few small sources, and therefore emissions were not quantified. MCAQD prepared the emission estimates for all area sources and provided quality assurance checks on all data. Table 3.1–1 contains a list of all area source categories, with Source Classification Codes (SCCs), addressed in this chapter.

Table 3.1–1. List of area source categories included in this ozone precursor inventory.

SCC code	Area source description	Section
	<i>Fuel combustion:</i>	3.2
2102004001	Industrial distillate oil: Boilers	3.2.1
2102004002	Industrial distillate oil: Engines	3.2.1
2102006000	Industrial natural gas	3.2.2
2103004001	Commercial/institutional distillate oil: Boilers	3.2.3
2103004002	Commercial/institutional distillate oil: Engines	3.2.3
2103006000	Commercial/institutional natural gas	3.2.4
2104004000	Residential distillate oil	3.2.5
2104006000	Residential natural gas	3.2.6
2104007000	Residential liquefied petroleum gas (LPG)	3.2.7
2104011000	Residential kerosene	3.2.8
2104008100	Residential Wood Combustion (RWC): Fireplace	3.2.9
2104008210	RWC: Woodstove: fireplace inserts: Non-EPA certified	3.2.9
2104008220	RWC: Woodstove: fireplace inserts: EPA certified; non-catalytic	3.2.9
2104008230	RWC: Woodstove: fireplace inserts: EPA certified; catalytic	3.2.9
2104008310	RWC: Woodstove: freestanding: Non-EPA certified	3.2.9
2104008320	RWC: Woodstove: freestanding: EPA certified, non-catalytic	3.2.9
2104008330	RWC: Woodstove: freestanding: EPA certified, catalytic	3.2.9
2104008400	RWC: Woodstove: Pellet-fired	3.2.9
2104008610	RWC: Hydronic heater: Outdoor	3.2.9
2104008700	RWC: Outdoor wood burning device, NEC	3.2.9
2104009000	RWC: Residential firelog	3.2.9
	<i>Industrial processes:</i>	3.3
2301000000	Chemical manufacturing	3.3.1
2302002100	Commercial cooking: Conveyorized charbroiling	3.3.2.1
2302002200	Commercial cooking: Under-fired charbroiling	3.3.2.1
2302003000	Commercial cooking: Deep fat frying	3.3.2.1
2302003100	Commercial cooking: Flat griddle frying	3.3.2.1
2302003200	Commercial cooking: Clamshell griddle frying	3.3.2.1
2302050000	Bakeries	3.3.2.2
2304000000	Secondary metal production	3.3.3
2308000000	Rubber/plastics product manufacturing	3.3.4
2312000000	Electrical equipment manufacturing	3.3.5
2399000000	Industrial processes not elsewhere classified (NEC)	3.3.6
	<i>Solvent use:</i>	3.4
2401001000	Architectural coatings	3.4.1.1
2401005000	Auto refinishing	3.4.1.2
2401008000	Traffic markings	3.4.1.3
2401015000	Factory-finished wood	3.4.1.4

Table 3.1-1. List of area source categories included in this inventory (continued).

AMS code	Area source description	Section
2401020000	Wood furniture	3.4.1.5
2401075000	Aircraft surface coating	3.4.1.6
2401090000	Miscellaneous surface coating	3.4.1.7
2415000000	Degreasing	3.4.2
2420000000	Dry cleaning	3.4.3
2425000000	Graphic arts	3.4.4
2440000000	Miscellaneous industrial solvent use	3.4.5
2460100000	Consumer & commercial products (C&CP): Personal care products	3.4.6
2460200000	C&CP: Household products	3.4.6
2460400000	C&CP: Automotive aftermarket products	3.4.6
2460500000	C&CP: Coatings and related products	3.4.6
2460600000	C&CP: Adhesives and sealants	3.4.6
2460800000	C&CP: FIFRA related products	3.4.6
2460900000	C&CP: Miscellaneous products, NEC	3.4.6
2461021000	Cutback asphalt	3.4.7
2461022000	Emulsified Asphalt	3.4.7
2461023000	Roofing Asphalt	3.4.7
2461850000	Agricultural pesticides	3.4.8
	<i>Storage and transport:</i>	3.5
2501011011	Residential portable gas cans (RPG): Permeation	3.5.1
2501011012	RPG: Evaporation	3.5.1
2501011013	RPG: Spillage during transport	3.5.1
2501011014	RPG: Refilling at the pump - vapor displacement	3.5.1
2501011015	RPG: Refilling at the pump - spillage	3.5.1
2501012011	Commercial portable gas cans (CPG): Permeation	3.5.1
2501012012	CPG: Evaporation	3.5.1
2501012013	CPG: Spillage during transport	3.5.1
2501012014	CPG: Refilling at the pump - vapor displacement	3.5.1
2501012015	CPG: Refilling at the pump - spillage	3.5.1
2501055120	Bulk plants	3.5.2
2501060051	Gasoline service stations Stage I: Submerged filling	3.5.3
2501060053	Gasoline service stations Stage I: Balanced submerged filling	3.5.3
2501060201	Gasoline service stations: Underground tank, breathing/emptying	3.5.5
2501080050	Airports: Aviation gasoline Stage I: Total	3.5.6
2501080100	Airports: Aviation gasoline Stage II: Total	3.5.6
2505030120	Gasoline tank trucks in transit	3.5.7
2505040120	Pipeline gasoline	3.5.8
2510000000	Volatile organic liquid (VOL) storage and transport	3.5.9
	<i>Waste treatment and disposal:</i>	3.6
2601000000	On-site incineration	3.6.1
2610000500	Open burning: Land clearing debris	3.6.2
2620000000	Landfills	3.6.3
2630020000	Publicly owned treatment works	3.6.4
2660000000	Leaking underground storage tanks	3.6.5
2650000000	Other waste	3.6.6
	<i>Miscellaneous area sources:</i>	3.7
2801500000	Agricultural field burning	3.7.1
2810030000	Structure fires	3.7.2
2810040000	Aircraft engine testing	3.7.3
2810050000	Vehicle fires	3.7.4
2810060100	Crematories	3.7.5
2830001000	Accidental releases	3.7.6
2850000000	Hospitals	3.7.7
n/a	Wildfires	3.7.8
n/a	Prescribed fires	3.7.9

For nearly all categories, emissions were calculated in one of the following ways:

- Emissions estimates for some categories were developed by conducting surveys on local usage (e.g., natural gas consumption) or derived from state-wide data (e.g., fuel oil use).
- For some widespread or diverse categories (e.g., consumer solvent use), emissions were calculated using published per-capita or per-employee emission factors.
- For source categories with some information available from annual emissions reports (e.g., bakeries), these data were combined with employment data to “scale up” reported emissions to reflect the entire source category.
- For those source categories with detailed emissions data available from most or all of the significant sources in the category, emissions were calculated based on detailed process-level and operational data provided by these sources.

The specific emissions estimation methodologies used for each source category (including the derivation and application of rule effectiveness) are described in greater detail in the respective sections.

3.2 Fuel combustion

Area-source emission estimates are provided in this section for the following categories of fuel consumption: Industrial distillate oil, industrial natural gas, commercial/institutional distillate oil, commercial/institutional natural gas, residential distillate oil, residential natural gas, residential liquefied petroleum gas, residential kerosene, and residential wood.

Data for natural gas combustion emission estimates came from a survey of the three natural gas suppliers in Maricopa County. Table 3.2–1 summarizes the natural gas sales data received from Maricopa County natural gas suppliers.

Table 3.2–1. Maricopa County natural gas sales by end-user category and supplier.

Natural gas supplier	Sales by end-user category (in MMCF/yr)					
	Electric Utilities	Industrial	Commercial/Institutional	Residential	Transport*	Other*
Southwest Gas	n/a	592.74	13,303.23	17,083.04	9,288.47	406.92
City of Mesa	n/a	91.17	1,631.61	1,030.07	175.13	n/a
El Paso	112,963.97	150.78	n/a	n/a	n/a	n/a
Total:	112,963.97	834.68	14,934.84	18,113.11	9,463.60	406.92

*For emissions calculations, sales from transport and other were grouped with industrial sales.

3.2.1 Industrial distillate oil

Annual emissions from industrial distillate oil combustion were derived from EPA NEI (US EPA, 2012c) calculations. Emissions come from two different sources, boilers and engines burning distillate oil.

Ozone season-day emissions for the county are calculated by first multiplying annual emissions by 25% to estimate ozone season totals. Ozone season emission totals are then divided by the number of days that activity occurs during the ozone season (6 days/week and 13 weeks), as recommended by EIIP guidance (US EPA, 2001a). Annual and season-day emissions in the eight-hour ozone nonattainment area were calculated by applying the ratio of industrial

employment in the nonattainment area to county-level emission calculations (99.57%). (See Section 1.5.1 for a discussion of the employment data used). Results for boilers and engines are shown in Tables 3.2–2 and 3.2–3, respectively.

Table 3.2–2. Annual and season-day emissions from area-source industrial distillate oil combustion for boilers.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.61	60.87	15.22	3.9	390.2	97.5
8-hr ozone NAA	0.61	60.61	15.15	3.9	388.5	97.1

Table 3.2–3. Annual and season-day emissions from area-source industrial distillate oil combustion for engines.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.00	1,838.26	395.65	0.0	11,783.7	2,536.2
8-hr ozone NAA	0.00	1,830.35	393.95	0.0	11,733.0	2,525.3

3.2.2 Industrial natural gas

All natural gas suppliers in Maricopa County were surveyed to gather information on the volume of natural gas distributed, by user category, within the county in 2011. Area-source industrial natural gas usage for the county is based on the reported total volume of natural gas sold to industrial sources (10,705.20 MMCF), minus natural gas used by industrial point sources (463.95 MMCF).

Natural gas is used for both external combustions (boilers and heaters) and internal combustion (generators), each of which have different emission factors. Thus the area-source natural gas usage derived above must be divided between these two categories. This apportionment was based on the percentages of external and internal natural gas combustion reported by all industrial area sources in 2008. A 2008 apportionment was used because 2011 data were not available for all industrial area sources at the time that these emission estimates were developed.

Annual emissions for the county were calculated by multiplying natural gas usage by the respective emission factors for external (SCC=102006* & 103006*) and internal (SCC=2020020*) combustion obtained from EPA’s WebFIRE database (US EPA, 2012a).

Table 3.2–4. Natural gas usage, emission factors, and annual emissions from area-source industrial natural gas consumption, by combustion type.

Combustion type	% of total	Natural gas usage (MMCF)	Emission factors (lb/MMCF)			Annual emissions (tons/yr)		
			VOC	NO _x	CO	VOC	NO _x	CO
External	98.44	10,081.49	5.5	100	84	27.72	504.07	423.42
Internal	1.56	159.76	116	2,840	399	9.27	226.86	31.87
Total:	100.00	10,241.25				36.99	730.94	455.30

Ozone season-day emissions for the county are calculated by first multiplying annual emissions by the percentage of industrial natural gas sold used during the ozone season (22.96%). (Figures reported by natural gas suppliers for the June–August time period are assumed to be representative for the July–September ozone season.) Ozone season emission totals are then divided by the number of days that activity occurs during the ozone season (6 days/wk × 13 wks/season).

Annual and season-day emissions within the eight-hour ozone nonattainment area were calculated by applying the ratio of industrial employment in the nonattainment area to county-level emission calculations (99.57%). (See Section 1.5.1 for a discussion of the employment data used).

Table 3.2–5. Annual and season-day emissions from area-source industrial natural gas combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	36.99	730.94	455.30	217.8	4,303.8	2,680.8
8-hr ozone NAA	36.83	727.80	453.34	216.9	4,285.3	2,669.3

3.2.3 Commercial/institutional distillate oil

Annual emissions from commercial/institutional distillate oil combustion were derived from EPA NEI (US EPA, 2012c) calculations. Emissions come from two different sources, boilers and engines burning distillate oil.

Ozone season-day emissions for the county are calculated by first multiplying annual emissions by 25% to estimate ozone season totals. Ozone season emission totals are then divided by the number of days that activity occurs during the ozone season (6 days/week and 13 weeks), as recommended by EIP guidance (US EPA, 2001a). Annual and season-day emissions in the eight-hour ozone nonattainment area were calculated by applying the ratio of industrial employment in the nonattainment area to county-level emission calculations (99.57%). (See Section 1.5.1 for a discussion of the employment data used.) Emissions estimates for boilers and engines are shown in Tables 3.3–6 and 3.3–7, respectively.

Table 3.2–6. Annual and season-day emissions from area-source commercial/institutional distillate oil combustion for boilers.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.00	0.12	0.03	0.0	0.8	0.2
8-hr ozone NAA	0.00	0.12	0.03	0.0	0.8	0.2

Table 3.2–7. Annual and season-day emissions from area-source commercial/institutional distillate oil combustion for engines.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.00	3.72	0.80	0.0	23.8	5.1
8-hr ozone NAA	0.00	3.70	0.80	0.0	23.7	5.1

3.2.4 Commercial/institutional natural gas

All natural gas suppliers in Maricopa County were surveyed to gather information on the volume of natural gas distributed, by user category, within the county in 2011. Area-source commercial and institutional (C&I) natural gas usage for the county is based on the reported total volume of natural gas sold to C&I sources (14,934.84 MMCF), minus natural gas used by C&I point sources (77.80 MMCF).

Natural gas is used for both external combustion (boilers, heaters) and internal combustion (generators), each of which have different emission factors. Thus the area-source natural gas usage derived above must be apportioned between these two categories. This apportionment was

based on the percentages of external and internal natural gas combustion reported by all C&I area sources in 2008. A 2008 apportionment was used because 2011 data were not available for all C&I area sources at the time that these emission estimates were developed.

Annual emissions for the county were calculated by multiplying natural gas usage by the respective emission factors for external (SCC=1020060*) and internal (SCC=2020020*) combustion obtained from EPA's WebFIRE database (US EPA, 2012a).

Table 3.2–8. Emission factors and annual emissions from area-source commercial/institutional natural gas combustion, by combustion type.

Combustion type	% of total	Natural gas usage (MMCF)	Emission factors (lb/MMCF)			Annual emissions (tons/yr)		
			VOC	NO _x	CO	VOC	NO _x	CO
External	98.34	14,610.42	5.5	100	84	40.18	730.52	613.64
Internal	1.66	246.63	116	2,840	399	14.30	350.21	49.20
Total:	100.00	14,857.04				54.48	1,080.73	662.84

Ozone season-day emissions for the county were calculated by first multiplying annual emissions by the percentage of C&I natural gas used during the ozone season (18.04%). (Figures reported by natural gas suppliers for the June–August time period are assumed to be representative of the July–September ozone season.) Ozone season emission totals are then divided by the number of days that activity occurs during the ozone season (6 days/wk × 13 wks/yr).

Annual and season-day emissions within the eight-hour ozone nonattainment area were calculated by applying the combined ratio of retail, office, public and other employment in the nonattainment area to county-level emission calculations (99.88%). (See Section 1.5.1 for a discussion of the employment data used).

Table 3.2–9. Annual and season-day emissions from area-source commercial/institutional natural gas combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	54.48	1,080.73	662.84	252.0	4,998.0	3,065.4
8-hr ozone NAA	54.42	1,079.44	662.05	251.7	4,992.0	3,061.7

3.2.5 Residential distillate oil

Annual emissions from residential distillate oil were derived from EPA NEI (US EPA, 2012c) calculations. Ozone season-day emissions would normally be calculated by dividing ozone season emissions by heating degree days (i.e. the number of degrees per day that the daily average temperature is below 65°F). However, data obtained from Arizona Energy Statistics (GOEP, 2013) indicated that there were no heating degree days reported during the 2011 ozone season (July–September). Thus, ozone season-day emissions from residential distillate oil combustion are assumed to be zero.

Annual and season-day emissions within the eight-hour ozone nonattainment area were calculated by multiplying county totals by the ratio of total population in the nonattainment area to the total population in the county (101.14%). See Section 1.5.1 for a further discussion of the population used. Table 3.2–10 summarizes annual and ozone season-day emissions from residential distillate oil combustion for both the county and the eight-hour ozone nonattainment area.

Table 3.2–10. Annual and season-day emissions from residential distillate oil combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.01	0.35	0.10	0.0	0.0	0.0
8-hr ozone NAA	0.01	0.35	0.10	0.0	0.0	0.0

3.2.6 Residential natural gas

All natural gas suppliers in Maricopa County were surveyed to gather information on the volume of natural gas sold, by user category, within the county. Annual emissions from residential natural gas combustion emissions were calculated by multiplying 2011 residential natural gas sales (18,113.11 MMCF) by emission factors for residential natural gas combustion summarized in the table below (US EPA, 1998).

Table 3.2–11. Residential natural gas combustion emission factors.

Pollutant	Emission Factor (lb/MMCF)
VOC	5.5
NO _x	94.0
CO	40.0

Ozone season-day emissions were calculated by first multiplying reported natural gas usage during the ozone season (1,978.95 MMCF) by the AP-42 emission factors for residential natural gas combustion to produce ozone season emissions. (Natural gas usage reported for the months of June–August is assumed to represent ozone season usage). Ozone season emissions were then divided by days during the ozone season that residential natural gas combustion occurs (7 days/wk × 13 wks/yr) (US EPA, 2001a).

Annual and season-day residential natural gas emissions in the eight-hour ozone nonattainment area were calculated by multiplying county-level emissions by the percentage of total resident population in the eight-hour ozone nonattainment area (100.78%).

Table 3.2–12. Annual and season-day emissions from residential natural gas combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	49.81	851.32	362.26	119.6	2,044.2	869.9
8-hr ozone NAA	50.20	857.96	365.09	120.5	2,060.1	876.7

3.2.7 Residential liquefied petroleum gas (LPG)

Annual emissions from residential liquefied petroleum gas (LPG) were derived from EPA NEI (US EPA, 2012c) calculations.

Ozone season-day emissions would normally be calculated by dividing ozone season emissions by heating degree days (i.e. the number of degrees per day that the daily average temperature is below 65°F). However, data obtained from Arizona Energy Statistics (GOEP, 2013) indicated that there were no heating degree days reported during the 2011 ozone season (July–September). Thus, ozone season-day emissions from residential liquefied petroleum gas (LPG) combustion are assumed to be zero.

Annual and season-day emissions within the eight-hour ozone nonattainment area were calculated by multiplying county totals by the ratio of total population in the nonattainment area to the total population in the county (101.14%). See Section 1.5.1 for a further discussion of the population used.

Table 3.2–13 summarizes annual and ozone season-day emissions from residential liquefied petroleum gas (LPG) combustion for both the county and the eight-hour ozone nonattainment area.

Table 3.2–13. Annual and season-day emissions from residential liquefied petroleum gas (LPG) combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	2.00	51.35	14.56	0.0	0.0	0.0
8-hr ozone NAA	2.02	51.93	14.73	0.0	0.0	0.0

3.2.8 Residential kerosene

Annual emissions from residential kerosene were derived from EPA NEI (US EPA, 2012c) calculations.

Ozone season-day emissions would normally be calculated by dividing annual emissions by heating degree days (i.e. the number of degrees per day that the daily average temperature is below 65°F). However, data obtained from Arizona Energy Statistics (GOEP, 2013) indicated that there was no heating degree days reported during the 2011 ozone season (July–September). Thus, ozone season-day emissions from residential kerosene combustion are assumed to be zero.

Annual and season-day emissions within the eight-hour ozone nonattainment area were calculated by multiplying county totals by the ratio of total population in the nonattainment area to the total population in the county (101.14%). See Section 1.5.1 for a further discussion of the population used.

Table 3.2–14 summarizes annual and season-day emissions from residential kerosene combustion for both the county and the eight-hour ozone nonattainment area.

Table 3.2–14. Annual and season-day emissions from residential kerosene combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.00	0.03	0.01	0.0	0.0	0.0
8-hr ozone NAA	0.00	0.03	0.01	0.0	0.0	0.0

3.2.9 Residential wood combustion

Annual emissions from residential wood combustion for Maricopa County were obtained from the US Environmental Protection Agency’s Residential Wood Combustion Estimation Tool (US EPA, 2012b). County-level annual emissions by appliance type are shown below in Table 3.2–15.

Table 3.2–15. Annual emissions by appliance type for Maricopa County from EPA’s residential wood combustion estimation tool.

SCC	Appliance Type	Annual emissions (tons/yr)		
		VOC	NO _x	CO
2104008100	Fireplace	191.08	26.29	1,506.38
2104008210	Woodstove: fireplace inserts; non-EPA certified	147.35	7.78	641.66
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic	10.70	2.03	125.54
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic	4.46	0.59	31.02
2104008310	Woodstove: freestanding, non-EPA certified	71.45	3.77	311.15
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	5.18	0.99	60.83
2104008330	Woodstove: freestanding, EPA certified, catalytic	2.16	0.29	15.04
2104008400	Woodstove: pellet-fired, general	0.01	1.19	4.97
2104008610	Hydronic heater: outdoor	0.00	0.00	0.00
2104008700	Outdoor wood burning device, NEC	3.99	0.55	31.49
2104009000	Residential firelog	73.32	14.24	231.82
Total		509.70	57.72	2,959.91

Ozone season-day emissions would normally be calculated by dividing ozone season emissions by heating degree days (i.e. the number of degrees per day that the daily average temperature is below 65°F). However, data obtained from Arizona Energy Statistics (GOEP, 2013) indicated that there was no heating degree days reported during the 2011 ozone season (July–September). Thus, ozone season-day emissions from residential wood combustion are assumed to be zero.

Annual and season-day emissions within the eight-hour ozone nonattainment area were calculated by multiplying county totals by the ratio of total population in the nonattainment area to the total population in the county (101.14%). See Section 1.5.1 for a further discussion of the population used.

Table 3.2–16 summarizes annual and season-day emissions from residential wood combustion for both the county and the eight-hour ozone nonattainment area.

Table 3.2–16. Annual and season-day emissions from residential wood combustion.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	509.70	57.72	2,959.91	0.0	0.0	0.0
8-hr ozone NAA	515.53	58.38	2,993.75	0.0	0.0	0.0

3.3 Industrial processes

3.3.1 Chemical manufacturing

Emissions from area-source chemical manufacturing were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources, and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The most recent data from the US Census Bureau’s County Business Patterns (CBP), representing 2010 employment, were used. Table 3.3–1 shows the NAICS codes and employment data used to calculate emissions from chemical manufacturing.

Table 3.3–1. County-level employment estimates for chemical manufacturing, by NAICS code.

NAICS code	NAICS description (and employment range)	Estimated employment
325	Chemical manufacturing	4,605
42469	Other chemical & allied products merchant wholesalers	1,484
424910	Farm supplies merchant wholesalers	904
33312	Construction machinery manufacturing (250–499)	375
Total:		7,368

Since there were no point sources in this category, an area-source employment estimate is used to “scale up” emissions reported from those facilities surveyed in 2011.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the percentage industrial employment within the nonattainment area. See Section 1.5.1 for a discussion of the employment data used.

Table 3.3–2 summarizes annual and season-day emissions from chemical manufacturing in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.3–2. Annual and season-day emissions from area-source chemical manufacturing.

Geographic area	Annual emissions (tons/yr)	Season-day emissions (lbs/day)
Maricopa County	77.42	599.0
8-hr ozone NAA	77.09	596.5

3.3.2 Food and kindred products

3.3.2.1 Commercial cooking

Emissions from commercial cooking were estimated for five types of commercial cooking equipment using per capita emissions factors developed by EPA for the 2008 National Emissions Inventory (NEI) (Pechan, 2012a). The per capita emission factors for each equipment type are contained in Table 3.3–3. EPA created the emission factors listed in Table 3.3–3 by taking 2002 emissions in the NEI and dividing by the 2002 population to develop per capita emission factors. The equipment types include: chain-driven charbroilers, under-fired charbroilers, deep-fat fryers, flat griddles, and clamshell griddles.

Table 3.3–3. Emission factors for commercial cooking equipment, by device type.

Equipment type	Emission Factor (lb/person)	
	VOC	CO
Chain-driven charbroilers	0.012056010	0.042446624
Under-fired charbroilers	0.041480307	0.135002176
Deep-fat fryers	0.012608151	0.000000000
Flat griddle fryers	0.005943281	0.012687330
Clamshell griddles	0.000231564	0.000000000

Annual commercial cooking emissions for Maricopa County were estimated by multiplying the MAG-estimated county population (4,129,646) by the per capita emission factors for each type of cooking equipment. See Section 1.5.1 for a discussion of the population data used.

Commercial cooking is assumed to occur uniformly throughout the year, therefore, it was assumed that 25% of annual activity occurs during the ozone season, and that activity occurs 7 days/week. Thus, season-day emissions were estimated by multiplying annual emissions by 25% then dividing the result by 91 (7 days/wk × 13 wks/ozone season). The results are shown in Table 3.3–4 below.

Table 3.3–4. Annual and daily emissions from commercial cooking equipment in Maricopa County.

Equipment type	Annual Emissions (tons/yr)		Season-day emissions (lbs/day)	
	VOC	CO	VOC	CO
Chain-driven charbroilers	24.89	87.64	136.8	481.6
Under-fired charbroilers	85.65	278.76	470.6	1,531.6
Deep-fat fryers	26.03	—	143.0	0.0
Flat griddles	12.27	26.20	67.4	143.9
Clamshell griddles	0.48	—	2.6	0.0
Total:	149.33	392.60	820.5	2,157.1

Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the county totals by the ratio of total population in the nonattainment area to the total population in the county (101.14%). See Section 1.5.1 for a discussion of the population data used. Table 3.3–5 summarizes the annual and season-day emissions from commercial cooking for the eight-hour ozone nonattainment area.

Table 3.3–5. Annual and daily emissions from commercial cooking equipment in the eight-hour ozone NAA.

Equipment type	Annual emissions (tons/yr)		Season-day emissions (lbs/day)	
	VOC	CO	VOC	CO
Chain-driven charbroilers	25.18	88.64	138.3	487.1
Under-fired charbroilers	86.63	281.93	476.0	1,549.1
Deep-fat fryers	26.33	0.00	144.7	0.0
Flat griddles	12.41	26.50	68.2	145.6
Clamshell griddles	0.48	0.00	2.7	0.0
Total:	151.03	397.07	829.8	2,181.7

3.3.2.2 Bakeries

Emissions from area-source bakeries were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources and County-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The most recent data from the US Census Bureau’s County Business Patterns (CBP) for 2010 employment were used. (Where employment estimates were provided as a range of values, the midpoint was used.) CBP estimates for Maricopa County employment in NAICS codes 311812 and 31183 (Commercial bakeries and Tortilla manufacturing) to total 2,491 persons. There were no point sources in this category, thus all emissions from this source category are reported as area sources. Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals.

Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county. Results are summarized in Table 3.3–6. See section 1.5.1 for a discussion of the employment data used.

Table 3.3–6. Annual and season-day emissions from area-source bakeries.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	78.18	547.8
8-hr ozone NAA	77.85	545.4

3.3.3 Secondary metal production

Annual emissions from secondary metal production facilities were derived from annual emissions reports from permitted sources. As this category consists primarily of foundries, it was assumed that there were no significant unpermitted sources within Maricopa County. Since all facilities considered in this section are located within the eight-hour ozone nonattainment area, total emission values for the county and the nonattainment area from secondary metal production are equal. Annual and season-day emissions are shown in Table 3.3–7.

Table 3.3–7. Annual and season-day emissions from area-source secondary metal production.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO_x	CO	VOC	NO_x	CO
Maricopa County	41.01	15.02	98.36	306.4	107.9	697.4
8-hr ozone NAA	41.01	15.02	98.36	306.4	107.9	697.4

3.3.4 Rubber/plastics product manufacturing

Emissions from area-source rubber and plastic manufacturing facilities were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources, and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category. The most recent data from the US Census Bureau’s County Business Patterns (CBP) for 2010 employment were used. Where CBP employment estimates were presented as a range, the midpoint values were chosen for these calculations. Table 3.3–8 shows the NAICS codes and employment data used to calculate emissions from rubber and plastic manufacturing facilities.

Table 3.3–8. County-level employment estimates for rubber and plastic product manufacturing, by NAICS code.

NAICS code	NAICS description (and employment range)	Estimated employment
325211	Plastic material and resin manufacturing (0–19)	10
325991	Custom compounding of purchased resins (100–249)	175
326140	Polystyrene foam product manufacturing	164
326199	All other plastics product manufacturing	3,027
326212	Tire retreading	135
326299	All other rubber product manufacturing	92
332313	Plate work manufacturing	151
336413	Other aircraft parts and aux. equipment manufacturing	2,086
337920	Blind and shade manufacturing (250–499)	375
339115	Ophthalmic goods manufacturing	97
423830	Industrial machinery & equip. merchant wholesalers	2,634
423930	Recyclable material merchant wholesalers	1,268
441310	Automotive parts and accessories stores	3,392
441320	Tire dealers	2,095
Total:		15,701

Some facilities in this category are considered point sources, and have been addressed in Chapter 2. To avoid double-counting, employment at point sources is subtracted from total employment.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county. See Section 1.5.1 for a discussion of the employment data used.

Table 3.3–9 summarizes annual and season-day emissions from area source rubber and plastic products manufacturing in Maricopa County and the eight-hour ozone nonattainment area.

Table 3.3–9. Annual and season-day emissions from area-source rubber/plastic product manufacturing.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	1,766.75	14,171.0
8-hr ozone NAA	1,759.15	14,110.1

3.3.5 *Electrical equipment manufacturing*

Annual and season-day emissions from electric equipment manufacturing were derived from annual emissions reports submitted by permitted sources. It was assumed that there were no significant unpermitted sources within Maricopa County and all electrical equipment manufacturing permitted sources are reported here as area-sources.

As all facilities addressed in this source category are located within the eight-hour ozone nonattainment area, emission totals for both areas are equal. Annual and season-day emissions are shown in Table 3.3–10.

Table 3.3–10. Annual and season-day emissions from area-source electric equipment manufacturing.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	122.80	23.47	2.98	746.2	135.8	16.4
8-hr ozone NAA	122.80	23.47	2.98	746.2	135.8	16.4

3.3.6 Industrial processes not elsewhere classified (NEC)

Annual area-source emissions from other industrial processes not elsewhere classified (NEC) were derived primarily from annual emissions reports from permitted facilities. Other industrial processes include a wide array of industrial activities that are often specific to the permitted facility that reported the process. For this reason, it is assumed there are no significant emissions from other industrial processes, other than those reported by permitted facilities on their annual emissions reports. Ozone season-day emissions were calculated based on operating schedule information provided by individual facilities through MCAQD’s annual emissions reporting program. Emissions estimates for the eight-hour ozone nonattainment area were derived using data on the location of the facilities that report other industrial processes.

In addition, emissions from ADEQ-permitted sources are included in this category due to a lack of specificity regarding the nature of the reported emissions. As a conservative estimate, all of these emissions were assumed to occur within the eight-hour ozone nonattainment area. Estimates of total emissions from this source category are presented in Table 3.3–11.

Table 3.3–11. Annual and season-day emissions from industrial processes not elsewhere classified.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	48.51	224.92	91.84	325.6	1,245.8	525.2
8-hr ozone NAA	47.55	224.92	91.84	318.0	1,245.8	525.2

3.4 Solvent use

3.4.1 Surface coating

3.4.1.1 Architectural coatings

VOC emissions from architectural coatings were calculated using a per-capita emission factor developed and used by EPA for the 2008 NEI (Pechan, 2012). Because Maricopa County Rule 335 contains an emission limit for coatings, the “controlled” VOC emission factor (2.41 lbs/person) was used.

Annual VOC emissions for architectural coating for both Maricopa County and the eight-hour ozone nonattainment area were calculated by multiplying the per-capita emission factor by the county and nonattainment area populations (4,129,646 and 4,176,870, respectively). See Section 1.5.1 for a discussion of the population data used.

Ozone season-day emissions were developed using default assumptions from EIIP (US EPA, 1995a). The seasonal factor for ozone season architectural coating activity was assumed to be 28 percent of annual activity. In addition, it was assumed that coating use may take place 7 days a week during the ozone season (13 wks/season). Thus, season-day emissions were calculated by multiplying annual VOC emissions by the seasonal factor and then dividing the results by 91 days per season. Table 3.4–1 presents the assumptions used as well as annual and season-day

VOC emissions from architectural coatings for Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–1. Annual and season-day emissions from architectural coating.

Geographic area	Population	Annual VOC emissions (tons/yr)	% annual activity in ozone season	Activity level (days/wk)	Season-day VOC emissions (lbs/day)
Maricopa County	4,129,646	4,976.22	28 %	7	30,622.9
8-hr ozone NAA	4,176,870	5,033.13	28 %	7	30,973.1

3.4.1.2 Auto refinishing

VOC emissions from auto refinishing were calculated using the per employee emission factor (89.0 lbs of VOC/employee) developed and reviewed by the Eastern Regional Technical Advisory Committee (ERTAC) advisory panel for the 2008 NEI (Pechan, 2012).

The most recent employment estimates (for the year 2010) from the US Census Bureau’s County Business Patterns (CBP) were used (US Census Bureau, 2012). Employment data is listed by the North American Industry Classification System (NAICS) code(s). Table 3.4–2 shows the NAICS codes and employment estimates used to calculate emissions from auto refinishing.

Table 3.4–2. County-level employment estimates for auto refinishing, by NAICS code.

NAICS code	NAICS description	Estimated employment
81112	Auto body, paint, interior, & glass repair	4,236
4411	Auto dealers	22,632
4412	Other motor vehicle dealers	3,093
Total:		29,961

The seasonal activity factor for ozone season auto refinishing was assumed to be 25 percent of annual activity. In addition, it was assumed that auto refinishing occurs evenly throughout the year, 5 days/wk (US EPA, 2001a). Thus, ozone season-day emissions were calculated by multiplying annual VOC emissions by the seasonal factor and then dividing the results by 65 days per season (5 days/wk × 13 wks/season).

Annual and season-day emissions for the eight-hour ozone nonattainment area were derived by multiplying Maricopa County annual and season-day emissions by the ratio of industrial employment in the nonattainment area to industrial employment in the county (99.57%). See Section 1.5.1 for a discussion of the employment data used.

Table 3.4–3. Annual and season-day emissions from auto refinishing.

Geographic area	Annual VOC emissions (tons/yr)	% annual activity in ozone season	Activity level (days/wk)	Season-day VOC emissions (lbs/day)
Maricopa County	1,333.26	25 %	5	10,255.9
8-hr ozone NAA	1,327.53	25 %	5	10,211.8

3.4.1.3 Traffic markings

VOC emissions from traffic markings were calculated using the emissions factor developed by EPA for the 2008 NEI (22.1 lbs of VOC/road mile) (Pechan, 2012). Annual VOC emissions for

the county were calculated by multiplying the VOC emission factor by 2010 Maricopa County public road and street mileage obtained from the Arizona Department of Transportation Highway Performance Monitoring System (HPMS). ADOT reported 16,253 miles of public roads and streets in Maricopa County in 2010, which was assumed to be representative of 2011 (M. Catchpole, pers. commun., August 9, 2012).

Annual VOC emissions for the eight-hour ozone nonattainment area were estimated by multiplying the 2010 Maricopa County public road and street mileage by the percentage of miles within the nonattainment area (95.28%) and then multiplying by the VOC emission factor.

MAG estimated the percentage of miles within the eight-hour ozone nonattainment area as compared to Maricopa County based on 2012 GIS highways and streets data (M. Poppen, pers. commun., October 1, 2012). The 2012 mileage data was assumed to be representative of 2011.

Ozone season-day emissions during the ozone season for Maricopa County and the eight-hour ozone nonattainment area were calculated assuming 33 percent of annual activity occurred during the ozone season (13 wks per year) and a typical activity level of 5 days per week (US EPA, 1997).

Table 3.4-4. Annual and season-day emissions from traffic markings.

Geographic area	Annual VOC emissions (tons/yr)	% annual activity in ozone season	Activity level (days/wk)	Season-day VOC emissions (lbs/day)
Maricopa County	179.60	33 %	5	1,823.6
8-hr ozone NAA	171.12	33 %	5	1,737.5

3.4.1.4 Factory-finished wood

Emissions from factory-finished wood coating were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources, and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The most recent data from the US Census Bureau’s County Business Patterns (CBP) for 2011 employment were used. Where CBP employment estimates were presented as a range, the midpoint value was chosen for these calculations. Table 3.4-5 shows the NAICS codes and employment data used to calculate emissions from factory-finished wood surface coating.

Table 3.4-5. County-level employment estimates for factory-finished wood coating, by NAICS code.

NAICS code	NAICS description (and employment range)	Estimated employment
321911	Wood window & door manufacturing	299
321918	Other millwork	163
337212	Custom architectural woodwork & millwork manufacturing	368
337215	Showcase, partition, shelving & locker manufacturing	163
337920	Blind & shade manufacturing (250-499)	375
Total:		1,368

Since there were no point sources in this category, an area-source employment estimate was used to “scale up” emissions reported from those facilities surveyed in 2011.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county (99.57%). See Section 1.5.1 for a discussion of the employment data used. Table 3.4–6 summarizes annual and season-day VOC emissions from factory-finished wood surface coating in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–6. Annual and season-day emissions from area-source factory-finished wood surface coating.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	137.72	1,396.7
8-hr ozone NAA	137.12	1390.7

3.4.1.5 Wood furniture

Emissions from wood furniture surface coating were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources, and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The most recent data from the US Census Bureau’s County Business Patterns (CBP) for 2010 employment were used. Where CBP employment estimates were presented as a range, the midpoint values was chosen for these calculations. Table 3.4–7 shows the NAICS codes and employment data used to calculate emissions from wood furniture surface coating.

Table 3.4–7. County-level employment estimates for wood furniture surface coating, by NAICS code.

NAICS code	NAICS code description	Estimated employment
337110	Wood kitchen cabinet & countertop manufacturing	693
337121	Upholstered household furniture manufacturing	72
337122	Non-upholstered wood household furniture manufacturing	1,303
337129	Wood television, radio & sewing machine cabinet mfg. (0–19)	10
337211	Wood office furniture manufacturing (0–19)	10
811420	Re-upholstery & furniture repair	132
Total:		2,220

Some facilities in this category are considered point sources and have been addressed in Chapter 2. To avoid double-counting, employment at point sources was subtracted from total employment.

Annual emissions were calculated by “scaling up” area-source emissions reported from those facilities surveyed in 2011.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial

employment in the county (99.57%). See Section 1.5.1 for a discussion of the employment data used.

Table 3.4–8 summarizes annual and season-day VOC emissions from wood furniture surface coating in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–8. Annual and season-day emissions from area-source wood furniture surface coating.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	416.56	3,434.7
8-hr ozone NAA	414.77	3,419.9

3.4.1.6 Aircraft surface coating

Annual emissions from aircraft surface coating facilities were derived from annual emissions reports from permitted sources. It is assumed that all aircraft surface coating facilities were surveyed in 2011 based on a comparison of county-level employment data (US Census Bureau, 2012) and annual emissions report employment data. Ozone season-day emissions were calculated based on operating schedule information provided in the facilities’ annual emissions reports. Since all facilities considered in this section are located within the eight-hour ozone nonattainment area, total emission values for the county and the nonattainment area are equal.

Table 3.4–9. Annual and season-day VOC emissions from area-source aircraft surface coating.

Geographic area	Annual emissions (tons/yr)	Season-day emissions (lbs/day)
Maricopa County	65.84	473.1
8-hr ozone NAA	65.84	473.1

3.4.1.7 Miscellaneous surface coating

Area-source VOC emissions from miscellaneous surface coating were estimated by a “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions and employment data from Maricopa County permitted facilities to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category

The typical “scale-up” methodology was revised slightly for this source category for a number of reasons. First, miscellaneous surface coating activity occurs, at some level, across an exceptionally broad spectrum of industries, both industrial and commercial/institutional. Additionally, annual emissions reports may be inconsistent in how activities are reported, and it is uncertain if all relevant activities are categorized as “miscellaneous surface coating” vs. some other category (e.g., manufacturing). Estimating total emissions from miscellaneous surface coating based on county employment by NAICS code (for which employment data are often presented only as a broad range), or all industrial employment (including industries which have little or no miscellaneous surface coating activities) would therefore be misleading and lead to an over-estimate of area-source emissions from this source category. Instead, the list of SIC codes used by facilities that reported miscellaneous surface coating activities was conservatively assumed to represent the “universe” of businesses that could possibly have significant miscellaneous surface coating activity. To avoid double-counting, employment at point sources was subtracted from total employment within these SIC categories.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county (99.57%). See Section 1.5.1 for a discussion of the employment data used.

Table 3.4–10 summarizes annual and season-day VOC emissions from area-source miscellaneous surface coating in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–10. Annual and season-day emissions from miscellaneous surface coating.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	316.38	2,450.5
8-hr ozone NAA	315.02	2,440.0

3.4.2 Degreasing

Area-source VOC emissions from degreasing were estimated by a “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions and employment data from Maricopa County permitted facilities to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The typical “scale-up” methodology was revised slightly for this source category for a number of reasons. First, degreasing activity occurs at some level across a wide spectrum of industries, both industrial and commercial/ institutional. Additionally, annual emissions reports may be inconsistent in how activities are reported and it is uncertain if all relevant activities are categorized as “degreasing” vs. some other category (e.g., manufacturing). Estimating total emissions from degreasing based on county employment by NAICS code (for which employment data are often presented only as a broad range), or all industrial employment (including industries which have little or no degreasing activities) would therefore be misleading and lead to an over-estimate of area-source emissions from this source category.

Instead, the list of SIC codes used by businesses that reported degreasing activities was conservatively assumed to represent the “universe” of businesses that could possibly have significant degreasing activity. To avoid double-counting, employment at point sources was subtracted from total employment within these SIC.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the percentage of industrial employment within the nonattainment area. (See Section 1.5.1 for a discussion of the employment data used.)

Table 3.4–11 summarizes annual and season-day emissions from area-source degreasing in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–11. Annual and season-day VOC emissions from area-source degreasing.

Geographic area	Annual emissions (tons/yr)	Season-day emissions (lbs/day)
Maricopa County	217.55	1,451.1
8-hr ozone NAA	216.62	1,445.1

3.4.3 Dry cleaning

Dry cleaning facilities are identified as one of two types: those that use perchloroethylene and those that use a petroleum solvent (140 or Stoddard solvent) or other VOC-based solvent. Perchloroethylene is a synthetic solvent that is not considered photochemically reactive and therefore is not included in this inventory. Data from the 2008 periodic emissions inventory were grown to 2011 based on total population.

Based on operating schedule information provided in the facilities' historic annual emissions reports, it is assumed that operations occur evenly throughout the year, 5 days per week, thus season-day emissions were derived by dividing the annual total emissions by 260 (= 5 days/ wk × 52 weeks/yr).

Annual and season-day emissions estimates for the eight-hour ozone nonattainment area were calculated by multiplying county-level emissions by the ratio of Maricopa County population to nonattainment area population. See Section 1.5.1 for a discussion of the population data used.

Table 3.4–12 summarizes the annual and season-day VOC emissions from dry cleaning.

Table 3.4–12. Annual and season-day emissions from dry cleaning.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	23.15	178.1
8-hr ozone NAA	23.42	180.1

3.4.4 Graphic arts

Emissions from graphic arts were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources, and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The most recent data from the US Census Bureau's County Business Patterns (CBP) for 2010 employment were used. Table 3.4–13 shows the NAICS codes and employment data used to calculate emissions from graphic arts.

Table 3.4–13. County-level employment estimates for graphic arts, by NAICS code.

NAICS code	NAICS description	Estimated employment
323	Printing & related support activities	3,892
5111	Newspaper, periodical, book & database publishers	3,800
Total:		7,692

There were no point sources in this category. An area-source employment estimate was used to “scale up” emissions reported from those facilities surveyed in 2011.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county (99.57%). See Section 1.5.1 for a discussion of the employment data used.

Table 3.4–14 summarizes annual and season-day emissions from graphic arts in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–14. Annual and season-day VOC emissions from area-source graphic arts sources.

Geographic area	Annual emissions (tons/yr)	Season-day emissions (lbs/day)
Maricopa County	290.98	2,225.7
8-hr ozone NAA	289.73	2,216.1

3.4.5 Miscellaneous industrial solvent use

Area-source VOC emissions from miscellaneous industrial solvent use were estimated by a “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions and employment data from Maricopa County permitted facilities to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The typical “scale-up” methodology was revised slightly for this source category for a number of reasons. First, miscellaneous industrial solvent use occurs at some level across a wide spectrum of industries. Additionally, annual emissions reports may be inconsistent in how activities are reported, and it is uncertain if all relevant activities are categorized as “miscellaneous industrial solvent use” vs. some other category (e.g., manufacturing). Estimating total emissions from miscellaneous industrial solvent use based on county employment by NAICS code (for which employment data are often presented only as a broad range), or all industrial employment (including industries which have little or no solvent use activities) would therefore be misleading and lead to an overestimate of area-source emissions from this source category.

Instead, the list of SIC codes used by businesses that reported miscellaneous industrial solvent use activities was conservatively assumed to represent the “universe” of businesses that could possibly have significant miscellaneous industrial solvent use activity. To avoid double-counting, employment at point sources (addressed in Chapter 2) was subtracted from total employment within these SICs.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county. See Section 1.5.1 for a discussion of the employment data used.

Table 3.4–15 summarizes annual and season-day VOC emissions from area-source miscellaneous industrial solvent use in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–15. Annual and season-day emissions from area-source miscellaneous industrial solvent use.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	721.85	5,126.6
8-hr ozone NAA	718.75	5,104.6

3.4.6 Consumer and commercial products

Consumer and commercial products emissions include emissions from the following seven product categories: personal care products, household products, automotive aftermarket products, adhesives and sealants, FIFRA-regulated products, coatings and related products, and miscellaneous products.

Annual area-source VOC emissions from consumer and commercial products were calculated by multiplying per-capita emission factors recommended by the Eastern Regional Technical Advisory Committee (Pechan, 2012c) by the population estimates for Maricopa County and the eight-hour ozone nonattainment area (see Section 1.5.1 for a discussion of population data). Ozone season-day emissions for the county and the eight-hour ozone nonattainment area were calculated by dividing annual emissions by 365 days as activity is assumed to occur uniformly throughout the year according to EIIP guidance (US EPA, 2001a).

Table 3.4–16. Annual and season-day emissions from consumer and commercial products.

Product category	Emission factor (lbs/person)	Maricopa County		8-hr ozone NAA	
		Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Personal care	1.9	3,923.16	21,496.8	3,968.03	21,742.6
Household	1.8	3,716.68	20,365.4	3,759.18	20,598.3
Automotive aftermarket	1.36	2,808.16	15,387.2	2,840.27	15,563.1
Coatings and related	0.95	1,961.58	10,748.4	1,984.01	10,871.3
Adhesives/sealants	0.57	1,176.95	6,449.0	1,190.41	6,522.8
FIFRA-regulated	1.78	3,675.38	20,139.1	3,717.41	20,369.4
Miscellaneous	0.07	144.54	792.0	146.19	801.0
Total:	8.43	17,406.46	95,377.9	17,605.51	96,468.5

3.4.7 Asphalt application

Asphalt is applied to pave, seal, and repair surfaces such as roads, parking lots, drives, walkways, roofs, and airport runways. In the past, MCAQD estimated emissions from asphalt application by allocating state-level asphalt usage data obtained from the Asphalt Institute to Maricopa County by the use of two surrogates: vehicle miles traveled (VMT) and population. However, the Asphalt Institute no longer compiles asphalt usage data by state. Therefore, 2011 emissions from asphalt application were calculated by growing 2008 asphalt emissions to 2011 based on VMT and population.

Asphalt emissions were grown for three categories of asphalt application: roofing, cutback and emulsified. A population-based growth factor was used to grow 2008 roofing asphalt emissions

to 2011, while a VMT-based growth factor was used to grow 2008 cutback and emulsified asphalt emissions to 2011.

Table 3.4–17 shows 2008 and 2011 VMT and population for Maricopa County and the eight-hour ozone nonattainment area.

Table 3.4–17. 2008 and 2011 population and VMT, by geographic area.

Total population	Maricopa County	8-hr ozone NAA
2008	4,279,760	4,322,710
2011	4,129,646	4,176,870
Change, 2008–2011	-3.51%	-3.37%
Vehicle miles traveled (mi/day)		
2008	91,257,000	88,713,000
2011	88,885,000	83,874,000
Change, 2008–2011	-2.60%	-5.45%

Table 3.4–18 details county VOC emissions from asphalt application by asphalt type and the growth factors used to estimate 2011 emissions.

Table 3.4–18. Emissions from asphalt use, by type, in Maricopa County.

Asphalt type	2008		2008:2011 growth factor	2011	
	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)		Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Cutback	858.15	4,689.3	-2.60%	835.84	4,567.4
Emulsified	889.17	4,858.9	-2.60%	866.06	4,732.6
Roofing	3.15	24.3	-3.51%	3.04	23.4
Total:	1,750.47	9,572.5		1,704.94	9,323.5

Annual and season-day emissions for the eight-hour ozone nonattainment area were also grown from 2008 by multiplying the 2008 nonattainment area emission by a 2008:2011 growth factor for VMT within the nonattainment area (for cutback and emulsified asphalt) and population within the nonattainment area (for roofing asphalt). Table 3.4–19 details nonattainment area asphalt emissions by type and the factors used to grow 2008 nonattainment area emissions to 2011.

Table 3.4–19. Emissions from asphalt use, by type, in the eight-hour ozone NAA.

Asphalt type	2008		2008:2011 growth factor	2011	
	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)		Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Cutback	834.22	4,558.6	-5.45%	788.72	4,309.9
Emulsified	864.39	4,723.4	-5.45%	817.24	4,465.8
Roofing	3.19	24.5	-3.37%	3.08	23.7
Total:	1,701.80	9,306.5		1,609.04	8,799.4

3.4.8 Agricultural pesticides

Annual emissions from agricultural pesticide usage within Maricopa County were obtained from the US Environmental Protection Agency's 2011 National Emissions Inventory data and documentation (US EPA, 2012c). US EPA estimated 362.93 tons of VOCs were emitted from agricultural pesticide usage in Maricopa County in 2011.

Agricultural pesticide data for 2011 were obtained from the Arizona Department of Agriculture's 1080 Investigative Search website (ADA, 2013). This data was used to determine ozone season emissions from agricultural pesticide applications. The data included quantities of pesticides applied and the date of pesticide application. Quantities reported in gallons were converted to pounds assuming 8.33 lbs per gallon.

The data showed approximately 2,086,356 lbs of agricultural pesticides were applied in Maricopa County in 2011. Based on the date of pesticide application, approximately, 36.4% (759,349 lbs.) of agricultural pesticides were applied during the ozone season. Ozone season-day emissions for Maricopa County were calculated by multiplying annual emissions (362.93 tons) by 36.4% and then dividing the result by 91 days/season (7 days/wk × 13 wks/ozone season).

Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying county totals by the ratio of agricultural land located in the nonattainment area to the agricultural land in the county (58.46%). See Section 1.5.1 for a further discussion of the land use data used.

Table 3.4-20. Annual and season-day emissions from agricultural pesticide application.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	362.93	2,903.4
8-hr ozone NAA	212.18	1,697.5

3.5 Storage and transport

3.5.1 Portable fuel containers

Annual Maricopa County emissions from area-source portable fuel containers (PFCs) were obtained from the US Environmental Protection Agency's 2011 National Emissions Inventory (US EPA, 2012c). These calculations identify a total of seven mechanisms by which emissions can be generated from portable fuel containers:

- Emissions associated with filling the gas can at the gas pump:
 - Displacement of the vapor within the can, and
 - Spillage of gasoline while filling the can
- Emissions associated with transporting the gas can:
 - Spillage of gasoline during transport
- Emissions (adjusted for changes in ambient temperature) associated with storage of the gasoline in the PFCs:
 - Emissions due to evaporation (i.e., diurnal emissions), and
 - Emissions due to permeation.

Two additional sources of emissions associated with using PFCs to refuel pieces of nonroad equipment are considered by the NONROAD model (described in Chapter 4) and thus not addressed here:

- Displacement of the vapor within nonroad equipment, and
- Spillage of gasoline while filling nonroad equipment.

Ozone season-day emissions for the county were calculated by dividing annual emissions by 365 days as activity is assumed to occur uniformly throughout the year.

Annual and ozone season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the county totals by the ratio of total population in the nonattainment area to total population in the county (101.14%). See Section 1.5.1 for a discussion of the employment data used.

Table 3.5–1 summarizes annual and season-day VOC emissions from portable fuel containers in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.5–1. Annual and season-day emissions from portable fuel containers (PFCs).

Emissions source	Maricopa County		Eight-hour ozone NAA	
	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Permeation: Residential	887.25	4,875.0	897.40	4,930.8
Evaporation/diurnal: Residential	1,732.33	9,518.3	1,752.15	9,627.2
Spillage during transport: Residential	226.04	1,242.0	228.63	1,256.2
Vapor displacement in PFCs: Residential	82.87	455.3	83.82	460.5
Spillage at pump: Residential	6.60	36.2	6.67	36.7
Permeation: Commercial	28.34	155.7	28.66	157.5
Evaporation/diurnal: Commercial	55.33	304.0	55.96	307.5
Spillage during transport: Commercial	308.36	1,694.3	311.89	1,713.7
Vapor displacement in PFCs: Commercial	159.71	877.5	161.54	887.6
Spillage at pump: Commercial	12.69	69.7	12.84	70.5
Displacement during refueling of nonroad equipment*				
Spillage during refueling of nonroad equipment*				
Total:	3,499.52	19,228.2	3,539.56	19,448.1

*These activities are included in the NONROAD model emissions calculations, described in Chapter 4.

3.5.2 Bulk plants

Emissions from this source category were calculated from annual emissions inventory reports from all bulk plants located within the county. It is assumed that there are no unpermitted bulk plants in Maricopa County. To avoid double-counting, emissions from bulk terminals are treated as point sources (totaling 105.94 tons/yr) and thus are reported in Chapter 2. Ozone season-day emissions were calculated based on operating schedule information provided in the facilities annual emissions reports. Since all facilities considered in this section are located within the eight-hour ozone nonattainment area, total emission values for the county and the eight-hour ozone nonattainment area are equal.

Table 3.5–2. Annual and season-day emissions from bulk plants.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	120.91	659.3
8-hr ozone NAA	120.91	659.3

3.5.3 Gasoline stations (Stage I)

Stage I gasoline distribution emissions occur when gasoline vapors are displaced from storage tanks during unloading of gasoline from tank trucks at service stations.

Following EPA methodologies (US EPA, 2001b), annual VOC emissions from gasoline service station unloading were calculated by multiplying gasoline sales (1,553,993 Mgals) (B. Steen, pers. commun., September 13, 2012) by emission factors provided in AP-42 (US EPA, 1995b) for each filling technology. Based on annual emissions reports from 2002, 98.5% of gasoline is delivered using balanced submerged filling with the remaining 1.5% delivered by submerged filling. Table 3.5–3 below shows the emission factors used.

Table 3.5–3. Emission factors for gasoline service stations (Stage I).

Emission source	VOC emission factors (lbs of VOC/Mgal throughput)
Submerged filling	7.3
Balanced submerged filling	0.3

Ozone season-day emissions were calculated by multiplying ozone-season (July–September) gasoline sales (376,616 Mgal) by the emission factors listed above, then dividing by 78 days (13 weeks in the ozone season \times 6 days/week).

As a conservative assumption, annual and season-day emissions for the eight-hour ozone nonattainment area are assumed to be equal to Maricopa County emissions.

Table 3.5–4. Annual and season-day emissions from gasoline service stations (Stage I).

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County and 8-hr ozone NAA:		
–Submerged filling	85.08	528.7
–Balanced submerged filling	229.60	1,426.8
Total:	314.68	1,955.5

3.5.4 Gasoline stations (Stage II)

Stage II gasoline service station emissions are the refueling emissions that occur during the transfer of gasoline from storage tanks at service stations to vehicle fuel tanks (i.e. vehicle refueling and spillage emissions). The MOVES2010b model that was used to calculate onroad emissions captures stage II emissions. Therefore, these emissions are addressed in Chapter 5 as part of the onroad mobile sources emissions and are no longer reported as an area source.

3.5.5 Gasoline stations underground tanks, breathing/emptying

Breathing losses are the expulsion of vapor from a tank vapor space that has expanded or contracted because of daily changes in temperature and barometric pressure; these emissions occur in the absence of any liquid level change in the tank. Emptying losses occur when the air that is drawn into the tank during liquid removal saturates with hydrocarbon vapor and expands, thus exceeding the fixed capacity of the vapor space and overflowing through the pressure vacuum valve.

Following EPA methodologies (US EPA, 2001b), annual VOC emissions from storage tank breathing and emptying were calculated by multiplying annual gasoline throughput (1,553,993 Mgal [B. Steen, ADOT, pers. commun., September 13, 2012]) by the emission factor for underground tank breathing and emptying (1.0 lb/Mgal) found in AP-42 Table 5.2-7 (US EPA, 1995b).

Ozone season-day VOC emissions were calculated using the same formula as above, using only the gasoline distributed during the ozone season (July–September, 376,616 Mgal) and dividing by the 91 days (13 weeks in the ozone season \times 7 days per week that gasoline storage occurs).

As a conservative estimate, all activity was assumed to occur within the nonattainment area; thus annual and season-day emissions estimates for the nonattainment area are equal to county totals.

Table 3.5-5. Annual and season-day emissions from gasoline service stations underground tank, breathing and emptying.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	777.00	4,138.6
8-hr ozone NAA	777.00	4,138.6

3.5.6 Airports: Aviation gasoline

Aviation gasoline is used by small reciprocating, piston-engine aircraft in civil aviation. Commercial and military aviation rarely use aviation gasoline. Aviation gasoline is shipped to airports and is filled into bulk terminals, and then into tanker trucks. The displacement vapors during the transfer of gasoline from tank trucks to storage tanks, and vice versa falls under the definition of stage I. Stage II involves the transfer of fuel from the tanker trucks into general aviation aircraft.

Annual emissions from aviation gasoline Stage I and Stage II were obtained from the US Environmental Protection Agency's 2011 National Emissions Inventory (US EPA, 2012c). Table 3.5-6 shows US EPA 2011 estimated VOC emissions from aviation gasoline for Maricopa County.

Table 3.5-6. Annual emissions from aviation gasoline for Maricopa County.

	VOC Emissions (tons/yr)
Aviation Gasoline Stage I	347.57
Aviation Gasoline Stage II	18.04

Due to lack of data, daily emissions were assumed to be equal throughout the year and were calculated by dividing annual emissions by 365 days/year.

Annual and season-day emission in the eight-hour ozone nonattainment area were calculated by multiplying county totals by the percentage of general aviation operations that occurred within the nonattainment area in 2011 (99.1%) (See Table 4.11–1 for general aviation aircraft operational data used).

Table 3.5–7. Annual and season-day emissions from aviation gasoline.

	Maricopa County		8-hr ozone NAA	
	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Aviation Gasoline Stage I	347.57	1904.5	344.41	1,887.2
Aviation Gasoline Stage II	18.04	98.8	17.87	97.9

3.5.7 Gasoline tank trucks in transit

Emissions from tank trucks in transit occur when gasoline vapor evaporates from (1) loaded tank trucks during transportation of gasoline from bulk terminals/plants to service stations, and (2) empty tank trucks returning from service stations to bulk terminals/plants. Annual VOC emissions from gasoline trucks in transit were calculated by multiplying county-level tank truck gasoline throughput by a 0.06 lb of VOC per 1,000 gallon emission factor (Pechan, 2012b).

Gasoline consumption for Maricopa County was determined from gasoline tax sales reports obtained from the Arizona Department of Transportation for 2011 (ADOT, 2012). Gasoline throughput for tank trucks was computed by multiplying the Maricopa County gasoline sales (1,553,992,539 gallons) by a transportation adjustment factor of 1.09 to account for gasoline that is transported more than once in a given area (i.e., transported from bulk terminals to bulk plant and then from bulk plant to service station) (Pechan, 2012b).

Ozone season gasoline throughput for tank trucks was estimated by multiplying the gallons of gasoline sold (376,615,906 gallons) during the ozone-season (July-September) in Maricopa County by the 1.09 transportation adjustment factor noted above to account for gasoline that is transported more than once. Ozone season-day VOC emissions were calculated by multiplying the estimated ozone season gasoline throughput for tank trucks by the 0.06 lb of VOC per 1,000 gallon emission factor noted above and then dividing by 78 days (13 weeks × 6 days/wk).

As a conservative estimate, all activity was assumed to occur within the nonattainment area; thus annual and season-day emissions estimates for the nonattainment area are equal to county totals.

Table 3.5–8. Annual and season-day emissions from gasoline trucks in transit.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	50.82	315.8
8-hr ozone NAA	50.82	315.8

3.5.8 Pipeline gasoline

Pipeline emissions result from the valves and pumps found at pipeline pumping stations and from the valves, pumps, and storage tanks at pipeline breakout stations.

Annual VOC emissions from gasoline pipelines were derived based on the ratio of pipeline emissions to total emissions for bulk terminals, bulk plants, and pipelines as reported in the US Environmental Protection Agency’s 2011 National Emissions Inventory (NEI) (US EPA, 2012c). The NEI reported that 2011 pipeline emissions for Maricopa County were 12.53% of total emissions from bulk terminals, bulk plants, and pipelines.

Thus, annual pipeline emissions for the county were derived by multiplying annual emissions reported in bulk plant emissions reports by 12.53%.

Ozone season-day emissions were calculated in the same manner, by multiplying season-day emissions (derived from operating schedule information provided in the facilities annual emissions reports) by 12.53%.

Since all facilities considered in this section are located within the eight-hour ozone nonattainment area, emissions for the county and the eight-hour ozone nonattainment area are equal.

Table 3.5–9. Annual and season-day emissions from pipeline gasoline.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	17.32	94.5
8-hr ozone NAA	17.32	94.5

3.5.9 Volatile organic liquid (VOL) storage and transport

Emissions from this source category were calculated by summing reported VOC emissions from volatile organic liquid storage/transfer emissions inventory reports. It is assumed that there are no significant unpermitted volatile organic liquid storage/transfer facilities in Maricopa County. To avoid double-counting, emissions from those facilities treated as point sources (totaling 28.8 tons/yr) are addressed in Chapter 2. Ozone season-day emissions were calculated based on operating schedule information provided in the facilities annual emissions reports.

Table 3.5–10. Annual and season-day emissions from area-source volatile organic liquid storage/transport.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	30.54	182.7
8-hr ozone NAA	28.80	169.3

3.6 Waste treatment and disposal

3.6.1 On-site incineration

This section includes emissions from on-site industrial incinerators, primarily burn-off ovens used to reclaim electric wire or other materials. Emissions from human and animal crematories are addressed in Section 3.7.5. There were no incinerators at residential (e.g., apartment complexes) or commercial/institutional facilities (e.g., hospitals, service establishments) in operation during 2011.

Emissions from on-site incineration were determined from annual emissions inventory reports. It is assumed that all incinerator emissions are accounted for, since all permitted incinerators

received surveys in 2011. All surveyed facilities are located within the eight-hour ozone nonattainment area, thus total emissions for the county and nonattainment area are equal.

Table 3.6–1. Annual and season-day emissions from on-site incineration.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.17	3.31	0.79	1.1	21.4	5.3
8-hr ozone NAA	0.17	3.31	0.79	1.1	21.4	5.3

3.6.2 Open burning: Land clearing debris

Emissions from controlled open burning are regulated by Maricopa County Air Pollution Control Regulations Rule 314 (Open Outdoor Fires and Indoor Fireplaces at Commercial and Institutional Establishments), which requires a burn permit for open burning in Maricopa County. Burn permits are issued primarily for purposes of agricultural ditchbank and fence row burning, tumbleweed burning, land clearance, and firefighting training. Maricopa County’s burn permit data base was used to identify all burn permits issued in 2011. A total of 57 open burn permits were issued during the year. The quantity and reported activity for the open burn permits (except for firefighting burn permits) are shown in Table 3.6–2.

Table 3.6–2. Maricopa County burn permit activity.

Category	Number of permits	Unit of measure	Total reported activity
Annual ditchbank & fence row	41	Linear Feet	1,967,795
Land clearance	4	Acres	14.14
Fire hazard	1	Acres	2

Emissions from land clearance and fire hazard open burning are addressed in this section whereas ditchbank and fence row burning are addressed in Section 3.7.1.

The activity data for land clearance and fire hazard were converted to tons of material burned using fuel loading factor for “weeds, unspecified” from AP-42 (US EPA, 1992). The emission and loading factors used are shown in Table 3.6–3.

Table 3.6–3. Emission and fuel loading factors for open burning.

Category	Emission factors (lbs/ton burned)			Fuel loading factors (tons/acre)
	VOC	NO _x	CO	
Weeds, unspecified	9	4	85	3.2

Activity data were multiplied by the 3.2 tons/acre fuel loading factor to derive the total mass of material burned. Annual emissions were then calculated by multiplying the amount of material burned by the AP-42 emission factors for “weeds, unspecified” (shown in Table 3.6–3). Based on an analysis of complaints received in 2011 reporting suspected open or illegal outside burning, emissions estimates were multiplied by a factor of 2.87 to account for unpermitted illegal outdoor burning.

It was assumed that land clearance and fire hazard open burning occur 5 days per week (most burn permits are issued for weekdays but permits may be issued on weekends depending on

circumstances) and evenly during the ozone season months (July–September). Thus, season-day emissions for Maricopa County were derived by dividing annual emissions (lbs/year) by 65 (5 days/wk × 13 wks/yr).

Annual and season-day emissions for the nonattainment area were calculated by multiplying the percentage of vacant land use located in the eight-hour ozone nonattainment area (44.55%) by the Maricopa County emissions estimates. See Section 1.5.2 for a discussion of the land use data used.

Table 3.6–4 summarizes 2011 annual and season-day emissions for the Maricopa County and the eight-hour ozone nonattainment area from land clearance and fire hazard open burning activity.

Table 3.6–4. Annual and season-day emissions from land clearance and fire hazard open burning.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.67	0.30	6.30	20.5	9.1	193.8
8-hr ozone NAA	0.30	0.14	2.81	9.1	4.1	86.4

3.6.3 Landfills

Emissions from municipal solid waste (MSW) landfills come from uncontrolled landfill gas emissions as well as from combustion from control measures, such as a flare. Total emissions were calculated from annual emissions inventory reports from all landfills located within the county. Northwest Regional Landfill was considered a point source; all other MSW landfills are reported here as area source landfills.

Since there are no landfills located outside the eight-hour ozone nonattainment area, total emission values for the county and the eight-hour ozone nonattainment area are equal. Annual and season-day emissions are shown in Table 3.6–5.

Table 3.6–5. Annual and season-day emissions from landfills.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	36.59	30.40	108.55	200.7	167.4	596.4
8-hr ozone NAA	36.59	30.40	108.55	200.7	167.4	596.4

3.6.4 Publicly owned treatment works

Annual emissions from publicly owned treatment works (POTW) in Maricopa County were obtained from the US Environmental Protection Agency’s 2011 National Emissions Inventory (US EPA, 2012c). EPA estimated 75.02 tons of VOC were emitted from POTWs in Maricopa County in 2011. There were no point sources in this category that needed to be subtracted.

Ozone season-day emissions were calculated by multiplying annual emissions by a 35% season adjustment factor and then dividing by 91 days per season (US EPA, 2001a).

Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the percentage of total population in the nonattainment area to the total population in the county (101.14%). See Section 1.5.1 for a discussion of the population data used.

Table 3.6–6. VOC emissions from publicly owned treatment works.

Geographic area	Annual emissions (tons/yr)	Season-day emissions (lbs/day)
Maricopa County	75.02	577.1
8-hr ozone NAA	75.88	583.7

3.6.5 Leaking underground storage tanks

Leaking underground storage tanks (LUST) are typically not considered a quantifiable source of air emissions until excavation and remediation efforts begin. The majority of air emissions from LUST site remediation occur during initial site action, which is typically tank removal.

Emissions from soil occur as the tank is being removed and when soil is deposited on the ground before treatment/disposal occurs (US EPA, 2001c).

A default emission rate of 28 lbs/day per remediation event was used to estimate VOC emissions from LUST remediation (US EPA, 2001c). Data obtained from the Arizona Department of Environmental Quality Leaking Underground Storage Tank Section indicated that 15 LUST opened in Maricopa County in 2011 (N. Giuntoli, pers. commun., March 19, 2013). Data were not available on the number or date of remediation that occurred in 2011; therefore, it was conservatively assumed that all 15 LUST were remediated in 2011 during the ozone season. It was also assumed that an initial site action (tank and soil removal) for an average LUST remediation lasts five days.

Ozone season-day emissions were calculated by dividing annual values by 65 (5 days/wk × 13 wks/ozone season). To be conservative, it was assumed that all gasoline retail outlets were located within the ozone nonattainment area and therefore, annual and season-day emissions for the eight-hour ozone nonattainment area were assumed to be equal to the Maricopa County totals.

Table 3.6–7. Annual and season-day emissions from remediation of leaking underground storage tanks.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	1.05	32.3
8-hr ozone NAA	1.05	32.3

3.6.6 Other waste

Annual area-source emissions from other industrial waste disposal were derived from annual emissions reports from permitted facilities. Other industrial waste disposal processes include a wide array of industrial activities that are often specific to the permitted facility that reported the process. For this reason, it is assumed there are no significant emissions from this category, other than those reported by permitted facilities on their annual emissions reports. Ozone season-day emissions were calculated based on operating schedule information provided by the facilities in their annual emissions report.

All surveyed facilities for this area source category are located inside the eight-hour ozone nonattainment area; therefore emissions for Maricopa County and the eight-hour ozone nonattainment area are equal. Table 3.6–8 summarizes annual and season-day emissions for Maricopa County and the nonattainment area.

Table 3.6–8. Annual and season-day emissions from other waste.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	2.12	22.19	77.93	10.9	122.8	431.4
8-hr ozone NAA	2.12	22.19	77.93	10.9	122.8	431.4

3.7 Miscellaneous area sources

3.7.1 Agricultural field burning

Agricultural ditchbank and fence row burning are regulated by Maricopa County Air Pollution Control Regulations Rule 314 (Open Outdoor Fires and Indoor Fireplaces at Commercial and Institutional Establishments) which requires a burn permit for open burning activity in Maricopa County. A total of 41 permits were issued during the year for ditchbank and fence row burning. The permit data indicated that a total of 1,967,795 linear feet of ditchbank and fence rows were burned in 2011.

To calculate the amount of material burned, MCAQD assumed that ditchbanks and fence rows in Maricopa County average 7 feet in width and are burned twice per year, based on a previous Maricopa County emissions inventory (MCESD, 1999).

MCAQD estimated 632.44 acres burned $[(1,967,795 \text{ linear ft.} \times 7 \text{ ft.} \times 2)/43,560 \text{ ft/acre}]$. Acres burned were converted to tons of material burned using a 3.2 tons/acre fuel loading factor for “weeds, unspecified” from AP-42 (US EPA, 1992). This resulted in an estimated 2,023.81 ton of material burned.

Annual emissions were then calculated by multiplying the amount of material burned by AP-42 emission factors for “weeds, unspecified” as shown in Table 3.7–1.

Table 3.7–1. Emission factors for open burning.

Category	Emission factors (lbs/ton burned)		
	VOC	NO _x	CO
Weeds, unspecified	9	4	85

Based on an analysis of 2011 complaints received reporting suspected open or illegal outside burning, emissions estimates were multiplied by a factor of 2.87 to account for unpermitted illegal outdoor burning.

It was assumed that ditchbank and fence row burning occurs 5 days per week. Thus, season-day emissions were calculated by dividing annual emissions (in lbs) by 65 (5 days/wk \times 13 wks/ozone season).

Annual and season-day emissions for the nonattainment area were calculated by multiplying the percentage of agricultural land use within the eight-hour ozone nonattainment area (58.46%) by the Maricopa County emissions estimates. See Section 1.5.2 for a discussion of the land use data used.

Table 3.7–2 summarizes annual and season-day emissions from ditchbank and fence row burning for Maricopa County and the eight-hour ozone nonattainment area.

Table 3.7–2. Annual and season-day emissions from ditchbank and fence row burning.

Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	26.14	11.62	246.85	804.2	357.4	7,595.5
8-hr ozone NAA	15.28	6.79	144.32	470.2	209.0	4,440.7

3.7.2 Structure fires

Structure fire emissions for Maricopa County were grown from 2008 based on county population growth from 2008 to 2011. Population data was provided by MAG and is shown in Table 3.7–3.

Table 3.7–3. Maricopa County population growth, 2008 to 2011.

	2008	2011	% change
Maricopa Co. Total Population	4,279,760	4,129,646	-3.51%

The 2008 annual emissions from structure fires in Maricopa County and the subsequently grown 2011 annual emissions are shown in Table 3.7–4.

Table 3.7–4. 2008 and 2011 annual emissions from structure fires in Maricopa County.

Year	Annual emissions (tons/yr)		
	VOC	NO _x	CO
2008	15.32	1.95	83.56
2011	14.78	1.88	80.63

Annual emissions for the eight-hour ozone nonattainment area were derived by multiplying annual county emissions by the percentage of total residential population within the nonattainment area (101.14%). See Section 1.5.1 for a discussion of the population data used.

It was assumed that structure fires occur 7 days a week; however, structure fires vary seasonally and may increase during cold weather. Because local season-specific data were not readily available, seasonal occurrences of residential and non-residential structure fires reported by the Federal Emergency Management Agency (FEMA) were used to derive a seasonal adjustment factor for the ozone season (US EPA, 2001d). FEMA reported that 20.9% of residential structure fires and 23.7% of non-residential structural fires occurred during July, August, and September 1994. Thus, an average occurrence of 22.3% $[(20.9\% + 23.7\%) \div 2]$ was used as a seasonal adjustment factor to estimate ozone season-day emissions.

Ozone season-day emissions for Maricopa County and the nonattainment area were derived by multiplying the annual emissions (in lbs) by the seasonal adjustment factor (22.3%) and then dividing by 91 (7 days/wk \times 13 wks/ozone season).

Table 3.7–5. Annual and season-day emissions from structure fires.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	14.78	1.88	80.63	72.4	9.2	395.2
8-hr ozone NAA	14.95	1.90	81.55	73.3	9.3	399.7

3.7.3 Aircraft engine testing

Annual emissions from engine testing facilities were derived from annual emissions reports from permitted sources that were not considered point sources in this inventory. It was assumed that there were no significant unpermitted sources within Maricopa County. Ozone season-day emissions were calculated based on operating schedule information provided in the facilities' annual emissions reports.

Since all facilities considered in this section are located within the eight-hour ozone nonattainment area, total emission values for the county and the nonattainment area are equal. Results are shown in Table 3.7–6.

Table 3.7–6. Annual and season-day emissions from aircraft engine testing.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	4.72	46.36	16.16	26.1	259.3	91.2
8-hr ozone NAA	4.72	46.36	16.16	26.1	259.3	91.2

3.7.4 Vehicle fires

Vehicle fire emissions for Maricopa County were grown from 2008 based on county population growth from 2008 to 2011. The population data used is shown in Table 3.7–3.

The 2008 annual emissions from vehicle fires in Maricopa County and the subsequently grown 2011 annual emissions are shown in Table 3.7–7.

Table 3.7–7. 2008 and 2011 annual emissions from vehicle fires in Maricopa County.

Year	Annual emissions (tons/yr)		
	VOC	NO _x	CO
2008	9.61	1.20	37.55
2011	9.27	1.16	36.23

Annual emissions for the eight-hour ozone nonattainment area were derived by multiplying annual county emissions by the percentage of total residential population within the nonattainment area (101.14%). See Section 1.5.1 for a discussion of the population data used.

It was assumed that vehicle fires occur evenly throughout the year. Thus, ozone season-day emissions were derived by dividing the Maricopa County and nonattainment area annual emissions (in lbs.) by 365 days/year. The results are shown in Table 3.7–8 below.

Table 3.7–8. Annual and season-day emissions from vehicle fires.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	9.27	1.16	36.23	50.8	6.4	198.5
8-hr ozone NAA	9.38	1.17	36.64	51.4	6.4	200.8

3.7.5 Crematories

Emissions from human and animal crematories were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources, and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category.

The most recent data from the US Census Bureau’s County Business Patterns (CBP) for 2010 employment were used. Table 3.7–9 shows the NAICS code and employment data used to calculate emissions from crematories.

Table 3.7–9. County-level employment estimates for crematories, by NAICS code.

NAICS code	NAICS description	Estimated employment
81222	Cemeteries and crematories	251

There were no point sources in this category. Area-source employment estimate were used to “scale up” emissions reported from those facilities surveyed in 2011.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of industrial employment in the nonattainment area to industrial employment in the county. See Section 1.5.1 for a discussion of the employment data used. Table 3.7–10 summarizes annual and season-day emissions from crematories in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.7–10. Annual and season-day emissions from crematories.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	1.18	11.19	2.23	51.1	88.5	17.3
8-hr ozone NAA	1.18	11.14	2.22	50.9	88.1	17.2

3.7.6 Accidental releases

As part of its air quality permit compliance program, MCAQD keeps an “upset log” for each calendar year that records excess emissions and accidental releases at permitted facilities. Annual emissions inventory reports also provide for recording of accidental releases. Data from these two sources documented the release of 0.45 tons of VOC for the year 2012.

Ozone season-day emissions were calculated based on the whether the reported release occurred during the ozone season. If emissions occurred during the ozone season, those emissions were summed and divided by the number of days in the ozone season to produce season-day emissions. Emissions within the eight-hour ozone nonattainment area are calculated based on locations of facilities that reported releases. Results are shown in Table 3.7–11.

Table 3.7–11. Annual and season-day emissions from accidental releases.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.45	0.0	0.0	2.1	0.0	0.0
8-hr ozone NAA	0.45	0.0	0.0	2.1	0.0	0.0

3.7.7 Hospitals

Emissions from hospitals were calculated by the “scaling up” method as described in EPA emissions inventory guidance (US EPA, 2001a). This method combines detailed emissions data from a subset of sources and county-level employment data from the US Census Bureau (2012) to develop a per-employee emission factor that is then used to estimate emissions from all sources in an industry category. The most recent data from the US Census Bureau’s County Business Patterns (CBP) for 2010 employment were used. CBP employment data for NAICS code 662110 (general medical and surgical hospitals) indicated 59,646 employees in this industry in Maricopa County.

Ozone season-day emissions were calculated in the same method as annual emissions, only using surveyed daily emissions instead of annual totals. Annual and season-day emissions for the eight-hour ozone nonattainment area were calculated by multiplying the Maricopa County emission totals by the ratio of population in the nonattainment area to population in the county. See Section 1.5.1 for a discussion of the employment data used.

Table 3.7–12 summarizes annual and season-day emissions from hospitals in both Maricopa County and the eight-hour ozone nonattainment area.

Table 3.7–12. Annual and season-day emissions from hospitals.

Geographic area	Annual VOC emissions (tons/yr)	Season-day VOC emissions (lbs/day)
Maricopa County	8.57	52.3
8-hr ozone NAA	8.66	52.9

3.7.8 Wildfires

2011 Maricopa County wildfire data were obtained from the Arizona State Forestry Division (ASFD) (G. Buettner, pers. commun., December 17, 2012); the National Wildfire Coordinating Group (NWCG, 2012), and the US Fire Administration, National Fire Data Center (USFA, 2012).

The Arizona State Forestry Division (ASFD) provides for the prevention and suppression of wildfires on state trust land and private lands located outside of incorporated communities. The wildfire data provided by ASFD includes wildfires that occur outside of local fire districts and municipalities on State, private, and U.S. Bureau of Land Management (BLM) land. In 2011, the (ASFD) reported 5 wildfires in Maricopa County, encompassing 15.2 acres.

Wildfire data provided by ASFD were compared to 2011 Incident Status Summary reports (ICS-209) to identify wildfires that may have occurred outside of ASFD jurisdiction. ICS-209 reports only include large wildfires, generally fires greater than 100 acres. ICS-209 reports showed two additional Maricopa County wildfires in 2011, totaling 2,006 acres (NWCG, 2012).

Lastly, 2011 National Fire Incident Reporting System (NFIRS) data were obtained from the US Fire Administration (USFA, 2012). NFIRS is a voluntary national reporting system used by fire departments to report fires and other incidents to which they respond and to maintain records of these incidents in a uniform manner. However, not all fire departments report to NFIRS and they may not report all of their fire incidents. The 2011 NFIRS data was culled for wildland fires greater than 1 acre that contained either latitude and longitude or township and range information. Wildfire data for Arizona included 18 fires which met these criteria; however, only 2 of these fires were located within Maricopa County, encompassing 7 acres. The NFIRS data was compared to the ASFD data to identify duplicates by comparing the incident dates and locations. One NFIRS fire was excluded from the combined dataset because it may have been a duplicate already captured in the ASFD data. Table 3.7–13 summarizes fire data obtained from each data source.

Table 3.7–13. 2011 wildfire activity in Maricopa County.

Data source	Number of fires in 2011	Acres burned
Arizona State Forestry Division	5	15.2
2011 NFIRS data	1	1.5
ICS-209	2	2,006.0
Total:	8	2,022.7

Estimates for fuel loading rates were assigned using fuel model codes from the National Fire Danger Rating System (NFDRS) and a table of fuel loading values for NFDRS fuel model categories (WGA/WRAP, 2005). The department used the NFDRS Fuel Model map in ArcGIS to identify NFDRS fuel types for fires with latitude and longitude data.

Table 3.7–14. Data used to estimate 2011 wildfire emissions.

NFDRS model category	Number of fires in 2011	Acres burned	Fuel loading factor (tons/acre)
Agriculture*	1	1.5	4.5
Barren*	1	0.1	0.75
Intermediate brush	4	2,019.5	15.0
Sagebrush grass	2	1.6	4.5
Total:	8	2,022.7	—

* “Agriculture” and “barren” NFDRS model descriptions were not included in WGA/WRAP 2002 fuel loading values for NFDRS fuel model categories. Therefore, it was assumed that “Agriculture” is similar to “sagebrush grass” and “Barren” is similar to “western grasses (annual)” and fuel loadings were assigned accordingly.

Estimates of the material burned were derived by multiplying the acres burned for each category by the applicable fuel loading factor.

Latitude and longitude data were used to determine the number of acres burned inside of the nonattainment area. Only one wildfire (=0.1 acre) occurred outside of the eight-hour ozone nonattainment area. Table 3.7–15 shows the number of wildfires and acres burned for Maricopa County and the eight-hour ozone nonattainment area and an estimate of material burned.

Table 3.7–15. Summary of 2011 wildfires, acres burned, and estimate of material burned.

Geographic Area	No. of fires	Acres burned	Material burned annually (tons/yr)	Material burned in 8-hr ozone season (tons/season)
Maricopa County	8	2,023	30,307	30,104
8-hr ozone NAA	7	2,023	30,306	30,104

Annual emissions from wildfires for each geographic area were calculated by multiplying the material burned for each area by the emission factor shown in Table 3.7–16 below. Emission factors were obtained from the Western Regional Air Partnership's (WRAP) 2002 Fire Emissions Inventory (WGA/WRAP, 2005).

Table 3.7–16. Emission factors for wildfires and prescribed broadcast burning.

Activity	Emission factors (lb/ton)		
	VOC	NO _x	CO
Wildfires and prescribed broadcast burning	13.6	6.2	289

Annual emissions from wildfires for Maricopa County and the nonattainment area are shown in Table 3.7–17.

Table 3.7–17. Annual emissions from wildfires.

Geographic Area	Annual emissions (tons/yr)		
	VOC	NO _x	CO
Maricopa County	206.08	93.95	4,379.29
8-hr ozone NAA	206.08	93.95	4,379.28

Because all fires that occurred during ozone season were within the nonattainment area, season-day emissions for the county and the nonattainment area were the same. Ozone season-day emissions were estimated by multiplying the material burned during ozone season by the appropriate emission factor and dividing the result by the number of ozone season burn days. In 2011, 32 burn days occurred during the ozone season in Maricopa County. Table 3.7–18 shows season-day emissions from wildfires in Maricopa County and the nonattainment area.

Table 3.7–18. Season-day emissions from wildfires.

Geographic Area	Ozone-season burn days	Season-day emissions (lbs/day)		
		VOC	NO _x	CO
Maricopa County	32	12,794.0	5,832.6	271,872.2
8-hr ozone NAA		12,794.0	5,832.6	271,872.2

3.7.9 Prescribed fires

Prescribed fire data were obtained from the Arizona Department of Environmental Quality (ADEQ) (B. Busby, pers. commun., November 8, 2012). The ADEQ reported that fourteen prescribed fires occurred in Maricopa County in 2011. Sixty-two acres of piled fuels were burned. All fourteen prescribed fires occurred inside the eight-hour ozone nonattainment area. Because all 2011 prescribed fires were piled fuels, material burned was derived by multiplying the number of acres burned by tons of piles per acre for each fire. Table 3.7–19 shows the data provided by the ADEQ, the amount of material burned for each fire, whether the fire occurred within the nonattainment area and during the ozone season.

Table 3.7–19. 2011 prescribed fire activity in Maricopa County.

Date	Burn number	Burn location	Tons/acre	Acres burned	Material burned (tons)	Within 8-hr NAA?	During ozone season?
01/05/2011	TNF0301	T7N,R8E,S36	1	5	5	Y	N
04/06/2011	TNF0301	T2N,R7E,S18	1	1	1	Y	N
04/13/2011	TNF0106	T6N,R7E,S33	1	1	1	Y	N
04/14/2011	TNF0106	T7N,R5E,S7	1	1	1	Y	N
04/19/2011	TNF0301	T3N,R8E,S27	1	10	10	Y	N
07/23/2011	TNF0611	T3N,R11E,S2	5	15	75	Y	Y
08/10/2011	TNF0301	T3N,R8E,S27	0.25	6	1.5	Y	Y
08/11/2011	TNF0301	T3N,R8E,S27	0.25	6	1.5	Y	Y
08/16/2011	TNF0301	T3N,R8E,S25	1	4	4	Y	Y
10/20/2011	TNF0301	T2N,R9E,S31	1	5	5	Y	N
11/08/2011	TNF0301	T2N,R9E,S31	3	5	15	Y	N
11/15/2011	TNF0106	T6N,R7E,S15	1	1	1	Y	N
11/16/2011	TNF0106	T7N,R6E,S1	1	1	1	Y	N
12/20/2011	TNF0301	T2N,R9E,S11	0.25	1	0.25	Y	N
Total:				62	122.25		

Prescribed fire emission factors for “piled fuels” were obtained from the Western Regional Air Partnership’s (WRAP) 2002 Fire Emissions Inventory (WGA/WRAP, 2005). The emission factors are listed below in Table 3.7–20.

Table 3.7–20. Emission factors for prescribed fire (piled fuels).

Type of fire	Emission factors (lbs/ton burned)		
	VOC	NO _x	CO
Prescribed fire (piled fuels)	6.3	6.2	74.3

Annual emissions from prescribed fires in Maricopa County were derived by multiplying material burned by the emission factor then dividing by 2000 lbs/ton.

Four prescribed fires occurred during the ozone season. The fires resulted in 82 tons of material burned. It was assumed the prescribed fires lasted one day. Ozone-season day emissions were derived by multiplying 82 tons of material burned by the emission factor (lbs/ton) and then dividing the resulting emissions by four burn days.

Since the prescribed fire data provided by ADEQ included burn location, GIS was used to determine the fires that burned inside the nonattainment area. All the 2011 prescribed fires burned within the eight-hour nonattainment area; therefore, annual and season-day emissions estimates for the nonattainment area are equal to county totals. Table 3.7–21 shows the annual and season-day from prescribed fires for Maricopa County and the nonattainment area.

Table 3.7–21. Annual and season-day emissions from prescribed fires.

Geographic Area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	0.39	0.38	4.54	129.2	127.1	1,523.2
8-hr ozone NAA	0.39	0.38	4.54	129.2	127.1	1,523.2

3.8 Summary of all area sources

Tables 3.8–1 and 3.8–2 summarize the total annual and average season-day emissions from all area sources addressed in this chapter, for both Maricopa County and the eight-hour ozone NAA, respectively.

Table 3.8–1. Annual and season-day emissions from all area sources in Maricopa County.

Source Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
<i>Fuel combustion:</i>						
Industrial distillate oil: Boilers	0.61	60.87	15.22	3.9	390.2	97.5
Industrial distillate oil: Engines	0.00	1,838.26	395.65	0.0	11,783.7	2,536.2
Industrial natural gas	36.99	730.94	455.30	217.8	4,303.8	2,680.8
Comm./inst. distillate oil: Boilers	0.00	0.12	0.03	0.0	0.8	0.2
Comm./inst. distillate oil: Engines	0.00	3.72	0.80	0.0	23.8	5.1
Comm./inst. natural gas	54.48	1,080.73	662.84	252.0	4,998.0	3,065.4
Residential distillate oil	0.01	0.35	0.10	0.0	0.0	0.0
Residential natural gas	49.81	851.32	362.26	119.6	2,044.2	869.9
Residential LPG	2.00	51.35	14.56	0.0	0.0	0.0
Residential wood combustion	509.7	57.72	2,959.91	0.0	0.0	0.0
Residential kerosene	0.00	0.03	0.01	0.0	0.0	0.0
All Fuel Combustion:	653.61	4,675.41	4,866.67	593.3	23,544.5	9,255.2
<i>Industrial processes:</i>						
Chemical manufacturing	77.42			599.0		
Commercial cooking	149.33		392.60	820.5		2,157.1
Bakeries	78.18			547.8		
Secondary metal production	41.01	15.02	98.36	306.4	107.9	697.4
Rubber/plastic product mfg.	1,766.75			14,171.0		
Electrical equipment mfg.	122.80	23.47	2.98	746.2	135.8	16.4
Industrial processes, NEC	48.51	224.92	91.84	325.6	1,245.8	525.2
All Industrial Processes:	2,284.00	263.41	585.79	17,516.5	1,489.5	3,396.2
<i>Solvent use:</i>						
Architectural coatings	4,976.22			30,622.9		
Auto refinishing	1,333.26			10,255.9		
Traffic markings	179.60			1,823.6		
Factory finished wood	137.72			1,396.7		
Wood furniture	416.56			3,434.7		
Aircraft surface coating	65.84			473.1		
Miscellaneous surface coating	316.38			2,450.5		
Degreasing	217.55			1,451.4		
Dry cleaning	23.15			178.1		
Graphics arts	290.98			2,225.7		
Miscellaneous industrial solvent use	721.85			5,126.6		
Consumer and commercial products	17,406.46			95,377.9		
Cutback asphalt	835.84			4,567.4		
Emulsified asphalt	866.06			4,732.6		
Roofing asphalt	3.04			23.4		
Agricultural pesticides	362.93			2,903.4		
All Solvent Use	28,153.45			167,043.9		

Table 3.8-1. Annual and season-day emissions from all area sources in Maricopa County (continued).

Source Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO_x	CO	VOC	NO_x	CO
<i>Storage/transport:</i>						
Residential portable gas cans	2,935.10			16,126.9		
Commercial portable gas cans	564.43			3,101.3		
Bulk plants	120.91			659.3		
Gas stations Stage I: Submerged fill	85.08			528.7		
Gas stations Stage I: Bal. submerged fill	229.60			1,426.8		
Gas stations Stage II	0.00			0.0		
Underground tanks: Breathing/emptying	777.00			4,138.6		
Airports: aviation gasoline Stage I	347.57			1,904.5		
Airports: aviation gasoline Stage II	18.04			98.8		
Truck: gasoline (tank trucks in transit)	50.82			315.8		
Pipeline gasoline	17.32			94.5		
Volatile organic liquids storage/transport	30.54			182.7		
All Storage/Transport	5,176.39			28,577.9		
<i>Waste treatment/disposal:</i>						
On-site incineration	0.17	3.31	0.79	1.1	21.4	5.3
Open burning: Land clearing debris	0.67	0.30	6.30	20.5	9.1	193.8
Landfills	36.59	30.40	108.55	200.7	167.4	596.4
Publicly owned treatment works	75.02			577.1		
Other waste	2.12	22.19	77.93	10.9	122.8	431.4
Leaking underground storage tanks	1.05			32.3		
All Waste Treatment/Disposal	116.10	56.04	190.06	837.8	315.6	1,119.6
<i>Misc. area sources:</i>						
Agricultural field burning	26.14	11.62	246.85	804.2	357.4	7,595.5
Structure fires	14.78	1.88	80.63	72.4	9.2	395.2
Aircraft engine testing	4.72	46.36	16.16	26.1	259.3	91.2
Vehicle fires	9.27	1.16	36.23	50.8	6.4	198.5
Crematories	1.18	11.19	2.23	51.1	88.5	17.3
Accidental releases	0.45	0.00	0.00	2.1	0.0	0.0
Hospitals	8.57			52.3		
Wildfires	206.08	93.95	4,379.29	12,794.0	5,832.6	271,872.2
Prescribed fires	0.39	0.38	4.54	129.2	127.1	1,523.2
All Misc. Area Sources	271.58	166.54	4,765.93	13,982.3	6,680.5	281,693.1
TOTAL, ALL AREA SOURCES	36,654.65	5,161.56	10,411.95	228,556.4	32,035.2	295,571.5

Table 3.8–2. Annual and season-day emissions from all area sources in the eight-hour ozone NAA.

Source Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
<i>Fuel combustion:</i>						
Industrial distillate oil: Boilers	0.61	60.61	15.15	3.9	388.5	97.1
Industrial distillate oil: Engines	0.00	1,830.35	393.95	0.0	11,733.0	2,525.3
Industrial natural gas	36.83	727.80	453.34	219.9	4,285.3	2,669.3
Comm./inst. distillate oil: Boilers	0.00	0.12	0.03	0.0	0.8	0.2
Comm./inst. distillate oil: Engines	0.00	3.70	0.80	0.0	23.7	5.1
Comm./inst. natural gas	54.42	1,079.44	662.05	251.7	4,992.0	3,061.7
Residential distillate oil	0.01	0.35	0.10	0.0	0.0	0.0
Residential natural gas	50.20	857.96	365.09	120.5	2,060.1	876.7
Residential LPG	2.02	51.93	14.73	0.0	0.0	0.0
Residential wood combustion	515.53	58.38	2,993.75	0.00	0.00	0.00
Residential kerosene	0.00	0.03	0.01	0.0	0.0	0.0
All Fuel Combustion	659.63	4,670.68	4,898.99	593.0	23,483.5	9,235.4
<i>Industrial processes:</i>						
Chemical manufacturing	77.09			596.5		
Commercial cooking	151.03		397.07	829.8		2,181.7
Bakeries	77.85			545.4		
Secondary metal production	41.01	15.02	98.36	306.4	107.9	697.4
Rubber/plastic product manufacturing	1,759.15			14,110.1		
Electrical equipment manufacturing	122.80	23.47	2.98	746.2	135.8	16.4
Industrial processes, NEC	47.55	224.92	91.84	318.0	1,245.8	525.2
All Industrial Processes	2,276.48	263.41	590.27	17,452.4	1,489.5	3,420.8
<i>Solvent use:</i>						
Architectural coatings	5,033.13			30,973.1		
Auto refinishing	1,327.53			10,211.8		
Traffic markings	171.12			1,737.5		
Factory finished wood	137.12			1,390.7		
Wood furniture	414.77			3,419.9		
Aircraft surface coating	65.84			473.1		
Miscellaneous surface coating.	315.02			2,440.0		
Degreasing	216.62			1,445.1		
Dry cleaning	23.42			180.1		
Graphics arts	289.73			2,216.1		
Miscellaneous industrial solvent use	718.75			5,104.6		
Consumer and commercial products	17,605.51			96,468.5		
Cutback asphalt	788.72			4,309.9		
Emulsified asphalt	817.24			4,465.8		
Roofing asphalt	3.08			23.7		
Agricultural pesticides	212.18			1,697.5		
All Solvent Use	28,139.77			166,557.4		

Table 3.8–2. Annual and season-day emissions from all area sources in the eight-hour ozone NAA (continued).

Source Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Storage/transport:						
Residential portable gas cans	2,968.67			16,311.4		
Commercial portable gas can:	570.89			3,136.7		
Bulk plants	120.91			659.3		
Gas stations Stage I: Submerged fill	85.08			528.7		
Gas stations Stage I: Bal. submerged fill	229.60			1,426.8		
Gas stations Stage II	0.00			0.0		
Underground tanks: Breathing/emptying	777.00			4,138.6		
Airports : Aviation gasoline Stage I	344.41			1,887.2		
Airports : Aviation gasoline Stage II	17.87			97.9		
Truck: Gasoline (tank trucks in transit)	50.82			315.8		
Pipeline gasoline	17.32			94.5		
Volatile organic liquids storage/transport	28.80			169.3		
All Storage/Transport:	5,211.35			28,766.2		
Waste treatment/disposal:						
On-site incineration	0.17	3.31	0.79	1.1	21.4	5.3
Open burning: Land clearing debris	0.30	0.13	2.81	9.1	4.1	86.4
Landfills	36.59	30.40	108.55	200.7	167.4	596.4
Publicly owned treatment works	75.88			583.7		
Other waste	2.12	22.19	77.93	10.9	122.8	431.4
Leaking underground storage tanks	1.05			32.3		
All Waste Treatment/Disposal	116.10	56.04	190.06	837.8	315.6	1,119.6
Misc. area sources:						
Agricultural field burning	15.28	6.79	144.32	470.2	209.0	4,440.7
Structure fires	14.95	1.90	81.55	73.3	9.3	399.7
Aircraft engine testing	4.72	46.36	16.16	26.1	259.3	91.2
Vehicle fires	9.38	1.17	36.64	51.4	6.4	200.8
Crematories	1.18	11.14	2.22	50.9	88.1	17.2
Accidental releases	0.45	0.00	0.00	2.1	0.0	0.0
Hospitals	8.66			52.9		
Wildfires	206.08	93.95	4,379.28	12,794.0	5,832.6	271,872.2
Prescribed fires	0.39	0.38	4.54	129.2	127.1	1,523.2
All Misc. Area Sources	261.09	161.70	4,664.71	13,650.0	6,531.8	278,544.9
ALL AREA SOURCES:	36,664.42	5,151.83	10,344.03	227,856.8	31,820.5	292,320.7

3.9 Quality assurance / quality control procedures

Quality assurance and quality control (QA/QC) activities for the area source emissions inventory were designed to create a comprehensive, accurate, representative and comparable inventory of area source emissions for Maricopa County and the nonattainment area. During each step of creating, building and reviewing the area source emissions inventory, quality checks and assurances were performed to establish confidence in the inventory structure and data.

Area source categories were identified for inclusion in the inventory based on the latest Emissions Inventory Improvement Program (EIIP) guidance available. In addition, recent EPA activities to develop county-level emissions estimates for newly created source categories (such as portable fuel containers) or refined source classification codes were also reviewed, and incorporated where relevant. Prior-year inventories for the region were also examined to identify possible additional categories for inclusion in the present inventory. The list of area source

categories developed based on these guidance documents was modified to fit the characteristics of Maricopa County, with some area source categories determined to be insignificant (e.g., emissions from industrial coal combustion, or oil and natural gas production, and snowmobile use).

Data for area source emission calculations were gathered from a wide universe of resources. Whenever applicable, local surveyed data (such as annual emissions report) was used as this data best reflects activity in the county and the nonattainment area. When local data was not available, state data from state agencies (such as the Arizona Department of Transportation) and regional bodies (such as the Western Regional Air Partnership [WRAP]) were used. National level data (such as the US Census Bureau) was used when no local, state or regional data was available. In addition, the most recent EIIP guidance for area sources was consulted for direction in determining the most relevant data source for use in emissions calculations.

Emissions calculations for area sources were performed by three air quality planners and one unit manager. All area source emission estimates were calculated in spreadsheets to ensure the calculations could be verified and reproduced. Whenever possible or available, the “preferred method” described in the most recent EIIP guidance documents for area sources was used to calculate emissions. Emissions were estimated using emission factors from EIIP guidance, AP-42, and local source testing. Local seasonal and activity data were used when available, with EPA and EIIP guidance used when no local seasonal or activity data existed. All calculations were evaluated to ensure that emissions from point sources were not being double-counted and to determine if rule effectiveness applied.

Once area source emission estimates had been produced, several quality control checks were performed to substantiate the calculations. Most area source calculations were peer-reviewed by two other planners, with all area sources being reviewed by at least one other planner. Peer review ensured that all emission calculations were reasonable and could be reproduced. Sensitivity analyses and computational method checks were performed on area sources when emissions seemed to be outside the expected ranges. When errors were found, the appropriate changes were made by the author of the calculations to ensure consistency of the emissions calculations. The peer-reviewed emissions estimates were combined into a draft area source chapter. This draft chapter was read through in its entirety by the unit manager and the three air quality planners for final review, with any identified errors corrected by the author of the section.

The draft version of the area source chapter was sent to the Arizona Department of Environmental Quality, the Arizona Department of Transportation, and the Maricopa Association of Governments for a quality assurance review. These agencies provided comments which were addressed and incorporated into the final area source chapter. The QA/QC activities described here have produced high levels of confidence in the area source emissions estimates detailed in this chapter, and represent the best efforts of the inventory preparers.

3.10 References

- ADA, 2013. Arizona Department of Agriculture, 1080 database. Internet address: <http://www.azda.gov/Search1080/Search.aspx>
- ADOT, 2012. Arizona Department of Transportation, Motor Vehicle Division, County Distribution Summary Report and Adjusted County MVF Distribution Report, for Jan. through December 2011.
- GOEP, 2013. Governor's Office of Energy Policy, Arizona Energy Statistics, Heating and Cooling Degree Days. Internet address: <http://www.azenergy.gov/doclib/Degreedays.pdf>.
- MCESD, 1999. 1999 Periodic Ozone Emissions Inventory for the Maricopa County, Arizona Nonattainment Area, Maricopa County Environmental Services Department, Rev. Aug. 2002.
- NWCG, 2012. National Wildfire Coordinating Group, Historical Incident ISC-209 reports. 2011 Significant Incident Summary Spreadsheet for southwest GACC Incidents. Internet address: http://fam.nwcg.gov/fam-web/hist_209/report_list_209.
- Pechan, 2012. Pechan Environmental Consulting. 2008 Nonpoint Emission Estimates. Solvent Usage – Surface Coatings. Solvent Utilization Documentation. Internet address: <http://cert.pechan.com/epa/npee2008/index.html>
- Pechan, 2012a. Pechan Environmental Consulting. 2008 Nonpoint Emission Estimates. Internet address: <http://cert.pechan.com/epa/npee2008/index.html#CommercialCooking>
- Pechan, 2012b. 2008 Nonpoint Emission Estimates. Pechan Environmental Consulting. Gasoline Distribution: Stage I: Tank Trucks in Transit, Internet address: <http://cert.pechan.com/epa/npee2008/index.html>
- Pechan, 2012c. 2008 Nonpoint Emission Estimates. Pechan Environmental Consulting. Solvent Usage – Other. Solvent Utilization Documentation, Table 2. Internet address: <http://cert.pechan.com/epa/npee2008/index.html>
- US Census Bureau, 2012. 2010 County Business Patterns (NAICS). Internet address: <http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl>
- US EPA, 1992. Compilation of Air Pollution Emission Factors (AP-42). Volume I: Stationary Point and Area Sources. Fifth ed. Chapter 2: Solid Waste Disposal, 2.5 Open Burning, Table 2.5-5. US EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC.
- US EPA, 1995a. Architectural Surface Coating. Emissions Inventory Improvement Program (EIIP) Vol. III, Chap. 1. Nov. 1995. Prepared by Eastern Research Group, Inc. for the Area Source Committee, EIIP. Internet address: <http://www.epa.gov/ttn/chief/eiip/techreport/volume03/archsfc.pdf>
- US EPA, 1995b. Compilation of Air Pollution Emission Factors (AP-42). Fifth Ed., Volume I, Chapter 5: Petroleum Industry, 5.2, Transportation and Marketing of Petroleum Liquids. Table 5.2-7. Jan. 1995. <http://www.epa.gov/ttn/chief/ap42/ch05/final/c05s02.pdf>
- US EPA, 1997. Traffic Markings. Emissions Inventory Improvement Program (EIIP) Vol. III, Chap. 14. May 1997. Prepared by Eastern Research Group, Inc. for the Area Source Committee, EIIP. Internet address: <http://www.epa.gov/ttnchie1/eiip/techreport/volume03/iii14.pdf>
- US EPA, 1998. Compilation of Air Pollution Emission Factors (AP-42). Fifth Ed., Volume 1, Chapter 1: External Combustion Sources. Natural Gas Combustion. Internet address: <http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf>
- US EPA, 2001a. Introduction to Area Source Emission Inventory Development. Emission Inventory Improvement Program (EIIP) Vol. III, Chapter 1. Revised Final, January 2001. Prepared by Eastern Research Group, Inc. for the Area Source Committee, EIIP. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii01_apr2001.pdf

- US EPA, 2001b. Gasoline Marketing (Stage I and Stage II). Emissions Inventory Improvement Program (EIIP) Vol. III, Chap 11. Revised Final, January 2001. Prepared by Eastern Research Group, Inc. for the Area Source Committee, EIIP. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii11_apr2001.pdf
- US EPA, 2001c. Leaking Underground Storage Tanks. Emission Inventory Improvement Program Vol. III, Area Source Method Abstract. May 2001. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/ust2_dec2000.pdf
- US EPA, 2001d. Structure Fires. Emission Inventory Improvement Program (EIIP) Vol. III, Chap. 18. Revised Final, Jan. 2001. Prepared by Eastern Research Group, Inc. for the Area Sources Committee, EIIP. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii18_apr2001.pdf
- US EPA, 2012a. WebFIRE. EPA's online emissions factor repository, retrieval, and development tool. Internet address: <http://www.epa.gov/ttn/chief/webfire/index.html>
- US EPA, 2012b. Residential Wood Combustion (RWC) Estimation Tool. Internet address: <ftp://ftp.epa.gov/EmisInventory/2011nei/doc/>
- US EPA, 2012c. 2011 National Emissions Inventory Information, Data and documentation. Internet address: <ftp://ftp.epa.gov/EmisInventory/2011nei/doc/>
- USFA, 2012. The United States Fire Administration, National Fire Data Center, National Fire Incident Reporting System (NFIRS), Data Archives: 2011 Public Data Release CD, December 11, 2012.
- WGA/WRAP, 2005. 2002 Fire Emission Inventory for the WRAP Region – Phase II. Project No. 178-6. Western Governors Association/Western Regional Air Partnership. July 22, 2005. Tables 5 and 6. Internet address: http://www.wrapair.org/forums/fejf/documents/WRAP_2002_PhII_EI_Report_20050722.pdf.

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4. Nonroad Mobile Sources

4.1 Introduction

Nonroad mobile sources are defined as those that move or are moved within a 12-month period and are not licensed or certified as highway vehicles. Nonroad mobile sources are vehicles and engines that fall under the following categories:

- Agricultural equipment, such as tractors, combines and balers;
- Airport ground support equipment, such as baggage tugs and terminal tractors;
- Commercial equipment, such as generators and pumps;
- Industrial equipment, such as forklifts and sweepers;
- Construction and mining equipment, such as graders, back hoes and trenchers;
- Lawn and garden equipment, such as leaf blowers and lawn mowers;
- Logging equipment (not present in Maricopa County);
- Pleasure craft, such as power boats and personal watercraft;
- Railway maintenance equipment, such as rail straighteners;
- Recreational equipment, such as all-terrain vehicles and off-road motorcycles;
- Underground mining and oil field equipment (not present in Maricopa County);
- Aircraft, such as jet and piston engines; and
- Locomotives, such as switching and line haul trains.

Emission calculations for most nonroad mobile source categories except aircraft, airport ground support equipment (GSE) and locomotives were derived using EPA's NONROAD2008a model (Core version 2008a, July 2009). Aircraft and airport GSE emission estimates were made using the Federal Aviation Administration's EDMS (Emissions Dispersion Modeling System) model, ver. 5.1.1. Locomotive emission calculations were derived from surveys of the three railroad companies that have operations in the county.

County specific temperature and fuel-related inputs are required for the operation of the NONROAD2008a model. Monthly temperature and fuel data were provided by the Arizona Department of Weights and Measures. The following table lists the local county inputs used:

Table 4.1–1. NONROAD2008 model county temperature and fuel-related inputs.

Month	Temperatures (°F)			Fuel	Diesel	Gasoline	Ethanol Blend		
	Max.	Min.	Average	RVP (psi)	Sulfur (ppm)	Sulfur (ppm)	ETOH (vol %)	Market share (%)	Total Oxygen (wt %)
January	64	45	54.9	9	9	15	9.92	100	3.66
February	69	48	58.5	9	9	16	10.29	100	3.85
March	79	54	66.8	8	9	11	9.52	100	3.58
April	87	61	74.2	8	9	14	7.90	100	2.98
May	91	66	78.7	7	9	13	9.41	100	3.48
June	107	80	93.4	7	10	18	9.38	100	3.45
July	106	84	95.2	7	9	21	9.70	100	3.62
August	104	82	93.2	7	6	18	9.58	100	3.70
September	101	79	90.1	7	6	18	9.73	100	3.60
October	91	65	78.1	8	9	15	9.49	100	3.56
November	81	56	68.7	8	6	14	10.17	100	3.80
December	65	46	56.0	8	16	12	9.02	100	3.41

Note: All other required temperature and fuel-related inputs not listed assumed NONROAD2008 default values.

The US EPA recommends adjusting default NONROAD2008a model values (such as equipment

population, activity levels of equipment, growth factors, etc.) where local data is available, as the default values in the model are derived from national averages. The NONROAD2008a model defaults were adjusted in the following manner:

- Equipment population numbers and activity levels for commercial lawn and garden equipment were adjusted based on 2003 survey results of the commercial lawn and garden industry performed by ENVIRON as part of an inventory developed to study the impact of visibility impairing pollutants (ENVIRON et al., 2003). Survey results show that for most categories of lawn and garden equipment, the equipment populations for Maricopa County are significantly lower than EPA default values, while the average annual hours of operation for most equipment types are slightly higher than EPA's values. Using these new local data results in a considerable decrease in emissions from this category, compared with earlier results using EPA default data.

Spatial allocation factors were developed (based on EPA guidance documents) to apportion nonroad emissions to the eight-hour ozone nonattainment area. The approaches used are described in each section of this chapter.

Temporal allocations (used to calculate ozone season-day emissions) for nonroad equipment categories modeled in the NONROAD2008a model are based on EPA recommendations on weekday and weekend day activity levels for each nonroad equipment category (US EPA, 1999). Table 4.1–2 below lists the weighted activity level allocation fractions for each equipment class for weekdays and weekend days. For this report, the most conservative (highest) allocation fraction in each nonroad equipment class was used to calculate season-day emissions.

Table 4.1–2. Default weekday and weekend day activity allocation fractions.

Equipment category	Weekday	Weekend day
Agricultural	0.1666667	0.0833334
Airport ground support	0.1428571	0.1428571
Commercial	0.1666667	0.0833334
Construction and mining	0.1666667	0.0833334
Industrial	0.1666667	0.0833334
Lawn and garden (residential)	0.1111111	0.2222222
Lawn and garden (commercial)	0.1600000	0.1000000
Logging	0.1666667	0.0833334
Pleasure craft	0.0600000	0.3500000
Railway maintenance	0.1800000	0.0500000
Recreational	0.1111111	0.2222222

4.2 Agricultural equipment

Annual emissions from agricultural equipment in Maricopa County were calculated using EPA's NONROAD2008a model, as discussed above. Ozone nonattainment area annual emissions were calculated based on EIIP guidance (US EPA, 2002) which recommends using the ratio of agricultural land inside the nonattainment area (161,371 acres) to agricultural land inside the county (276,016 acres). See Section 1.5.2 for a discussion of land use data used.

$$\text{Ozone nonattainment area emissions from agricultural equipment} = \frac{\text{Total Maricopa County VOC emissions from agricultural equipment}}{\text{Total Maricopa County VOC emissions from agricultural equipment}} \times \text{Agricultural land use allocation factor}$$

$$= 38.53 \text{ tons} \quad \times \quad 58.46\%$$

$$= 22.52 \text{ tons VOC/yr}$$

County season-day emissions were calculated by multiplying ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for agricultural equipment listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999), as follows:

$$\begin{aligned} \text{Maricopa County VOC} &= \text{Ozone season} \times 2,000 \quad \times \text{daily activity allocation factor} \div 13 \\ \text{season-day emissions} & \quad \text{VOC emissions} \quad (\text{lb/ton}) \quad \text{for agricultural equipment} \quad (\text{weeks/season}) \\ (\text{lbs/day}) & \quad (\text{tons/season}) \quad \text{expressed as (week/day)} \\ & = 12.84 \quad \times 2,000 \quad \times 0.166667 \quad \div 13 \\ & = 392.3 \text{ lbs/day} \end{aligned}$$

Ozone nonattainment area season-day emissions were calculated by multiplying County season-day emissions by the agricultural land use allocation factor:

$$\begin{aligned} \text{Ozone nonattainment area} &= \text{Maricopa County VOC} \quad \times \quad \text{Agricultural land use allocation factor} \\ \text{season-day emissions} & \quad \text{season-day emissions} \\ & = 392.3 \text{ lbs/day} \quad \times \quad 58.46\% \\ & = 192.5 \text{ lbs/day} \end{aligned}$$

Table 4.2–1. Annual and season-day emissions from agricultural equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	38.53	330.49	303.71	329.3	2,762.6	2,584.4
8-hr ozone NAA	22.52	193.22	177.56	192.5	1,615.1	1,510.9

4.3 Airport ground support equipment

Annual emissions from airport ground support equipment (GSE) and auxiliary power units (APUs) were calculated using the Emissions Dispersion Modeling System (EDMS, v. 5.1.3) from the U.S. Federal Aviation Administration (FAA). Activity data on 2011 aircraft operations and GSE use for eight major airports were obtained from FAA’s Air Traffic Activity Data System. In addition, activity data for 2011 for six small general aviation airports were assumed to be the same as those in 2008, which was included in MAG’s 2009 survey data. (Further details concerning the modeling input data and results are described in Section 4.11, Aircraft).

Emissions from GSE and APUs at Luke Air Force Base (AFB) for the year 2011 are assumed to be the same as those used in the 2008 PM₁₀ Periodic Emissions Inventory Report for the Maricopa County, Arizona, Nonattainment Area (MCAQD, 2011) based on input from Luke AFB.

Table 4.3–1. Annual emissions (tons/yr) from airport ground support equipment (GSE) and auxiliary power units (APUs).

	Maricopa County			8-hr ozone NAA		
	VOC	NO _x	CO	VOC	NO _x	CO
GSE	104.94	317.86	3,171.63	104.40	316.39	3,155.22
APU	7.04	88.18	104.36	7.03	88.10	103.86
Total:	111.98	406.04	3,275.99	111.43	404.49	3,259.08

Table 4.3–2. Season-day emissions (lbs/day) from airport GSE and APU.

	Maricopa County			8-hr ozone NAA		
	VOC	NO _x	CO	VOC	NO _x	CO
GSE	549.4	1,663.2	16,597.8	546.7	1,656.0	16,516.8
APU	37.8	473.4	557.3	37.8	473.0	554.8
Total:	587.3	2,136.6	17,155.0	584.5	2,128.9	17,071.7

4.4 Commercial equipment

Annual emissions from commercial equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of industrial employment in the nonattainment area to Maricopa County totals, as data on the number of wholesale establishments recommended by EIIP guidance (US EPA, 2002) was not available. See Section 1.5.1 for a discussion of the industrial employment data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/ weekend day activity allocation factor for commercial equipment (0.1666667) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on industrial employment ratios as described above.

Table 4.4–1. Annual and season-day emissions from commercial equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	1,924.41	1,361.42	30,224.21	14,537.1	8,334.7	203,404.4
8-hr ozone NAA	1,916.15	1,355.57	30,094.46	14,474.7	8,299.0	202,531.2

4.5 Construction and mining equipment

Annual emissions from construction and mining equipment in Maricopa County were calculated using EPA’s NONROAD2008a model as described in Section 4.1. Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of construction employment in the nonattainment area to Maricopa County totals as a conservative estimate, since the EIIP-recommended allocation factor of total dollar value of construction was unavailable (US EPA, 2002). See Section 1.5.1 for a discussion of the population data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/ weekend day activity allocation factor for construction/mining equipment (0.1666667) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US

EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on construction employment ratios as described above.

Table 4.5–1. Annual and season-day emissions from construction and mining equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	1,881.88	12,937.30	14,396.92	13,116.9	87,972.9	99,942.8
8-hr ozone NAA	1,941.80	13,349.23	14,855.32	13,534.5	90,774.0	103,125.0

4.6 Industrial equipment

Annual emissions from industrial equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of industrial employment in the nonattainment area to Maricopa County totals as a conservative estimate, since the number of employees in manufacturing, as recommended by EIIP guidance (US EPA, 2002), was not available. See Section 1.5.1 for a discussion of the industrial employment data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/ weekend day activity allocation factor for industrial equipment (0.1666667) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on industrial employment ratios as described above.

Table 4.6–1. Annual and season-day emissions from industrial equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	341.25	1,839.35	7,140.99	2,212.6	11,763.4	46,138.5
8-hr ozone NAA	339.78	1,831.45	7,110.33	2,203.1	11,712.9	45,940.4

4.7 Lawn and garden equipment

Annual emissions from lawn and garden equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. These results reflect new equipment population and usage estimates from survey work done in early 2003 for the Arizona Department of Environmental Quality (discussed further in Section 4.1). Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County totals, since the number of housing units, as recommended by EIIP guidance, was not available (US EPA, 2002). See Section 1.5.1 for a discussion of the population data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/ weekend day activity allocation factor for lawn and garden equipment (0.1600000 for the commercial segment, 0.2222222 for residential) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on population as described above.

Table 4.7–1. Annual and season-day emissions from lawn and garden equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	4,913.96	866.64	54,798.41	51,990.4	6,998.4	523,235.5
8-hr ozone NAA	4,970.15	876.55	55,425.05	52,584.9	7,078.4	529,218.9

4.8 Pleasure craft

Annual emissions from pleasure craft equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of lake surface area in the nonattainment area to Maricopa County totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.2 for a discussion of the land use data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/ weekend day activity allocation factor for pleasure craft (0.350000) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on lake surface area as described above.

Table 4.8–1. Annual and season-day emissions from pleasure craft equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
8-hr ozone NAA	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3

4.9 Railway maintenance equipment

Annual emissions from railway maintenance equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.1 for a discussion of the population data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/ weekend day activity allocation factor for railway maintenance equipment (0.1800000) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on the population ratio as described above.

Table 4.9–1. Annual and season-day emissions from railway maintenance equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	1.94	8.55	16.48	14.2	59.0	117.8
8-hr ozone NAA	1.96	8.64	16.67	14.4	59.7	119.1

4.10 Recreational equipment

Annual emissions from recreational equipment in Maricopa County were calculated using EPA's NONROAD2008a model, as described in Section 4.1. Annual emissions for the eight-hour ozone nonattainment area for this category were derived by applying the ratio of passive open space and vacant land use in the nonattainment area to Maricopa County totals, as recommended by EIIIP guidance (US EPA, 2002). See Section 1.5.2 for a discussion of the land use data used.

County season-day emissions were calculated by multiplying Maricopa County ozone season emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for recreational equipment (0.2222222) listed in Table 4.1–2, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999). Ozone nonattainment area season-day emissions were calculated based on land use as described above.

Table 4.10–1. Annual and season-day emissions from recreational equipment.

Geographic area	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Maricopa County	1,518.97	66.10	6,373.46	17,804.4	679.3	74,424.8
8-hr ozone NAA	684.30	29.78	2,871.27	8,020.9	306.0	33,528.7

4.11 Aircraft

Emissions from aircraft at the largest airports in Maricopa County were estimated using the Federal Aviation Administration's Emissions and Dispersion Model (EDMS, v. 5.1.3). The FAA EDMS model combines specified aircraft and activity levels with default emissions factors in order to estimate annual emissions inventories for a specific airport. The model calculates emissions of sulfur oxides (SO_x), oxides of nitrogen (NO_x), particulate matter (only for certain categories of airframes and engines), carbon monoxide (CO), and hydrocarbons (HC). The model can also estimate emissions from ground support equipment (GSE) and auxiliary power units (APUs), using either default profiles or user-specified activity of these components. The EDMS runs were executed by the Maricopa Association of Governments. The contact person for the EDMS emission estimates is Adam Xia (602-254-6300).

Aircraft emissions were estimated for four aircraft categories:

1. Air carriers (abbreviated "AC"): Larger commercial aircraft with at least 60 seats or 18,000 lbs payload capacity, used for scheduled service to transport passengers and/or freight;
2. Air taxis ("AT"): Smaller commercial turbine- or piston-powered aircraft with less than 60 seats or 18,000 lbs payload capacity;
3. General aviation ("GA"): Aircraft used on an unscheduled basis for recreational flying, personal transportation, and other activities, including business travel; and
4. Military ("ML"): Aircraft used to support military operations.

First, three databases from FAA's website provide the year 2011 aircraft activity, fleet mix for the types of aircraft used, and hourly/weekly/monthly operational profiles for eight major airports (Chandler Municipal, Falcon Field, Glendale Municipal, Phoenix Deer Valley, Phoenix Goodyear, Phoenix-Mesa Gateway, Phoenix Sky Harbor, and Scottsdale airport). The three databases are (1) FAA's Air Traffic Activity Data System (ATADS) (FAA, 2012a); (2)

Enhanced Traffic Management System Counts (ETMSC) database; and (3) FAA Aviation Performance Metrics (APM) database (FAA, 2012b).

To supplement the FAA's database for the eight major airports, MAG conducted a survey of six additional small general aviation airports (Buckeye Municipal, Gila Bend Municipal, Pleasant Valley, Sky Ranch at Carefree, Stellar Airpark, and Wickenburg Municipal airport) in Maricopa County to gather the year 2008 data on aircraft activity (landings and take-offs or LTOs) and estimated average taxi/idle times in 2009. The year 2008 data for these small general aviation airports are assumed to be the same as those in year 2011, since no updated aircraft activity data were available for the year 2011. Table 4.11-1 summarizes the activity level for each aircraft category for each airport included in the modeling, and indicates the data sources for each airport's activity (reported number of operations) and fleet mix.

One required meteorological input for EDMS is an atmospheric mixing height, which is defined as the height (or depth) above ground where relatively vigorous vertical mixing occurs due to convection. To calculate the time-varying mixing height, the latest version of the EPA AERMOD Meteorological Preprocessor (AERMET version 11059) was employed.

Table 4.11–1. Annual airport operations (by aircraft category) and related data sources.

Airport	Airport Code	Operations Data Source¹	Fleet Mix Data Source²	Aircraft Type³	2011 Operations
Buckeye Municipal	BXK	airnav.com	Generic GA profile	GA	53,070
Chandler Municipal	CHD	FAA/ATADS	FAA/ETMSC	AC	6
				AT	2,168
				GA	158,960
				ML	456
Falcon Field	FFZ	FAA/ATADS	FAA/ETMSC	AC	4
				AT	2,718
				GA	214,486
				ML	2,872
Gila Bend Municipal	E63	airnav.com	Generic GA profile	GA	3,536
Glendale Municipal	GEU	FAA/ATADS	FAA/ETMSC	AT	1,070
				GA	85,998
				ML	56
Luke Air Force Base	LUF	[2011 F-16 aircraft emissions were grown based on the total number of F-16 operations in 2008 vs. 2011]			
Phoenix Deer Valley	DVT	FAA/ATADS, Survey response	Survey response, FAA/ETMSC	AC	2
				AT	3,832
				GA	313,362 *
				ML	248
Phoenix Goodyear	GYR	FAA/ATADS, Survey response	Survey response, FAA/ETMSC	AC	146
				AT	312
				GA	132,566 *
				ML	5,582
Phoenix-Mesa Gateway (formerly Williams Gateway)	IWA	FAA/ATADS	FAA/ETMSC	AC	7,782
				AT	9,176
				GA	147,596
				ML	6,646
Phoenix Sky Harbor	PHX	FAA/ATADS	FAA/ETMSC	AC	375,104
				AT	63,796
				GA	20,582
				ML	2,506
Pleasant Valley	P48	airnav.com	Generic GA profile	GA	6,010
Scottsdale	SDL	FAA/ATADS	FAA/ETMSC	AC	6
				AT	12,970
				GA	127,924
				ML	740
Sky Ranch at Carefree	18AZ	Survey response	Generic GA profile	GA	3,030
Stellar Airpark	P19	airnav.com	Generic GA profile	GA	39,056
Wickenburg Municipal	E25	Survey responses	Generic GA profile	GA	12,000

1. FAA/ATADS: Federal Aviation Administration's Air Traffic Activity Data System (database); <http://aspm.faa.gov>.

2. FAA/ETMSC: Federal Aviation Administration's Enhanced Traffic Management System Counts (database); <http://aspm.faa.gov>.

3. AC: Air Commercial; AT: Air Taxi; GA: General Aviation; ML: Military

* includes touch-and-go operations reported by airport.

Both the 2011 hourly surface meteorological data and the 2011 one-minute Automated Surface Observing System (ASOS) wind data from the National Weather Service (NWS) station at the Phoenix Sky Harbor were used (NCDC, 2012). Full year upper air data in 2011 at the Tucson station (station number 23160) were obtained from the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Radiosonde Database (ESRL, 2012). Ultimately, a single mixing height dataset in 2011 is used for all airports, except Luke Air Force Base.

F-16 aircraft emissions estimates for Luke AFB for the year 2011 were scaled using a ratio of the number of F-16s in 2011 to the number of F-16s in 2008. The emissions from “transient” aircraft and on-wing engine testing in 2011 were assumed to be the same as those in 2008 based on input from Luke AFB. Emissions from the military aircraft, “transient” aircraft, and on-wing engine testing were summed into a single “ML” category for Luke AFB. This summation method is consistent with that used in the 2008 PM₁₀ Periodic Emissions Inventory Report for the Maricopa County, Arizona, Nonattainment Area (MCAQD, 2011).

As with all other airports included in this inventory, emissions from ground support equipment (GSE) at Luke AFB are addressed in Section 4.3, Airport ground support equipment and auxiliary power units.

The following section describes how activity and emissions were estimated for a representative airport, Falcon Field (FFZ). The FAA’s Air Traffic Activity System (ATADS, available at www.aspm.faa.gov) provided data on 2011 activity by aircraft type; these results are contained in Table 4.11–1. While ATADS reported a total of 214,486 general aviation operations at this airport in 2011, further information on the aircraft types comprising this activity was needed. The FAA’s Enhanced Traffic Management System Counts (ETMSC) database was used to “grow” available aircraft-specific operational data as described below.

The ETMSC database on general aviation activity at Falcon Field airport (FFZ) in 2011 comprises 145 different aircraft types, totaling 3,731 operations (See Table 4.11–2). To simplify modeling input requirements, this aircraft-specific activity data were ranked in order of decreasing frequency. Activity data for the most frequently reported aircraft was then grown to represent all general aviation activity. How this approach was applied for general aviation activity at Falcon Field airport is shown in Table 4.11–2.

This approach of ranking reported activity, and then growing this subset of data, typically resulted in a set of 10 to 30 aircraft types being modeled for each airport/aircraft class combination, representing 75 to 100% of all reported activity.

Ozone season-day emissions were calculated by dividing ozone season total emissions by 92 (the number of days in the ozone season). Tables 4.11–3 and 4.11–4 list the total annual emissions and season-day emissions, by airport and aircraft type for airports within and outside the eight-hour ozone nonattainment area, respectively.

Tables 4.11–3 and 4.11–4 list the total annual and seasonal daily emissions by aircraft type, for airports located inside and outside the eight-hour ozone nonattainment area, respectively.

Table 4.11–2. Growing aircraft-specific activity for EDMS modeling input.

Rank	Aircraft Type	ETMSC- Reported Operations	% of Total Reported Operations	Cumulative Percent	“Grown” Operations for EDMS Modeling
1	DA40 - Diamond Star DA40	536	14.37%	14.37%	40,796
2	BE9L - Beech King Air 90	350	9.38%	23.75%	26,640
3	P28R - Cherokee Arrow/Turbo	250	6.70%	30.45%	19,028
4	DA42 - Diamond Twin Star	163	4.37%	34.82%	12,406
5	BE20 - Beech 200 Super King	130	3.48%	38.30%	9,894
6	C25B - Cessna Citation CJ3	118	3.16%	41.46%	8,982
7	PC12 - Pilatus PC-12	110	2.95%	44.41%	8,372
8	C680 - Cessna Citation Sovereign	103	2.76%	47.17%	7,840
9	C441 - Cessna Conquest	99	2.65%	49.83%	7,536
10	B350 - Beech Super King Air 350	86	2.31%	52.13%	6,546
11	BE36 - Beech Bonanza 36	84	2.25%	54.38%	6,394
12	C172 - Cessna Skyhawk 172/Cutlass	83	2.22%	56.61%	6,318
13	CL60 - Bombardier Challenger 600/601/604	70	1.88%	58.48%	5,328
14	P46T - Piper Malibu Meridian	68	1.82%	60.31%	5,176
15	SR22 - Cirrus SR 22	67	1.80%	62.10%	5,100
16	P28A - Piper Cherokee	62	1.66%	63.76%	4,718
17	COL4 - Lancair LC-41 Columbia 400	52	1.39%	65.16%	3,958
18	TBM7 - Socata TBM-7	50	1.34%	66.50%	3,806
19	C182 - Cessna Skylane 182	48	1.29%	67.78%	3,654
20	C560 - Cessna Citation V/Ultra/Encore	47	1.26%	69.04%	3,578
21	M20P - Mooney M-20C Ranger	46	1.23%	70.28%	3,502
22	C210 - Cessna 210 Centurion	44	1.18%	71.46%	3,348
23	PAY2 - Piper Cheyenne 2	40	1.07%	72.53%	3,044
24	C525 - Cessna CitationJet/CJ1	38	1.02%	73.55%	2,892
25	BE35 - Beech Bonanza 35	37	0.99%	74.54%	2,816
26	C414 - Cessna Chancellor 414	37	0.99%	75.53%	2,814
⋮	⋮	⋮	⋮	⋮	
145	T34P - Beech T-34B Mentor	1	< 0.1%	100.00%	(n/a)
Total:		3,731			214,486

Table 4.11–3. Annual and season-day emissions, by aircraft type, for airports in the eight-hour ozone NAA.

Facility	Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
		VOC	NO _x	CO	VOC	NO _x	CO
Buckeye Municipal	GA	5.46	2.69	211.10	26.7	11.3	1,172.3
Chandler Municipal	AC	0.02	0.00	0.04	0.4	0.0	0.8
	AT	12.82	1.23	13.52	69.0	6.2	73.5
	GA	127.56	14.18	1,329.77	629.0	62.4	7,236.4
	ML	0.05	0.04	4.85	1.0	0.7	91.2
	Total	140.45	15.45	1,348.17	699.3	69.2	7,401.9
Falcon Field	AC	0.01	0.00	0.02	0.2	0.0	0.4
	AT	7.15	2.27	11.43	36.5	10.5	58.9
	GA	103.99	31.13	1,170.22	484.1	126.8	6,009.2
	ML	3.73	2.67	9.86	17.4	10.8	47.2
	Total	114.88	36.07	1,191.53	538.1	148.1	6,115.7
Gila Bend Municipal	GA	0.36	0.18	14.29	1.8	0.9	71.0
Glendale Municipal	AT	3.67	0.88	5.17	15.6	3.6	22.3
	GA	88.19	17.14	519.57	449.8	78.3	2,899.0
	ML	0.05	0.01	0.14	0.1	0.0	0.4
	Total	91.91	18.02	524.88	465.5	81.9	2,921.7
Luke Air Force Base	ML	154.13	347.83	601.72	844.5	1905.9	3,297.1
Phoenix Deer Valley	AC	0.00	0.00	0.00	0.0	0.0	0.0
	AT	13.65	3.00	17.69	60.0	11.9	78.4
	GA	93.34	52.99	2,382.41	525.7	278.4	15,313.0
	ML	0.20	0.11	0.70	1.2	0.5	3.9
	Total	107.19	56.10	2,400.81	586.9	290.8	15,395.2
Phoenix Goodyear	AC	0.12	0.40	0.92	0.5	1.6	4.4
	AT	0.53	1.01	1.49	2.4	4.5	6.9
	GA	43.39	13.80	1,224.97	234.8	62.9	7,380.0
	ML	3.55	1.31	17.22	25.8	8.6	132.6
	Total	47.60	16.52	1,244.61	263.6	77.6	7,523.9
Phoenix Sky Harbor Intl	AC	266.99	1,823.15	1,893.82	1,414.1	8,732.7	9,944.4
	AT	26.03	101.94	182.25	143.0	506.8	1,004.2
	GA	42.59	7.41	140.93	198.2	31.1	702.2
	ML	110.67	14.01	119.21	474.6	52.9	510.3
	Total	446.28	1,946.50	2,336.21	2,230.0	9,323.5	12,161.0
Phoenix-Mesa Gateway Airport	AC	2.25	27.46	33.32	12.3	138.9	179.9
	AT	56.62	3.53	58.50	285.8	16.2	298.1
	GA	146.94	9.81	713.40	666.4	39.8	3,512.1
	ML	47.87	25.62	100.88	202.6	95.6	428.0
	Total	253.68	66.42	906.11	1,167.2	290.5	4,418.1
Pleasant Valley	GA	0.21	1.61	2.69	1.1	7.6	14.6
Scottsdale	AC	0.02	0.00	0.04	0.0	0.0	0.0
	AT	57.90	8.19	69.79	242.1	31.8	295.1
	GA	274.72	67.08	650.51	1,271.3	283.6	3,082.5
	ML	1.33	0.35	3.64	5.3	1.2	14.6
	Total	333.96	75.63	723.98	1,518.7	316.5	3,392.1
Skyranch at Carefree	GA	1.63	0.58	16.13	4.9	1.6	55.5
Stellar Airpark	GA	7.69	2.38	197.13	37.5	9.9	1,053.5
8-hr ozone NAA total:		1,705.43	2,585.98	11,719.36	8,385.8	12,535.3	64,993.6

AC: Air Commercial; AT: Air Taxi; GA: General Aviation; ML: Military

Table 4.11–4. Annual and season-day emissions, by aircraft type, for airports outside the eight-hour ozone NAA.

Facility	Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
		VOC	NO _x	CO	VOC	NO _x	CO
Wickenburg Municipal	GA	13.90	2.84	62.02	65.2	12.9	331.8
Maricopa County total:		1,719.33	2,588.82	11,781.38	8,451.0	12,548.2	65,325.4

4.12 Locomotives

Annual emissions from locomotives were calculated based on diesel fuel usage provided by Burlington Northern/Santa Fe Railway (BNSF), Union Pacific Railway (UP) and Amtrak. Railway operations from these companies fall into three categories: Class I haul lines, yard/switching operations, and passenger trains. Annual emissions were calculated by multiplying diesel fuel usage by the emission factors listed in Table 4.12–1 (US EPA, 2009).

Table 4.12–1. Emission factors for locomotives.

Activity type	Emission factors (lbs/gal diesel)		
	VOC	NO _x	CO
Class I haul line	0.018	0.328	0.059
Yard/switch operations	0.032	0.517	0.060
Passenger trains	0.019	0.367	0.059

Fuel use reported by railroads and emission totals are summarized in Table 4.12–2.

Table 4.12–2. Fuel use and annual emissions from locomotives in Maricopa County.

Locomotive type	Diesel fuel used (gals)	Annual emissions (tons/yr)		
		VOC	NO _x	CO
Class I haul line	7,706,715	68.74	1,263.13	231.75
Yard/switch operations	520,076	8.43	134.44	12.63
Passenger trains	46,301	0.43	8.51	1.36
Total:	8,273,092	77.60	1,406.08	245.74

Eight-hour ozone nonattainment area emissions were calculated by multiplying Maricopa County emissions by the percentage of track miles inside the eight-hour ozone nonattainment area, determined by GIS mapping. Results are shown in Table 4.12–3.

Table 4.12–3. Annual emissions from locomotives in the eight-hour ozone NAA.

Locomotive type	Track in nonattainment area (%)	Annual emissions (tons/yr)		
		VOC	NO _x	CO
Class I haul line	60.65%	41.69	766.09	140.56
Yard/switch operations	100.00%	8.43	134.44	12.63
Passenger trains	6.98%	0.03	0.59	0.09
Total:		50.15	901.12	153.29

Ozone season-day emissions for both the county and the eight-hour ozone nonattainment area (shown in Table 4.12–4) were calculated by dividing annual totals by 365 days per year, as locomotive activity is assumed to be uniform throughout the year.

Table 4.12–4. Season-day emissions from locomotives in Maricopa County and the eight-hour ozone NAA.

Locomotive type	Maricopa County			8-hr ozone NAA		
	Season-day emissions (lbs/day)					
	VOC	NO _x	CO	VOC	NO _x	CO
Class I haul line	376.6	6,921.3	1,269.9	228.4	4,197.7	770.2
Yard/switch operations	46.2	736.7	69.2	46.2	736.7	69.2
Passenger trains	2.4	46.6	7.4	0.2	3.3	0.5
Total:	425.2	7,704.5	1,346.5	274.8	4,937.7	839.9

4.13 Summary of all nonroad mobile source emissions

Table 4.13–1 summarizes annual and season day emissions of VOC, NO_x, and CO from nonroad mobile sources in Maricopa County, respectively. Table 4.13–2 shows annual and season-day emissions for these pollutants for the eight-hour ozone nonattainment area.

Table 4.13–1. Annual and season-day emissions from nonroad mobile sources in Maricopa County.

Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Agricultural	38.53	330.49	303.71	329.3	2,762.6	2,584.4
Airport GSE & APUs	111.98	406.04	3,275.98	587.3	2,136.6	17,155.0
Commercial	1,924.41	1,361.42	30,224.21	14,537.1	8,334.7	203,404.4
Construction & mining	1,881.88	12,937.30	14,396.92	13,116.9	87,972.9	99,942.8
Industrial	341.25	1,839.35	7,140.99	2,212.6	11,763.4	46,138.5
Lawn & garden	4,913.96	866.64	54,798.41	51,990.4	6,998.4	523,235.5
Pleasure craft	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
Railway maintenance	1.94	8.55	16.48	14.2	59.0	117.8
Recreational	1,518.97	66.10	6,373.46	17,804.4	679.3	74,424.8
Aircraft	1,719.33	2,588.82	11,781.38	8,451.0	12,548.2	65,325.4
Locomotives	77.60	1,406.08	245.74	425.2	7,704.5	1,346.5
Total:	13,060.24	21,907.35	129,806.94	120,995.4	142,956.4	1,060,413.4

Table 4.13–2. Annual and season-day emissions from nonroad mobile sources in the eight-hour ozone NAA.

Category	Annual emissions (tons/yr)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
Agricultural	22.52	193.22	177.56	192.5	1,615.1	1,510.9
Airport GSE & APUs	111.43	404.49	3,259.08	584.5	2,128.9	17,071.7
Commercial	1,916.15	1,355.57	30,094.46	14,474.7	8,299.0	202,531.2
Construction & mining	1,941.80	13,349.23	14,855.32	13,534.5	90,774.0	103,125.0
Industrial	339.78	1,831.45	7,110.33	2,203.1	11,712.9	45,940.4
Lawn & garden	4,970.15	876.55	55,425.05	52,584.9	7,078.4	529,218.9
Pleasure craft	530.39	96.56	1,249.66	11,527.0	1,996.8	26,738.3
Railway maintenance	1.96	8.64	16.67	14.4	59.7	119.1
Recreational	684.30	29.78	2,871.27	8,020.9	306.0	33,528.7
Aircraft	1,705.43	2,585.98	11,719.36	8,385.8	12,535.3	64,993.6
Locomotives	50.15	901.12	153.29	274.8	4,937.7	839.9
Total:	12,274.06	21,632.59	126,932.05	111,797.1	141,443.8	1,025,617.7

4.14 Quality assurance procedures

Established procedures were used to check, and correct when necessary, the nonroad mobile sources emissions estimates. All NONROAD model input and output files, and Excel spreadsheets used to calculate the emissions, were checked by personnel who were not involved in the development of the modeling inputs/outputs and spreadsheets. In addition, the emissions estimates were reviewed for reasonableness by external agency staff.

4.15 References

- ENVIRON et al., 2003. Maricopa County 2002 Comprehensive Emission Inventory for the Cap and Trade Oversight Committee, Final Report prepared for Arizona Department of Environmental Quality, Oct. 9, 2003.
- ESRL, 2012. NOAA/ESRL Radiosonde Database, (<http://www.esrl.noaa.gov/raobs/>).
- FAA, 2012a. Air Traffic Activity System (ATADS), (<http://aspm.faa.gov/opsnet/sys/Airport.asp>).
- FAA, 2012b. Aviation Performance Metrics (APM), (<https://aspm.faa.gov/apm/sys/AnalysisAP.asp>).
- MCAQD, 2011. 2008 PM₁₀ Periodic Emissions Inventory for the Maricopa County, Nonattainment Area.
- NCDC, 2012. The 2008 1-minute Automated Surface Observing System (ASOS) Data, (<ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/>)
- US EPA, 2009. Emission Factors for Locomotives. Office of Transportation and Air Quality. Rep. EPA420-F-09-025, April 2009. Internet address: <http://www.epa.gov/otaq/regs/nonroad/locomotv/420f09025.pdf>.
- US EPA, 2002. Geographic Allocation of State Level Nonroad Engine Population Data to the County Level. EPA Office of Transportation and Air Quality, Rep. EPA420-P-02-009, July. Internet address: <http://www.epa.gov/otaq/models/nonrdmdl/p02009.pdf>
- US EPA, 1999. Weekday and Weekend Day Temporal Allocation of Activity in the NONROAD Model. EPA Office of Transportation and Air Quality, Rep. EPA420-P-99-033, March. Internet address: <http://www.epa.gov/otaq/models/nonrdmdl/p99033.pdf>

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5. Onroad Mobile Sources

5.1 Introduction

Onroad mobile source emissions for ozone precursors, such as volatile organic compounds (VOCs), nitrogen oxides (NO_x), and carbon monoxide (CO), have been calculated for the eight-hour ozone nonattainment area (NAA) and Maricopa County for the 2011 Periodic Emissions Inventory (PEI).

Motor Vehicle Emission Simulator (MOVES2010b) is the latest model developed by the U.S. Environmental Protection Agency (EPA) for the purpose of estimating onroad and off-network motor vehicle emission factors.

The MOVES2010b modeling accounted for the oxygenated fuel and the Arizona Vehicle Inspection/Maintenance (I/M) programs applied in Maricopa County in 2011. The fuel use assumptions, including oxygen content and Reid Vapor Pressure (RVP), were derived from the 2011 fuel inspection results provided by the Arizona Department of Weights and Measures.

In order to develop the 2011 onroad mobile source emissions, the 2011 vehicle miles traveled (VMT) estimates by facility type and road type were derived from the 2011 Highway Performance Monitoring System (HPMS) data provided by the Arizona Department of Transportation (ADOT). The distribution of VMT by vehicle type is based on the July 2011 vehicle registration data for Maricopa County provided by ADOT. The VMT by vehicle type was provided as local input data for MOVES2010b to produce onroad emissions.

The main references for preparing the onroad mobile source portion of the 2011 emissions inventory were:

- Emission Inventory Requirements for Ozone State Implementation Plans (US EPA, 1991);
- Procedures for Emission Inventory Preparation Volume IV: Mobile Sources (US EPA, 1992a);
- Quality Review Guidelines for 1990 Base Year Emission Inventories (US EPA, 1992b);
- User's Guide for the SMOKE-MOVES Integration Tool (US EPA, 2010);
- Motor Vehicle Emission Simulator (MOVES) - User Guide Version, MOVES2010b (US EPA, 2012a);
- Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for State Implementation Plan Development, Transportation Conformity, and Other Purposes (US EPA, 2012b); and
- Using MOVES to Prepare Emissions Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a and 2010b (US EPA, 2012c).

5.2 Onroad emissions

Vehicle exhaust and evaporative emission factors for VOC, NO_x, and CO were calculated using MOVES2010b. The MOVES2010b runs were executed by MAG. The contact person for the MOVES2010b emission estimates is Ieesuck Jung (602-254-6300).

5.2.1 MOVES2010b model

The emissions were calculated using MOVES2010b. MOVES2010b is EPA's state-of-the-art emissions modeling tool, which replaces EPA's previous mobile source emissions model, MOBILE6.2. MOVES2010b is intended for official use to estimate national, state, and county level inventories of criteria air pollutants from highway vehicles. The user of MOVES2010b is allowed to specify vehicle types, time periods, geographical areas, pollutants, vehicle operating characteristics, and road types for a particular scenario to be modeled by creating a Run Specification (RunSpec).

In order to calculate vehicle emissions for the calendar year 2011, MOVES2010b was executed using local input data for each month of the year and each geographical area (the eight-hour ozone nonattainment area and Maricopa County). Each scenario was created using the County Domain/Scale and the Inventory Calculation Type. The specific MOVES2010b model RunSpec and RunSpec summaries are described in Appendix C.

5.2.2 MOVES2010b local input data

Compared with MOBILE6.2, MOVES2010b requires a more detailed level of local data, including fuel data, I/M program, meteorological data, vehicle population, source type age distribution, annual VMT, monthly/daily/hourly VMT fractions, road type distribution, average speed distribution, ramp fraction, and Alternative Vehicle and Fuel Technologies (AVFT) strategy.

5.2.2.1 Fuel data

Regarding the fuel local input data, MOVES2010b provides two MOVES tables, which are [fuelsupply] and [fuelformulation]. The fuel data for each month were derived from the 2011 fuel inspection results in Maricopa County provided by the Arizona Department of Weights and Measures. The 2011 fuel inspection results reflected the committed control measure – California Phase 2 Reformulated Gasoline with (1) 3.5% Oxygen Content from November 1 through March 31 (MAG, 2003) and (2) 7 psi from May 1 through September 30 (MAG, 2009). The fuel data for Maricopa County were also applied to the eight-hour ozone nonattainment area. The specific MOVES tables for fuel data are presented in Appendix C.

5.2.2.2 I/M programs

MOVES2010b has an [IMCoverage] table for I/M programs; this table was prepared using MOBILE6.2 input. This table reflects the actual proportions of vehicles subject to the specified levels of inspection. The term "I/M vehicles" denotes vehicles which are required to undergo an emission test and/or inspection under the Vehicle Inspection/Maintenance Program. It is important to note that participation in the I/M program is required for all vehicles registered in Area A, with the exception of certain model years and vehicle classes. However, it is assumed that 91.6 percent of the vehicles operating within the eight-hour ozone nonattainment area and Maricopa County participate in the I/M program and the remaining 8.4 percent do not participate in the program. These percentages reflect the control measures "Tougher Enforcement of Vehicle Registration and Emissions Test Compliance" and "Expansion of Area A Boundaries," described in the MAG Eight-Hour Ozone Redesignation Request and Maintenance Plan for the

Maricopa Nonattainment Area (MAG, 2009). This percentage is directly applied to the Compliance Factor in the [IMCoverage] table. The same I/M programs were applied for the eight-hour ozone nonattainment area and Maricopa County. The specific MOVES table for I/M programs is presented in Appendix C.

5.2.2.3 *Meteorological data*

MOVES2010b requires hourly temperature and relative humidity data by specific month of the year. Meteorological data for the Phoenix Sky Harbor International Airport in 2011 were obtained from the National Climatic Data Center (<http://www.ncdc.noaa.gov/>). The same hourly average temperature and relative humidity data for each month were applied for the eight-hour ozone nonattainment area and Maricopa County. The specific MOVES table [ZoneMonthHour] for meteorological data is presented in Appendix C.

5.2.2.4 *Vehicle population*

In order to capture start, evaporative, and extended idle emissions, MOVES2010b introduced a new mobile source emission category called off-network emissions. In MOVES2010b, these off-network emissions are directly determined by population of vehicles in an area. The vehicle population in Maricopa County was obtained from the July 2011 vehicle registration data provided by ADOT. The vehicle population data were allocated to the 28 MOBILE6.2 vehicle types based on MOBILE6.2 VMT fractions for 2011. Then, the vehicle population data allocated to the 28 MOBILE6.2 vehicle types were assigned to the 13 MOVES source types using the match-up table (Table A.1) in EPA's technical guidance (EPA, 2012c). The vehicle population in the eight-hour ozone nonattainment area was estimated by applying the population ratio of the two geographical areas to the vehicle population in Maricopa County. The specific MOVES table [SourceTypeYear] for vehicle population is presented in Appendix C.

5.2.2.5 *Source type age distribution*

MOVES2010b categorizes vehicles according to vehicle classes and model years. The source type age distribution was prepared using EPA's data converter that takes the registration distribution input file created for MOBILE6.2 and converts it to the appropriate MOVES age distribution input table [SourceTypeAgeDistribution]. The same source type age distribution was applied for the eight-hour ozone nonattainment area and Maricopa County. The specific MOVES table for source type age distribution is presented in Appendix C.

5.2.2.6 *Annual VMT*

The 2011 daily VMTs by facility type were used to estimate onroad exhaust and evaporative emissions. The 2011 VMT distributions by facility type for the eight-hour ozone nonattainment area and Maricopa County were obtained from the 2011 Maricopa County Estimates of Daily Vehicle Travel by Highway Functional Classification provided by ADOT. The 2011 VMT distributions were multiplied by the 2011 HPMS VMT for the eight-hour ozone nonattainment area and Maricopa County. The resultant VMT estimates by facility type for the eight-hour ozone nonattainment area and Maricopa County are shown in Table 5.2-1.

Since MOVES2010b requires annual VMTs by HPMS vehicle type as a local input, the daily VMTs by HPMS vehicle type were derived from the 2011 traffic assignment data provided by

the MAG transportation modeling group in May 2011 and the daily VMTs by facility type and the estimated percentages of daily vehicle travel by vehicle type and highway functional classification provided by ADOT. Then, the daily VMTs by HPMS vehicle type were multiplied by 365 days to obtain the annual VMTs by HPMS vehicle type. The specific MOVES table [HPMSvTypeYear] for annual VMT is presented in Appendix C.

Table 5.2–1. 2011 daily VMT by facility type (annual average daily traffic).

Facility Type		8-hr ozone NAA (thousand miles/day)	Maricopa County (thousand miles/day)
Rural	Interstate	1,833	3,247
	Other Principal Arterial	897	1,589
	Minor Arterial	166	293
	Major Collector	734	1,301
	Minor Collector	95	168
	Local	149	264
Urban	Interstate	10,906	11,182
	Other Freeway/Expressway	19,263	19,750
	Other Principal Arterial	21,474	22,017
	Minor Arterial	13,767	14,115
	Collector	4,680	4,799
	Local	9,910	10,160
Total:		83,874	88,885

5.2.2.7 Road type distribution

MOVES2010b requires the distribution of VMTs by road type as a local input. The road type VMT distribution by HPMS vehicle type was derived from the 2011 traffic assignment data and the daily VMTs by HPMS vehicle type mentioned in the previous section. As suggested in EPA's technical guidance (US EPA, 2010), the same road type distribution by HPMS vehicle type was used for all MOVES source types within an HPMS vehicle class. The specific MOVES table [RoadTypeDistribution] for road type distribution is presented in Appendix C.

5.2.2.8 VMT fraction

Since VMT varies by month, day of week, and hour, MOVES2010b requires month/day/hour VMT fractions as a local input in order to derive hourly VMT for each weekday/weekend and month from the annual VMT. The month/day/hour VMT fractions were developed from data recorded by continuous traffic counters on freeways (ADOT Freeway Management System) and arterials (Phoenix Automatic Traffic Recorders) during the year 2007. The specific MOVES tables [MonthVMTFraction], [DayVMTFraction], and [HourVMTFraction] for VMT fractions are presented in Appendix C.

5.2.2.9 Average speed distribution

In MOVES2010b, vehicle power, speed, and acceleration have a significant effect on vehicle emissions for all pollutants. MOVES2010b estimates those emission effects by assigning activity to operating mode distributions, which are determined by the distribution of vehicle hours traveled (VHT) by average speed. As recommended in EPA's technical guidance (US EPA, 2010), estimates of local average speeds were developed by post-processing the output from the 2011 traffic assignment data provided by the MAG transportation modeling group in May 2011. To develop the average speed distribution, VHTs in sixteen speed bins were accumulated separately for each hour of the day, source type, and road type in Maricopa County. Then, the average speed distribution was calculated by normalizing VHTs in sixteen speed bins for each hour of the day, source type, and road type. The same methodology was applied to develop the speed estimates for the eight-hour ozone nonattainment area. The specific MOVES table [AvgSpeedDistribution] for the average speed distribution is presented in Appendix C.

5.2.2.10 Ramp fraction

MOVES2010b requires the ramp fraction, which represents the percent of VHT on ramps, on both rural restricted roads (road type 2) and urban restricted roads (road type 4). The fraction of VHT on ramps was derived by dividing the total VHTs on ramps by the total VHTs for each restricted road type. Those VHTs were obtained from the 2011 traffic assignment data provided by the MAG transportation modeling group in May 2011. The specific MOVES table [RoadType] for ramp fractions is presented in Appendix C.

5.2.2.11 AVFT strategy

MOVES2010b allows users to modify the fuel engine fraction using different fuels and technologies in each model year in order to reflect the local situation. The fleet information for transit buses for model years 1997 through 2011 was provided by Valley Metro and used to prepare the AVFT input file. Since the fleet data are available only for specific model years, MOVES2010b default values were obtained from the [fuelEngFraction] table in the MOVES default database and used for the rest of the model years. The specific MOVES table [AVFT] for AVFT strategy is presented in Appendix C.

5.2.2.12 Stage II refueling control programs

As an option, MOVES2010b allows to apply Stage refueling emission control programs. Since 1994, the Stage II refueling program has been implemented in Area A as one of committed control measures (MAG, 2009). The program efficiency of 46 percent for the refueling displacement vapor losses and the refueling spillage losses are assumed for LDGVs, LDGTs, and HDGVs (Yantorno, 2007). The same program efficiency was applied to the eight-hour ozone nonattainment area and Maricopa County. The specific MOVES table [CountyYear] for Stage II refueling control programs is presented in Appendix C.

5.2.3 MOVES2010b outputs

MOVES2010b was executed with the RunSpec files described in Appendix C to obtain exhaust and evaporative emissions for VOC, NO_x, and CO. These values were obtained for the following categories by month:

- Vehicle classes: light duty gasoline vehicles (LDGV), light duty gasoline trucks 1 and 2 (LDGT1), light duty gasoline trucks 3 and 4 (LDGT2), heavy duty gasoline vehicles 2B thru 8B and gasoline buses (HDGV), motorcycles (MC), light duty diesel vehicles (LDDV), light duty diesel trucks 1 thru 4 (LDDT), heavy duty diesel vehicles class 2B (2BHDDV), heavy duty diesel vehicles classes 3, 4, and 5 (LHDDV), heavy duty diesel vehicles classes 6 and 7 (MHDDV), heavy duty diesel vehicles classes 8A and 8B (HHDDV), and heavy duty diesel buses (BUSES)
- Facility types: rural interstate, rural principal arterial, rural minor arterial, rural major collector, rural minor collector, rural local, urban interstate, urban freeway/expressway, urban principal arterial, urban minor arterial, urban collector, urban local, and off-network, which was newly added in MOVES2010b
- Days: weekdays and weekend days

5.2.4 MOVES2010b emission estimates

MOVES2010b was used to generate onroad emissions by vehicle class, facility type, weekdays/weekend days, and month. By specifying the output time aggregate level as month, the model produces monthly emissions including weekday and weekend emissions for a given month. The annual emissions were calculated by aggregating monthly onroad emissions derived by MOVES2010b. The ozone season-day emissions were calculated by dividing the three-month peak ozone season emissions from July through September by 92 days.

Tables 5.2–2 and 5.2–3 show the calculated annual and ozone season-day VOC, NO_x, and CO emissions by facility type and vehicle class in the eight-hour ozone nonattainment area and Maricopa County, respectively.

Table 5.2–2. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in the eight-hour ozone NAA.

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NO _x	CO	VOC	NO _x	CO
Rural Interstate	LDGV	2201001110	28.13	110.70	758.49	163.3	604.9	5,232.5
	LDGT1	2201020110	51.89	243.02	1,356.15	303.6	1,314.9	9,185.7
	LDGT2	2201040110	26.73	125.19	698.62	156.4	677.4	4,732.0
	HDGV	2201070110	13.02	72.48	319.37	74.6	369.0	1,921.9
	MC	2201080110	6.40	4.22	69.24	34.8	21.0	368.5
	LDDV	2230001110	0.05	0.84	0.40	0.3	4.6	2.7
	LDDT	2230060110	1.62	13.96	8.85	9.2	77.5	60.3
	2BHDDV	2230071110	0.71	6.18	3.89	4.0	34.4	26.5
	LHDDV	2230072110	3.85	32.92	20.87	21.8	182.4	141.9
	MHDDV	2230073110	10.86	164.12	45.16	57.2	807.2	237.2
	HHDDV	2230074110	23.31	570.60	116.92	123.1	2,806.7	614.3
BUSES	2230075110	1.20	23.68	6.14	6.3	116.5	32.3	
Rural Principal Arterial	LDGV	2201001130	20.73	70.04	387.68	119.5	403.2	2,614.6
	LDGT1	2201020130	18.86	76.50	363.07	109.6	434.4	2,408.3
	LDGT2	2201040130	9.72	39.41	187.04	56.5	223.8	1,240.7
	HDGV	2201070130	3.53	17.03	71.63	20.3	90.3	435.2
	MC	2201080130	11.93	6.20	105.39	64.6	31.0	561.0
	LDDV	2230001130	0.04	0.63	0.26	0.2	3.7	1.7
	LDDT	2230060130	0.66	5.13	3.60	3.7	29.9	24.0
	2BHDDV	2230071130	0.29	2.28	1.58	1.6	13.3	10.6
	LHDDV	2230072130	1.57	12.04	8.49	8.8	70.1	56.7
	MHDDV	2230073130	2.27	27.40	8.99	11.9	135.0	47.2
	HHDDV	2230074130	3.98	80.40	19.42	21.0	396.0	102.0
BUSES	2230075130	0.40	6.97	1.97	2.1	34.3	10.3	
Rural Minor Arterial	LDGV	2201001150	20.14	68.06	376.72	116.1	391.8	2,540.7
	LDGT1	2201020150	18.33	74.33	352.81	106.5	422.1	2,340.3
	LDGT2	2201040150	9.44	38.29	181.75	54.9	217.4	1,205.6
	HDGV	2201070150	3.43	16.55	69.61	19.7	87.8	422.9
	MC	2201080150	11.59	6.03	102.42	62.8	30.1	545.1
	LDDV	2230001150	0.04	0.61	0.26	0.2	3.6	1.7
	LDDT	2230060150	0.64	4.98	3.49	3.6	29.0	23.4
	2BHDDV	2230071150	0.28	2.21	1.54	1.6	12.9	10.3
	LHDDV	2230072150	1.53	11.70	8.25	8.6	68.1	55.1
	MHDDV	2230073150	2.20	26.63	8.73	11.6	131.1	45.9
	HHDDV	2230074150	3.87	78.12	18.87	20.4	384.8	99.1
BUSES	2230075150	0.39	6.77	1.91	2.1	33.4	10.0	
Rural Major Collector	LDGV	2201001170	3.75	12.69	70.22	21.6	73.0	473.5
	LDGT1	2201020170	3.42	13.86	65.76	19.9	78.7	436.2
	LDGT2	2201040170	1.76	7.14	33.88	10.2	40.5	224.7
	HDGV	2201070170	0.64	3.08	12.97	3.7	16.4	78.8
	MC	2201080170	2.16	1.12	19.09	11.7	5.6	101.6
	LDDV	2230001170	0.01	0.11	0.05	0.0	0.7	0.3
	LDDT	2230060170	0.12	0.93	0.65	0.7	5.4	4.4
	2BHDDV	2230071170	0.05	0.41	0.29	0.3	2.4	1.9
	LHDDV	2230072170	0.28	2.18	1.54	1.6	12.7	10.3
	MHDDV	2230073170	0.41	4.96	1.63	2.2	24.4	8.5
	HHDDV	2230074170	0.72	14.56	3.52	3.8	71.7	18.5
BUSES	2230075170	0.07	1.26	0.36	0.4	6.2	1.9	

Table 5.2–2. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in the eight-hour ozone NAA (continued).

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
Rural Minor Collector	LDGV	2201001190	0.87	2.94	16.26	5.0	16.9	109.6
	LDGT1	2201020190	0.79	3.21	15.22	4.6	18.2	101.0
	LDGT2	2201040190	0.41	1.65	7.84	2.4	9.4	52.0
	HDGV	2201070190	0.15	0.71	3.00	0.9	3.8	18.2
	MC	2201080190	0.50	0.26	4.42	2.7	1.3	23.5
	LDDV	2230001190	0.00	0.03	0.01	0.0	0.2	0.1
	LDDT	2230060190	0.03	0.21	0.15	0.2	1.3	1.0
	2BHDDV	2230071190	0.01	0.10	0.07	0.1	0.6	0.4
	LHDDV	2230072190	0.07	0.50	0.36	0.4	2.9	2.4
	MHDDV	2230073190	0.10	1.15	0.38	0.5	5.7	2.0
HHDDV	2230074190	0.17	3.37	0.81	0.9	16.6	4.3	
BUSES	2230075190	0.02	0.29	0.08	0.1	1.4	0.4	
Rural Local	LDGV	2201001210	9.08	30.68	169.82	52.3	176.6	1,145.3
	LDGT1	2201020210	8.26	33.51	159.04	48.0	190.3	1,055.0
	LDGT2	2201040210	4.26	17.26	81.93	24.7	98.0	543.5
	HDGV	2201070210	1.55	7.46	31.38	8.9	39.6	190.6
	MC	2201080210	5.22	2.72	46.17	28.3	13.6	245.7
	LDDV	2230001210	0.02	0.27	0.12	0.1	1.6	0.8
	LDDT	2230060210	0.29	2.25	1.58	1.6	13.1	10.5
	2BHDDV	2230071210	0.13	1.00	0.69	0.7	5.8	4.6
	LHDDV	2230072210	0.69	5.27	3.72	3.9	30.7	24.8
	MHDDV	2230073210	0.99	12.00	3.94	5.2	59.1	20.7
HHDDV	2230074210	1.74	35.22	8.51	9.2	173.5	44.7	
BUSES	2230075210	0.18	3.05	0.86	0.9	15.0	4.5	
Urban Interstate	LDGV	2201001230	315.59	1,122.85	8,542.12	1,828.0	6,198.7	58,613.4
	LDGT1	2201020230	389.33	1,602.91	9,784.95	2,271.6	8,744.6	65,893.5
	LDGT2	2201040230	200.56	825.74	5,040.73	1,170.2	4,504.8	33,945.1
	HDGV	2201070230	125.37	594.77	2,799.95	712.5	3,011.8	16,433.1
	MC	2201080230	128.88	73.37	1,238.82	698.9	365.4	6,593.8
	LDDV	2230001230	0.54	8.81	4.59	3.0	49.4	30.9
	LDDT	2230060230	13.00	102.99	71.45	73.3	575.8	483.3
	2BHDDV	2230071230	5.68	45.66	31.36	32.0	255.6	212.6
	LHDDV	2230072230	31.01	242.58	169.13	174.7	1,354.0	1,141.6
	MHDDV	2230073230	93.83	1,316.73	378.86	494.4	6,475.6	1,990.4
HHDDV	2230074230	173.92	3,747.08	854.68	918.0	18,429.4	4,490.3	
BUSES	2230075230	14.35	272.67	73.30	75.6	1,341.1	385.1	
Urban Freeway And Express- way	LDGV	2201001250	331.11	1,178.07	8,962.22	1,917.9	6,503.5	61,496.0
	LDGT1	2201020250	408.48	1,681.74	10,266.18	2,383.3	9,174.7	69,134.0
	LDGT2	2201040250	210.43	866.35	5,288.63	1,227.8	4,726.3	35,614.5
	HDGV	2201070250	131.53	624.02	2,937.66	747.5	3,160.0	17,241.3
	MC	2201080250	135.22	76.98	1,299.75	733.2	383.3	6,918.1
	LDDV	2230001250	0.56	9.25	4.82	3.2	51.9	32.4
	LDDT	2230060250	13.64	108.06	74.96	76.9	604.1	507.1
	2BHDDV	2230071250	5.96	47.91	32.90	33.6	268.2	223.0
	LHDDV	2230072250	32.53	254.51	177.45	183.3	1,420.6	1,197.8
	MHDDV	2230073250	98.44	1,381.48	397.49	518.7	6,794.1	2,088.3
HHDDV	2230074250	182.48	3,931.36	896.71	963.2	19,335.8	4,711.2	
BUSES	2230075250	15.05	286.08	76.90	79.3	1,407.1	404.0	

Table 5.2–2. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in the eight-hour ozone NAA (continued).

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
Urban Principal Arterial	LDGV	2201001270	867.65	2,461.71	14,822.61	4,980.2	14,626.5	98,722.0
	LDGT1	2201020270	723.35	2,268.85	11,877.79	4,187.4	13,305.9	77,666.8
	LDGT2	2201040270	372.63	1,168.80	6,118.85	2,157.1	6,854.6	40,010.1
	HDGV	2201070270	159.42	526.27	2,610.59	907.1	2,833.3	15,528.2
	MC	2201080270	364.35	120.97	2,387.52	1,968.4	603.7	12,707.9
	LDDV	2230001270	1.49	24.89	10.67	8.3	150.4	69.4
	LDDT	2230060270	25.26	203.10	142.81	141.2	1,229.5	939.0
	2BHDDV	2230071270	11.03	90.29	62.60	61.7	547.5	412.4
	LHDDV	2230072270	60.30	478.09	338.58	336.9	2,889.2	2,221.8
	MHDDV	2230073270	99.13	1,116.86	362.02	522.0	5,499.7	1,901.7
HHDDV	2230074270	167.56	2,988.26	778.64	883.9	14,715.7	4,090.3	
BUSES	2230075270	14.31	229.46	66.76	75.4	1,130.0	350.7	
Urban Minor Arterial	LDGV	2201001290	441.02	1,251.27	7,534.27	2,531.4	7,434.6	50,180.0
	LDGT1	2201020290	367.67	1,153.25	6,037.43	2,128.4	6,763.4	39,477.6
	LDGT2	2201040290	189.41	594.10	3,110.19	1,096.5	3,484.2	20,337.0
	HDGV	2201070290	81.03	267.50	1,326.95	461.1	1,440.2	7,892.9
	MC	2201080290	185.20	61.49	1,213.57	1,000.5	306.8	6,459.4
	LDDV	2230001290	0.76	12.65	5.42	4.2	76.4	35.3
	LDDT	2230060290	12.84	103.24	72.59	71.8	625.0	477.3
	2BHDDV	2230071290	5.61	45.89	31.82	31.4	278.3	209.6
	LHDDV	2230072290	30.65	243.01	172.10	171.2	1,468.6	1,129.3
	MHDDV	2230073290	50.39	567.70	184.01	265.3	2,795.5	966.6
HHDDV	2230074290	85.17	1,518.92	395.78	449.3	7,479.9	2,079.1	
BUSES	2230075290	7.27	116.63	33.93	38.3	574.4	178.3	
Urban Collector	LDGV	2201001310	86.13	244.37	1,471.39	494.4	1,451.9	9,799.8
	LDGT1	2201020310	71.80	225.22	1,179.07	415.7	1,320.8	7,709.7
	LDGT2	2201040310	36.99	116.02	607.40	214.1	680.4	3,971.7
	HDGV	2201070310	15.82	52.24	259.14	90.0	281.3	1,541.4
	MC	2201080310	36.17	12.01	237.00	195.4	59.9	1,261.5
	LDDV	2230001310	0.15	2.47	1.06	0.8	14.9	6.9
	LDDT	2230060310	2.51	20.16	14.18	14.0	122.1	93.2
	2BHDDV	2230071310	1.10	8.96	6.21	6.1	54.4	40.9
	LHDDV	2230072310	5.99	47.46	33.61	33.4	286.8	220.5
	MHDDV	2230073310	9.84	110.87	35.94	51.8	545.9	188.8
HHDDV	2230074310	16.63	296.63	77.29	87.7	1,460.8	406.0	
BUSES	2230075310	1.42	22.78	6.63	7.5	112.2	34.8	
Urban Local	LDGV	2201001330	415.75	1,179.56	7,102.48	2,386.3	7,008.5	47,304.1
	LDGT1	2201020330	346.60	1,087.15	5,691.42	2,006.4	6,375.7	37,215.2
	LDGT2	2201040330	178.55	560.05	2,931.94	1,033.6	3,284.5	19,171.4
	HDGV	2201070330	76.39	252.17	1,250.90	434.7	1,357.6	7,440.6
	MC	2201080330	174.58	57.96	1,144.02	943.2	289.2	6,089.2
	LDDV	2230001330	0.71	11.93	5.11	4.0	72.0	33.3
	LDDT	2230060330	12.11	97.32	68.43	67.7	589.1	449.9
	2BHDDV	2230071330	5.29	43.26	30.00	29.6	262.4	197.6
	LHDDV	2230072330	28.89	229.09	162.23	161.4	1,384.4	1,064.6
	MHDDV	2230073330	47.50	535.16	173.46	250.1	2,635.3	911.2
HHDDV	2230074330	80.29	1,431.87	373.10	423.5	7,051.3	1,960.0	
BUSES	2230075330	6.86	109.95	31.99	36.1	541.4	168.1	

Table 5.2–2. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in the eight-hour ozone NAA (continued).

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
	LDGV	220100100	9,402.26	4,424.20	43,163.97	61,052.9	23,759.3	183,525.8
	LDGT1	220102000	2,588.87	1,468.89	19,360.70	16,455.7	7,981.9	96,124.0
	LDGT2	220104000	1,333.66	756.70	9,973.69	8,477.2	4,111.9	49,518.4
	HDGV	220107000	372.55	217.03	4,052.96	2,338.4	1,182.2	20,958.3
	MC	220108000	547.02	2.43	83.60	4,271.9	9.8	208.1
Off- Network	LDDV	223000100	6.48	27.63	25.05	22.4	120.8	131.4
	LDDT	223006000	3.32	26.59	16.91	7.6	120.8	87.9
	2BHDDV	223007100	1.42	11.66	7.35	3.2	52.9	38.2
	LHDDV	223007200	7.79	62.35	39.03	17.8	283.1	202.6
	MHDDV	223007300	24.50	144.11	189.20	112.6	621.4	1,016.4
	HHDDV	223007400	418.93	2,672.32	1,119.58	2,179.6	12,161.2	5,908.3
	BUSES	223007500	1.63	4.45	96.15	0.1	0.0	522.5

Table 5.2–3. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in Maricopa County.

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
Rural Interstate	LDGV	2201001110	41.81	166.74	1,147.40	242.9	911.2	7,919.6
	LDGT1	2201020110	100.56	475.25	2,658.13	588.5	2,571.6	18,011.7
	LDGT2	2201040110	51.80	244.83	1,369.34	303.2	1,324.8	9,278.8
	HDGV	2201070110	21.52	118.92	538.20	123.8	610.0	3,301.0
	MC	2201080110	11.22	7.49	122.76	61.0	37.3	653.4
	LDDV	2230001110	0.07	1.25	0.60	0.4	6.9	4.1
	LDDT	2230060110	3.14	27.11	17.13	17.7	150.4	116.7
	2BHDDV	2230071110	1.37	12.00	7.53	7.8	66.7	51.4
	LHDDV	2230072110	7.47	63.90	40.44	42.2	354.2	275.0
	MHDDV	2230073110	17.23	281.49	73.31	90.8	1,384.5	385.2
HHDDV	2230074110	45.10	1,129.87	228.30	238.2	5,557.7	1,199.4	
BUSES	2230075110	1.71	34.23	8.79	9.0	168.4	46.2	
Rural Principal Arterial	LDGV	2201001130	33.65	113.61	629.45	193.9	654.0	4,244.8
	LDGT1	2201020130	36.88	149.19	708.92	214.4	847.2	4,701.6
	LDGT2	2201040130	19.00	76.86	365.20	110.4	436.4	2,422.1
	HDGV	2201070130	6.69	31.89	135.07	38.5	169.7	824.3
	MC	2201080130	21.15	10.98	186.63	114.5	54.8	993.4
	LDDV	2230001130	0.06	1.02	0.43	0.3	5.9	2.8
	LDDT	2230060130	1.30	10.05	7.05	7.3	58.6	47.1
	2BHDDV	2230071130	0.57	4.46	3.10	3.2	26.1	20.7
	LHDDV	2230072130	3.08	23.59	16.65	17.3	137.3	111.1
	MHDDV	2230073130	4.17	51.42	16.61	22.0	253.2	87.3
HHDDV	2230074130	7.84	159.49	38.37	41.4	785.5	201.6	
BUSES	2230075130	0.72	12.48	3.53	3.8	61.5	18.5	
Rural Minor Arterial	LDGV	2201001150	32.70	110.40	611.65	188.5	635.5	4,124.9
	LDGT1	2201020150	35.84	144.97	688.88	208.3	823.2	4,568.7
	LDGT2	2201040150	18.46	74.68	354.88	107.3	424.1	2,353.6
	HDGV	2201070150	6.50	30.98	131.25	37.4	164.9	801.0
	MC	2201080150	20.55	10.67	181.35	111.3	53.2	965.3
	LDDV	2230001150	0.06	0.99	0.42	0.3	5.8	2.8
	LDDT	2230060150	1.26	9.76	6.85	7.1	56.9	45.8
	2BHDDV	2230071150	0.55	4.34	3.01	3.1	25.3	20.2
	LHDDV	2230072150	2.99	22.92	16.18	16.8	133.4	107.9
	MHDDV	2230073150	4.05	49.96	16.14	21.3	246.1	84.8
HHDDV	2230074150	7.62	154.98	37.28	40.2	763.3	195.9	
BUSES	2230075150	0.70	12.13	3.43	3.7	59.8	18.0	
Rural Major Collector	LDGV	2201001170	6.09	20.58	114.00	35.1	118.4	768.8
	LDGT1	2201020170	6.68	27.02	128.40	38.8	153.4	851.6
	LDGT2	2201040170	3.44	13.92	66.14	20.0	79.0	438.7
	HDGV	2201070170	1.21	5.78	24.46	7.0	30.7	149.3
	MC	2201080170	3.83	1.99	33.80	20.7	9.9	179.9
	LDDV	2230001170	0.01	0.18	0.08	0.1	1.1	0.5
	LDDT	2230060170	0.23	1.82	1.28	1.3	10.6	8.5
	2BHDDV	2230071170	0.10	0.81	0.56	0.6	4.7	3.8
	LHDDV	2230072170	0.56	4.27	3.01	3.1	24.9	20.1
	MHDDV	2230073170	0.76	9.31	3.01	4.0	45.9	15.8
HHDDV	2230074170	1.42	28.89	6.95	7.5	142.3	36.5	
BUSES	2230075170	0.13	2.26	0.64	0.7	11.1	3.4	

Table 5.2–3. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in Maricopa County (continued).

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
Rural Minor Collector	LDGV	2201001190	1.41	4.76	26.39	8.1	27.4	178.0
	LDGT1	2201020190	1.55	6.26	29.73	9.0	35.5	197.1
	LDGT2	2201040190	0.80	3.22	15.31	4.6	18.3	101.6
	HDGV	2201070190	0.28	1.34	5.66	1.6	7.1	34.6
	MC	2201080190	0.89	0.46	7.83	4.8	2.3	41.7
	LDDV	2230001190	0.00	0.04	0.02	0.0	0.2	0.1
	LDDT	2230060190	0.05	0.42	0.30	0.3	2.5	2.0
	2BHDDV	2230071190	0.02	0.19	0.13	0.1	1.1	0.9
	LHDDV	2230072190	0.13	0.99	0.70	0.7	5.8	4.7
	MHDDV	2230073190	0.17	2.16	0.70	0.9	10.6	3.7
HHDDV	2230074190	0.33	6.69	1.61	1.7	32.9	8.5	
BUSES	2230075190	0.03	0.52	0.15	0.2	2.6	0.8	
Rural Local	LDGV	2201001210	14.74	49.77	275.73	85.0	286.5	1,859.5
	LDGT1	2201020210	16.15	65.35	310.54	93.9	371.1	2,059.6
	LDGT2	2201040210	8.32	33.67	159.98	48.4	191.2	1,061.0
	HDGV	2201070210	2.93	13.97	59.17	16.8	74.3	361.1
	MC	2201080210	9.27	4.81	81.75	50.2	24.0	435.1
	LDDV	2230001210	0.03	0.45	0.19	0.1	2.6	1.2
	LDDT	2230060210	0.57	4.40	3.09	3.2	25.7	20.6
	2BHDDV	2230071210	0.25	1.96	1.36	1.4	11.4	9.1
	LHDDV	2230072210	1.35	10.33	7.29	7.6	60.1	48.7
	MHDDV	2230073210	1.83	22.52	7.28	9.6	110.9	38.2
HHDDV	2230074210	3.43	69.87	16.81	18.1	344.1	88.3	
BUSES	2230075210	0.31	5.47	1.55	1.7	26.9	8.1	
Urban Interstate	LDGV	2201001230	321.75	1,147.02	8,736.08	1,863.8	6,328.9	59,952.7
	LDGT1	2201020230	398.95	1,645.13	10,050.63	2,327.9	8,971.4	67,690.5
	LDGT2	2201040230	205.52	847.49	5,177.59	1,199.2	4,621.6	34,870.8
	HDGV	2201070230	129.18	613.34	2,887.04	734.1	3,105.0	16,939.0
	MC	2201080230	131.85	75.30	1,270.33	715.0	375.0	6,761.5
	LDDV	2230001230	0.55	8.99	4.69	3.1	50.4	31.5
	LDDT	2230060230	13.33	105.63	73.26	75.1	590.3	495.6
	2BHDDV	2230071230	5.82	46.83	32.15	32.9	262.1	218.0
	LHDDV	2230072230	31.79	248.83	173.43	179.1	1,388.4	1,170.7
	MHDDV	2230073230	96.93	1,361.53	391.49	510.7	6,696.0	2,056.8
HHDDV	2230074230	179.94	3,879.33	884.45	949.8	19,079.9	4,646.8	
BUSES	2230075230	14.81	281.59	75.68	78.0	1,385.0	397.6	
Urban Freeway and Express- way	LDGV	2201001250	337.58	1,203.43	9,165.73	1,955.5	6,640.2	62,901.2
	LDGT1	2201020250	418.57	1,726.04	10,544.93	2,442.3	9,412.6	71,019.7
	LDGT2	2201040250	215.63	889.17	5,432.23	1,258.2	4,848.9	36,585.8
	HDGV	2201070250	135.53	643.51	3,029.03	770.2	3,257.7	17,772.0
	MC	2201080250	138.33	79.00	1,332.81	750.1	393.4	7,094.0
	LDDV	2230001250	0.58	9.43	4.92	3.2	52.9	33.1
	LDDT	2230060250	13.98	110.83	76.86	78.8	619.4	519.9
	2BHDDV	2230071250	6.11	49.13	33.73	34.5	275.0	228.7
	LHDDV	2230072250	33.36	261.06	181.96	187.9	1,456.7	1,228.3
	MHDDV	2230073250	101.70	1,428.49	410.75	535.8	7,025.3	2,158.0
HHDDV	2230074250	188.78	4,070.12	927.95	996.5	20,018.3	4,875.3	
BUSES	2230075250	15.54	295.43	79.40	81.9	1,453.1	417.2	

Table 5.2–3. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in Maricopa County (continued).

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
Urban Principal Arterial	LDGV	2201001270	887.40	2,518.28	15,177.93	5,093.7	14,946.0	101,100.4
	LDGT1	2201020270	740.73	2,323.35	12,173.14	4,288.1	13,611.0	79,607.5
	LDGT2	2201040270	381.59	1,196.87	6,271.01	2,209.0	7,011.7	41,009.9
	HDGV	2201070270	163.87	541.20	2,685.49	932.4	2,910.9	15,968.7
	MC	2201080270	372.91	123.95	2,445.17	2,014.6	618.5	13,014.7
	LDDV	2230001270	1.53	25.46	10.92	8.5	153.6	71.0
	LDDT	2230060270	25.87	207.85	146.31	144.6	1,256.8	962.1
	2BHDDV	2230071270	11.30	92.40	64.13	63.2	559.6	422.5
	LHDDV	2230072270	61.76	489.28	346.88	345.0	2,953.3	2,276.6
	MHDDV	2230073270	102.21	1,151.68	373.34	538.2	5,671.2	1,961.2
HHDDV	2230074270	172.44	3,077.56	801.69	909.6	15,155.6	4,211.4	
BUSES	2230075270	14.77	236.81	68.89	77.8	1,166.2	361.9	
Urban Minor Arterial	LDGV	2201001290	451.06	1,280.03	7,714.88	2,589.1	7,597.0	51,389.0
	LDGT1	2201020290	376.51	1,180.95	6,187.56	2,179.6	6,918.4	40,464.2
	LDGT2	2201040290	193.96	608.37	3,187.53	1,122.8	3,564.0	20,845.2
	HDGV	2201070290	83.30	275.09	1,365.02	473.9	1,479.6	8,116.9
	MC	2201080290	189.55	63.00	1,242.87	1,024.0	314.4	6,615.3
	LDDV	2230001290	0.78	12.94	5.55	4.3	78.1	36.1
	LDDT	2230060290	13.15	105.65	74.37	73.5	638.8	489.0
	2BHDDV	2230071290	5.74	46.97	32.60	32.1	284.5	214.8
	LHDDV	2230072290	31.39	248.70	176.32	175.4	1,501.2	1,157.2
	MHDDV	2230073290	51.95	585.39	189.77	273.6	2,882.6	996.9
HHDDV	2230074290	87.65	1,564.31	407.50	462.3	7,703.5	2,140.7	
BUSES	2230075290	7.51	120.37	35.02	39.5	592.8	184.0	
Urban Collector	LDGV	2201001310	88.09	249.98	1,506.66	505.6	1,483.6	10,035.9
	LDGT1	2201020310	73.53	230.63	1,208.39	425.7	1,351.1	7,902.4
	LDGT2	2201040310	37.88	118.81	622.50	219.3	696.0	4,070.9
	HDGV	2201070310	16.27	53.72	266.58	92.6	289.0	1,585.2
	MC	2201080310	37.02	12.30	242.72	200.0	61.4	1,291.9
	LDDV	2230001310	0.15	2.53	1.08	0.8	15.2	7.1
	LDDT	2230060310	2.57	20.63	14.52	14.4	124.8	95.5
	2BHDDV	2230071310	1.12	9.17	6.37	6.3	55.6	41.9
	LHDDV	2230072310	6.13	48.57	34.43	34.3	293.2	226.0
	MHDDV	2230073310	10.15	114.32	37.06	53.4	563.0	194.7
HHDDV	2230074310	17.12	305.50	79.58	90.3	1,504.4	418.1	
BUSES	2230075310	1.47	23.51	6.84	7.7	115.8	35.9	
Urban Local	LDGV	2201001330	425.21	1,206.67	7,272.74	2,440.7	7,161.6	48,443.8
	LDGT1	2201020330	354.93	1,113.27	5,832.94	2,054.7	6,521.9	38,145.1
	LDGT2	2201040330	182.84	573.50	3,004.85	1,058.5	3,359.8	19,650.5
	HDGV	2201070330	78.52	259.32	1,286.79	446.8	1,394.8	7,651.6
	MC	2201080330	178.68	59.39	1,171.64	965.3	296.4	6,236.2
	LDDV	2230001330	0.73	12.20	5.23	4.1	73.6	34.0
	LDDT	2230060330	12.40	99.59	70.11	69.3	602.2	461.0
	2BHDDV	2230071330	5.41	44.27	30.73	30.3	268.2	202.5
	LHDDV	2230072330	29.59	234.45	166.21	165.3	1,415.1	1,090.9
	MHDDV	2230073330	48.97	551.84	178.89	257.9	2,717.4	939.8
HHDDV	2230074330	82.63	1,474.66	384.14	435.8	7,262.0	2,018.0	
BUSES	2230075330	7.08	113.47	33.01	37.3	558.8	173.4	

Table 5.2-3. Annual and ozone season-day onroad mobile source emissions by facility type and vehicle class in Maricopa County (continued).

Facility Type	Vehicle Class	SCC	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
			VOC	NO _x	CO	VOC	NO _x	CO
	LDGV	2201001000	9,343.57	4,398.52	42,913.45	60,666.2	23,621.4	182,460.8
	LDGT1	2201020000	2,565.00	1,457.16	19,206.53	16,298.8	7,918.2	95,359.0
	LDGT2	2201040000	1,321.36	750.66	9,894.27	8,396.3	4,079.0	49,124.2
	HDGV	2201070000	369.74	215.64	4,033.93	2,320.0	1,174.6	20,862.9
	MC	2201080000	539.75	2.40	82.65	4,215.5	9.7	205.7
Off-	LDDV	2230001000	6.44	27.47	24.90	22.3	120.1	130.6
Network	LDDT	2230060000	3.29	26.39	16.79	7.6	119.8	87.2
	2BHDDV	2230071000	1.41	11.57	7.30	3.2	52.5	37.9
	LHDDV	2230072000	7.74	61.88	38.74	17.6	281.0	201.1
	MHDDV	2230073000	26.03	153.86	192.53	120.6	666.0	1,033.9
	HHDDV	2230074000	448.68	2,863.21	1,186.93	2,336.0	13,033.7	6,262.1
	BUSES	2230075000	1.62	4.42	95.35	0.1	0.0	518.1

5.3 Summary of ozone precursor emissions from onroad mobile sources

Tables 5.3–1 and 5.3–2 show the annual and ozone season-day onroad mobile source emissions by facility type in the eight-hour ozone nonattainment area and Maricopa County, respectively.

Table 5.3–1. Annual and ozone season-day onroad mobile source emissions by facility type in the eight-hour ozone NAA.

Facility Type	Annual emissions (tons/year)			Season-day emissions (lbs/day)			
	VOC	NOx	CO	VOC	NOx	CO	
Rural	Interstate	167.77	1,367.91	3,404.10	954.6	7,016.5	22,555.8
	Principal Arterial	73.98	344.03	1,159.12	419.8	1,865.0	7,512.3
	Minor Arterial	71.88	334.28	1,126.36	408.1	1,812.1	7,300.1
	Major Collector	13.39	62.30	209.96	76.1	337.7	1,360.6
	Minor Collector	3.12	14.42	48.60	17.8	78.3	314.9
	Local	32.41	150.69	507.76	183.8	816.9	3,290.7
Urban	Interstate	1,492.06	9,956.16	28,989.94	8,452.2	51,306.2	190,213.1
	Freeway/Expressway	1,565.43	10,445.81	30,415.67	8,867.9	53,829.6	199,567.7
	Principal Arterial	2,866.48	11,677.55	39,579.44	16,229.6	64,386.0	254,620.3
	Minor Arterial	1,457.02	5,935.65	20,118.06	8,249.4	32,727.3	129,422.4
	Collector	284.55	1,159.19	3,928.92	1,610.9	6,391.4	25,275.2
	Local	1,373.52	5,595.47	18,965.08	7,776.6	30,851.4	122,005.2
Off-network	14,708.43	9,818.36	78,128.19	94,939.4	50,405.3	358,241.9	
Total	24,110.04	56,861.82	226,581.20	148,186.2	301,823.7	1,321,680.2	

Table 5.3–2. Annual and ozone season-day onroad mobile source emissions by facility type in Maricopa County.

Facility Type	Annual emissions (tons/year)			Season-day emissions (lbs/day)			
	VOC	NOx	CO	VOC	NOx	CO	
Rural	Interstate	303.00	2,563.08	6,211.93	1,725.5	13,143.7	41,242.5
	Principal Arterial	135.11	645.04	2,111.01	767.0	3,490.2	13,675.3
	Minor Arterial	131.28	626.78	2,051.32	745.3	3,391.5	13,288.9
	Major Collector	24.46	116.83	382.33	138.9	632.0	2,476.9
	Minor Collector	5.66	27.05	88.53	32.0	146.3	573.7
	Local	59.18	282.57	924.74	336.0	1,528.8	5,990.5
Urban	Interstate	1,530.42	10,261.01	29,756.82	8,668.7	52,854.0	195,231.5
	Freeway/Expressway	1,605.69	10,765.64	31,220.30	9,094.9	55,453.5	204,833.2
	Principal Arterial	2,936.38	11,984.69	40,564.90	16,624.7	66,014.4	260,967.9
	Minor Arterial	1,492.55	6,091.77	20,618.99	8,450.1	33,554.9	132,649.3
	Collector	291.50	1,189.67	4,026.73	1,650.4	6,553.1	25,905.5
	Local	1,406.99	5,742.63	19,437.28	7,966.0	31,631.8	125,046.8
Off-network	14,634.63	9,973.18	77,693.37	94,404.2	51,076.0	356,283.5	
Total	24,556.85	60,269.94	235,088.25	150,603.7	319,470.2	1,378,165.5	

Tables 5.3–3 and 5.3–4 present the same emissions by vehicle class in the eight-hour ozone nonattainment area and Maricopa County, respectively.

Table 5.3–3. Annual and ozone season-day onroad mobile source emissions by vehicle class in the eight-hour ozone NAA.

Vehicle Class	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
LDGV	11,942.21	12,157.14	93,378.25	75,668.9	68,649.4	521,757.3
LDGT1	4,997.65	9,932.44	66,509.59	30,440.7	56,125.6	408,747.3
LDGT2	2,574.55	5,116.70	34,262.49	15,681.6	28,913.2	210,566.7
HDGV	984.43	2,651.31	15,746.11	5,819.4	13,873.3	90,103.4
MC	1,609.22	425.76	7,951.01	10,016.4	2,120.7	42,083.4
LDDV	10.85	100.12	57.82	46.7	550.2	346.9
LDDT	86.04	688.92	479.65	471.5	4,022.6	3,161.3
2BHDDV	37.56	305.81	210.30	205.9	1,788.7	1,388.6
LHDDV	205.15	1,621.70	1,135.36	1,123.8	9,453.6	7,469.4
MHDDV	440.46	5,409.17	1,789.81	2,303.5	26,530.0	9,424.9
HHDDV	1,158.77	17,368.71	4,663.83	6,083.6	84,483.4	24,528.1
BUSES	63.15	1,084.04	396.98	324.2	5,313.0	2,102.9
Total	24,110.04	56,861.82	226,581.20	148,186.2	301,823.7	1,321,680.2

Table 5.3–4. Annual and ozone season-day onroad mobile source emissions by vehicle class in Maricopa County.

Vehicle Class	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
LDGV	11,985.06	12,469.79	95,292.09	75,868.1	70,411.7	535,379.4
LDGT1	5,125.88	10,544.57	69,728.72	31,170.0	59,506.6	430,578.7
LDGT2	2,640.60	5,432.05	35,920.83	16,057.2	30,654.8	221,813.1
HDGV	1,015.54	2,804.70	16,447.69	5,995.1	14,668.3	94,367.6
MC	1,655.00	451.74	8,402.31	10,247.0	2,250.3	44,488.1
LDDV	10.99	102.95	59.03	47.5	566.4	354.9
LDDT	91.14	730.13	507.92	500.2	4,256.8	3,351.0
2BHDDV	39.77	324.10	222.70	218.7	1,892.8	1,472.4
LHDDV	217.34	1,718.77	1,202.24	1,192.3	10,004.6	7,918.3
MHDDV	466.15	5,763.97	1,890.88	2,438.8	28,272.7	9,956.3
HHDDV	1,242.98	18,784.48	5,001.56	6,527.4	91,383.2	26,302.6
BUSES	66.40	1,142.69	412.28	341.4	5,602.0	2,183.1
Total	24,556.85	60,269.94	235,088.25	150,603.7	319,470.2	1,378,165.5

Table 5.3–5 summarizes annual and ozone season-day emissions for VOC, NO_x, and CO from all onroad mobile sources in the eight-hour ozone nonattainment area and Maricopa County in 2011.

Table 5.3–5. Annual and ozone season-day emissions from all onroad mobile sources in the eight-hour ozone NAA and Maricopa County.

	Annual emissions (tons/year)			Season-day emissions (lbs/day)		
	VOC	NO _x	CO	VOC	NO _x	CO
8-hr ozone NAA	24,110.04	56,861.82	226,581.20	148,186.2	301,823.7	1,321,680.2
Maricopa County	24,556.85	60,269.94	235,088.25	150,603.7	319,470.2	1,378,165.5

5.4 Quality assurance process

5.4.1 VMT estimates

Normal quality assurance procedures, including automated and manual consistency checks, were conducted by MAG in developing the 2011 TransCAD traffic assignment network used to generate the VMT data. The VMT estimates using the MAG travel demand model have been validated by the MAG transportation modeling group.

5.4.2 Emission estimates

The quality assurance process performed on the MOVES2010b analyses included accuracy, completeness, and reasonableness checks. For accuracy and completeness, all calculations were checked by an independent reviewer. Any errors found were corrected and the corrections were then rechecked by the reviewer.

5.4.3 Draft emissions inventory for ozone precursors

The draft onroad mobile source portion of the 2011 periodic emissions inventory for ozone precursors was reviewed using published EPA quality review guidelines for base year emissions inventories (EPA, 1992b). The procedure review (Levels I, II, and III) included checks for completeness, consistency, and the correct use of appropriate procedures.

5.5 References

- MAG, 2003. Carbon Monoxide Redesignation Request and Maintenance Plan for the Maricopa County Nonattainment Area, May 2003.
- MAG, 2009. MAG Eight-Hour Ozone Redesignation Request and Maintenance Plan for the Maricopa Nonattainment Area, February 2009.
- US EPA, 1991. Emission Inventory Requirements for Ozone State Implementation Plans, EPA-450/4-91-010, March 1991.
- US EPA, 1992a. Procedures for Emission Inventory Preparation Volume IV: Mobile Sources, EPA-450/4-81-026d (Revised), 1992.
- US EPA, 1992b. Quality Review Guidelines for 1990 Base Year Emission Inventories, EPA-454/R-92-007, July 1992.
- US EPA, 2010. User's Guide for the SMOKE-MOVES Integration Tool, EPA Contract EP-D-07-102 (WA 3-03), July 2010.
- US EPA, 2012a. Motor Vehicle Emission Simulator (MOVES) - User Guide Version, MOVES2010b, EPA-420-B-12-001, March 2012.
- US EPA, 2012b. Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for State Implementation Plan Development, Transportation Conformity, and Other Purposes, EPA-420-B-12-010, April 2012.
- US EPA, 2012c. Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a and 2010b, EPA-420-B-12-028, April 2012.
- Yantorno, D., 2007. E-mail correspondence with Mr. Duane Yantorno at the Arizona Department of Weights and Measures, February 16, 2007.

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6. Biogenic Sources

6.1 Introduction

Biogenic emissions have been estimated for the 2011 Periodic Emissions Inventory for ozone precursors in Maricopa County (9,223 square miles) and the eight-hour ozone nonattainment area (NAA) (5,025 square miles). The Model of Emissions of Gases and Aerosols from Nature (MEGAN) has been used to estimate the biogenic emissions. MEGAN is a state-of-the-art biogenic emissions model developed by the National Center for Atmospheric Research (NCAR). Some important corrections and improvements were made in the latest version of MEGAN2.1 (Guenther et al, 2012; Jiang et al, 2011) compared to previous versions (Guenther, 2006a, 2006b, and 2007; Guenther et al, 2006). The most important change is that higher temporal and spatial resolution of land use and land cover data for MEGAN input has become available. MEGAN, with the vegetation data released in 2011, was applied to compute biogenic emissions in Maricopa County and the eight-hour ozone nonattainment area. Estimated emissions for volatile organic compounds (VOC), carbon monoxide (CO), and nitrogen oxides (NO_x) are included in this biogenic emissions inventory. The MEGAN runs were executed by the Maricopa Association of Governments. The contact person for the MEGAN emission estimates is Feng Liu (602-254-6300).

6.2 Modeling domain

As a numerical model, the MEGAN inputs and outputs are given in user-defined two-dimensional grid cells. To develop biogenic emissions for the 2011 Periodic Emissions Inventory for ozone precursors, the 4-km modeling domain that covers the entire area of Maricopa County were employed. The target area is the eight-hour ozone nonattainment area within the County. The definition of the domain in the Lambert Conformal Conic Projection (LCP) coordinate system is presented in Table 6.2–1. Since MEGAN estimates biogenic emissions for the entire modeling domain rather than specific areas, additional input files, masking areas covered by the eight-hour ozone nonattainment area and Maricopa County, were developed by applying Geographic Information Systems (GIS) to calculate emissions for those two target areas. In order to represent the target area, the masking file assigns 1.0 for the grid cells fully covered by the target area, a fractional value for grid cells partially covered by the target area, and 0.0 for grid cells outside the target area. As shown in Figure 6.3–1, biogenic emissions for the eight-hour ozone nonattainment area and Maricopa County were extracted from MEGAN runs for the masked grid cells in the 4-km modeling domain.

Table 6.2–1. Two modeling domains defined in the LCP coordinate system.

Grid Horizontal Resolution	Grid Size	LCP Range (km)	Target Area
4-km	65 by 65	(–131.4713, –129.4593) to (127.9845, 131.1945)	Eight-hour ozone NAA and Maricopa County

6.3 Input data

To calculate biogenic emissions using MEGAN, the following gridded input files for land cover and meteorological data were prepared:

1. EFMAP_LAI file: This file provides emission factors (EF) for 20 MEGAN species including NO_x, CO and VOC, and 8-day average leaf index (LAI) for year 2011 in each grid cell.
2. PFTF file: This input file gives percentage of four plant function types (PFT) including broadleaf trees (BT), needle leaf trees (NT), grass and crops (HB) and shrubs (SB) for each model domain grid location.
3. METCRO2D file: This file contains meteorological parameters including temperature, short wave radiation, wind speed, humidity and soil moisture for each grid.

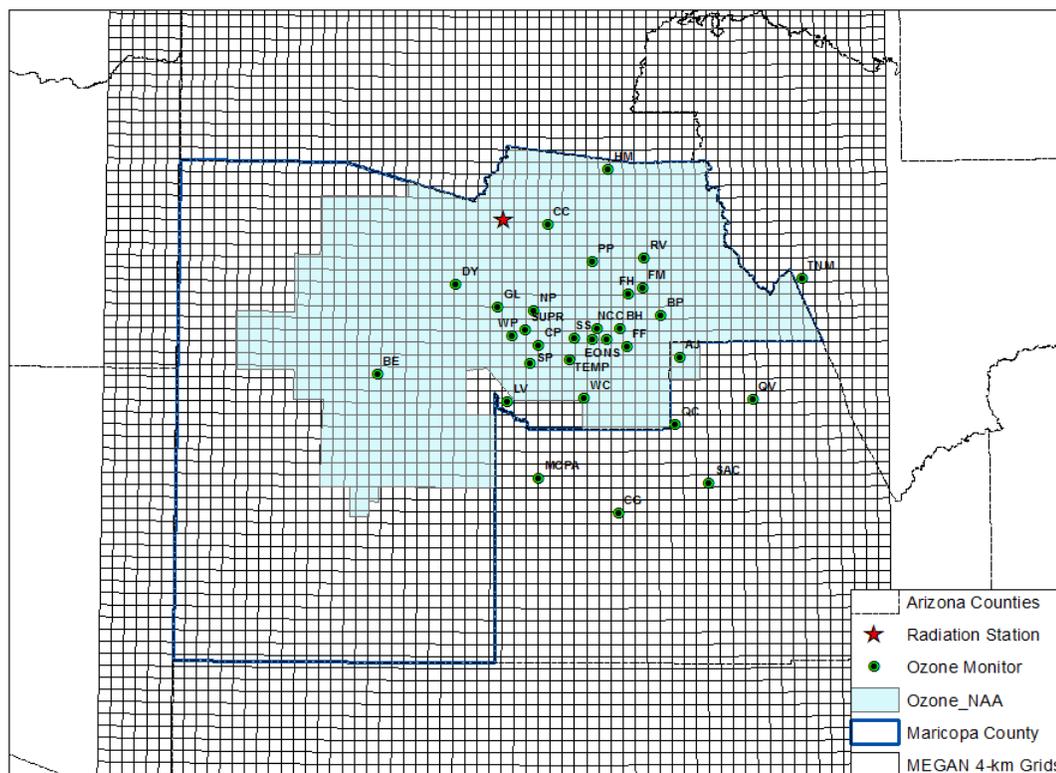


Figure 6.3–1. The masked grid cells in the 4-km modeling domain.

6.3.1 Land cover data

The land cover data, including the 8-day averaged LAI input files for North America for years 2003 to 2011 based on NASA MODIS data, monthly mean PFT, and EF, are provided by the EFMAP_LAI and PFTF files. These input data were derived from the MEGAN land cover database available at the resolution of 30 seconds latitude by 30 seconds longitude (1x1 km²) in netCDF format (<http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm>).

6.3.2 Weather data

The weather data used by MEGAN are temperature, downward short wave radiation, wind speed, humidity and soil moisture. The Measurement and Instrumentation Data Center (MIDC) collects irradiance and meteorological data from nation-wide stations. One of those stations is located in northern Phoenix (33.83°N, 112.17°W, see red star in Figure 6.3–1) and is operated by the National Renewable Energy Laboratory (NREL). The archived hourly temperature, wind speed, humidity and radiation data from this site are available to the public. Monthly mean

diurnal cycles of the weather parameters were calculated based on hourly data for the year 2011, and a netCDF file representing 24-hour data for each month was prepared for MEGAN inputs. Biogenic emissions of VOC, NO_x, and CO are first governed by temperature and then highly dependent on downward short wave radiation. Figure 6.3–2 shows monthly mean (left panel) and annual mean diurnal cycle (right panel) of temperature. Figure 6.3–3 illustrates monthly averaged and annual mean diurnal cycle of short wave radiation. The maximum monthly temperature was recorded in August, while the highest radiation was observed in June. The maximum monthly temperature appeared two months later than the highest radiation. The peak hourly temperature was observed around 4:00 – 6:00 pm and lagged three hours behind the peak radiation. The delay is due to the fact that heating of the air occurs not from the sun’s rays, but from heating of the earth and infrared radiation leaving the ground in the form of heat. As a result, maximum seasonal emission rates appear in the summer. The highest hourly emission rates take place in the afternoon because the emission rates are positively related to both temperature and short wave radiation (Guenther et al., 2006, 2012). The maximum monthly VOC, NO_x, and CO biogenic emission rates would be expected to occur in the same month as the maximum temperature.

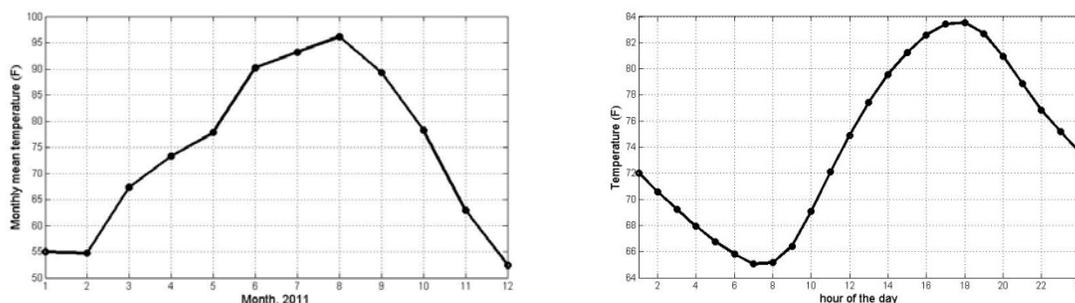


Figure 6.3–2. Monthly averaged temperature (left panel) and annual mean diurnal cycle of temperature (right panel) in 2011.

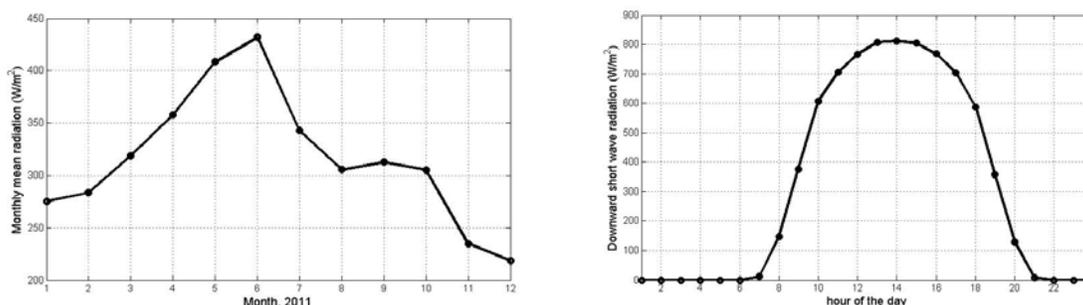


Figure 6.3–3. Monthly averaged radiation (left panel) and annual mean diurnal cycle of radiation (right panel) in 2011.

6.4 Emission estimation

MEGAN runs for the modeling domain provide hourly emission outputs for the year 2011. Figure 6.4–1 illustrates isoprene (ISOP), a major contributor to VOCs, and NO_x emission rates simulated by MEGAN at 17:00 MST in August, 2011. The high ISOP emissions occur in northeastern portion. The high NO_x emissions appear at the central part of Maricopa County and southeastern portion. Daily mean emissions for each month in 2011 are derived by using the hourly outputs for each month. In addition, monthly total emissions were obtained by multiplying the daily mean emissions for each month by the number of days in the month. The

daily mean emissions for the 12 months in 2011 are shown in Tables 6.4–1 and 6.4–2 for the eight-hour ozone nonattainment area and Maricopa County, respectively.

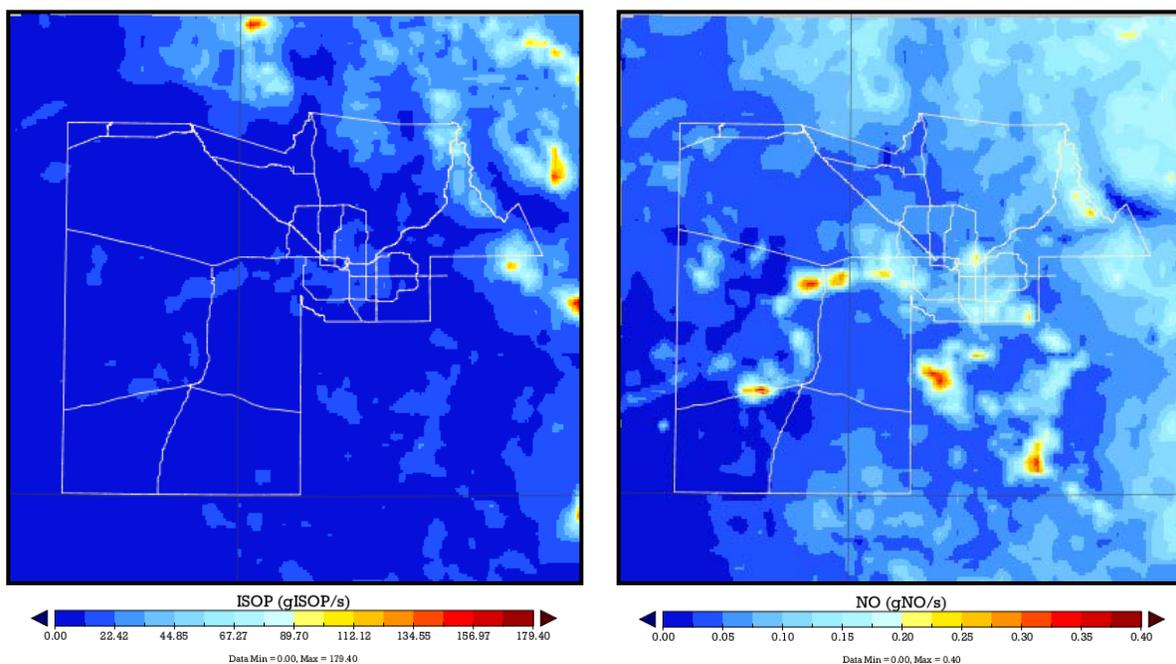


Figure 6.4–1. Estimated emission rates of ISOP (left panel) and NO_x (right panel) at 17:00 MST, August 2011 by MEGAN model.

Table 6.4–1. Daily mean biogenic emissions for each month in the eight-hour ozone NAA.

Month	VOC		NO _x		CO	
	kg/day	lbs/day	kg/day	lbs/day	kg/day	lbs/day
January	15,264.7	33,652.9	210.5	464.1	2,950.2	6,504.1
February	35,341.7	77,915.0	351.6	775.1	5,262.4	11,601.6
March	73,407.4	161,835.4	796.7	1,756.4	10,665.2	23,512.7
April	97,461.1	214,864.7	910.5	2,007.3	11,966.6	26,381.8
May	139,906.1	308,439.8	1,113.0	2,453.7	14,937.6	32,931.7
June	313,026.5	690,104.5	2,308.4	5,089.1	27,998.8	61,726.7
July	314,669.0	693,725.6	2,855.0	6,294.2	29,982.6	66,100.2
August	326,736.8	720,330.5	3,415.3	7,529.4	32,557.0	71,775.8
September	208,257.6	459,128.9	2,209.6	4,871.3	22,623.7	49,876.7
October	86,989.6	191,779.0	994.4	2,192.3	11,389.6	25,109.7
November	20,395.5	44,964.3	309.9	683.2	3,687.5	8,129.5
December	11,230.4	24,758.8	171.8	378.8	2,295.1	5,059.8

Table 6.4–2. Daily mean biogenic emissions for each month in Maricopa County.

Month	VOC		NO _x		CO	
	kg/day	lbs/day	kg/day	lbs/day	kg/day	lbs/day
January	23,123.3	50,978.1	316.3	697.3	5,654.4	12,465.8
February	53,015.2	116,878.4	524.0	1,155.2	9,971.5	21,983.4
March	104,165.5	229,645.3	1,152.6	2,541.0	19,383.1	42,732.4
April	139,181.0	306,841.2	1,330.8	2,933.9	22,591.4	49,805.5
May	200,913.3	442,937.5	1,641.2	3,618.2	28,869.2	63,645.6
June	451,990.3	996,466.9	3,432.5	7,567.4	55,292.2	121,898.3
July	451,204.3	994,734.0	4,207.9	9,276.8	58,566.5	129,116.9
August	467,398.8	1,030,436.7	5,031.7	11,093.0	63,445.8	139,873.9
September	300,464.1	662,409.2	3,278.2	7,227.2	44,256.1	97,567.9
October	129,711.0	285,963.5	1,506.4	3,321.0	23,713.3	52,278.8
November	30,063.3	66,278.2	462.5	1,019.6	7,101.2	15,655.4
December	16,413.2	36,184.9	252.8	557.3	4,255.2	9,381.1

Monthly mean emissions for Maricopa County and the eight-hour ozone nonattainment area are illustrated in Figure 6.4–2. Monthly emission values for the eight-hour ozone nonattainment area and Maricopa County are presented in Tables 6.4–3 and 6.4–4, respectively. It can be seen that the maximum monthly VOC, NO_x, and CO emissions took place in August, because monthly mean temperatures reached the maximum levels in this month.

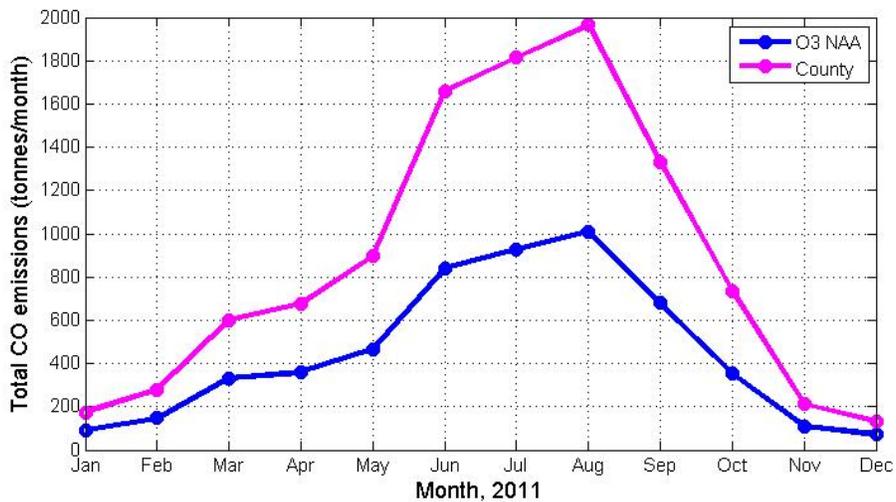
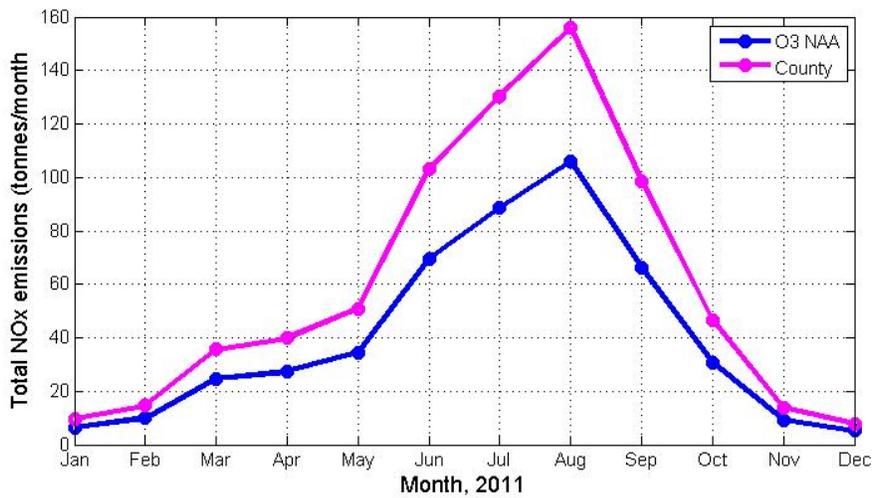
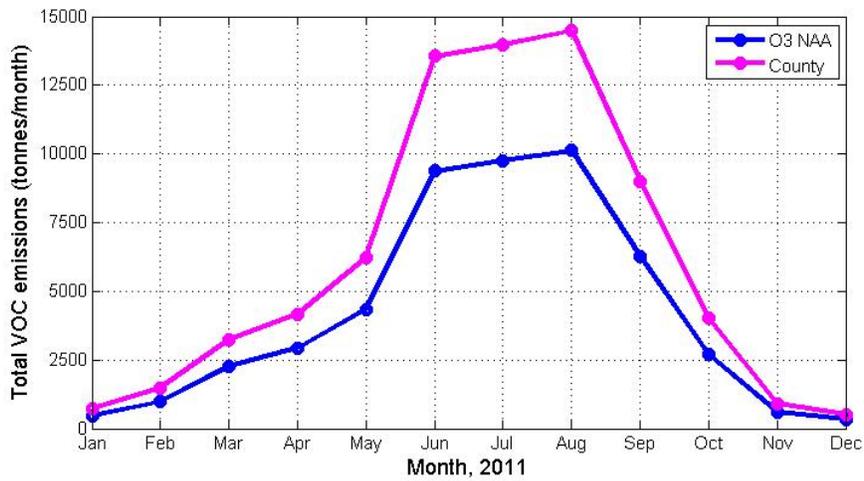


Figure 6.4–2. Monthly emissions of VOC (top), NO_x (middle) and CO (bottom) in Maricopa County (pink solid line, abbreviated as “County”) and the eight-hour ozone NAA (blue solid line, abbreviated as “O3 NAA”).

Table 6.4-3. Monthly biogenic emissions in the eight-hour ozone NAA.

Month	VOC		NO _x		CO	
	Metric tons	Short tons	Metric tons	Short tons	Metric tons	Short tons
January	473.21	521.62	6.53	7.19	91.46	100.81
February	989.57	1,090.81	9.84	10.85	147.35	162.42
March	2,275.63	2,508.45	24.70	27.22	330.62	364.45
April	2,923.83	3,222.97	27.32	30.11	359.00	395.73
May	4,337.09	4,780.82	34.50	38.03	463.07	510.44
June	9,390.80	10,351.57	69.25	76.34	839.96	925.90
July	9,754.74	10,752.75	88.51	97.56	929.46	1,024.55
August	10,128.84	11,165.12	105.87	116.71	1,009.27	1,112.53
September	6,247.73	6,886.93	66.29	73.07	678.71	748.15
October	2,696.68	2,972.57	30.83	33.98	353.08	389.20
November	611.87	674.46	9.30	10.25	110.63	121.94
December	348.14	383.76	5.33	5.87	71.15	78.43

Table 6.4-4. Monthly biogenic emissions in Maricopa County.

Month	VOC		NO _x		CO	
	Metric tons	Short tons	Metric tons	Short tons	Metric tons	Short tons
January	716.82	790.16	9.81	10.81	175.29	193.22
February	1,484.43	1,636.30	14.67	16.17	279.20	307.77
March	3,229.13	3,559.50	35.73	39.39	600.88	662.35
April	4,175.43	4,602.62	39.92	44.01	677.74	747.08
May	6,228.31	6,865.53	50.88	56.08	894.95	986.51
June	13,559.71	14,947.00	102.98	113.51	1,658.77	1,828.47
July	13,987.33	15,418.38	130.44	143.79	1,815.56	2,001.31
August	14,489.36	15,971.77	155.98	171.94	1,966.82	2,168.05
September	9,013.92	9,936.14	98.35	108.41	1,327.68	1,463.52
October	4,021.04	4,432.43	46.70	51.48	735.11	810.32
November	901.90	994.17	13.88	15.29	213.04	234.83
December	508.81	560.87	7.84	8.64	131.91	145.41

6.5 Summary of biogenic source emissions

Ozone season daily emissions for Maricopa County and the eight-hour ozone nonattainment area in 2011 are shown in Table 6.5-1. Annual emissions for Maricopa County and the eight-hour ozone nonattainment area in 2011 are summarized in Table 6.5-2. Emissions of VOC, NO_x, and CO all decreased in 2011 compared to MEGAN results for PEI 2008. Due to the incorporation of land cover data that are more characteristic of plants located in the desert southwest, as well as improvements to the MEGAN model, the 2011 data shown in Tables 6.5-1 and 6.5-2 represent a substantial improvement over previous biogenic emission estimates for Maricopa County and the eight-hour ozone NAA.

Table 6.5–1. Season-day biogenic emissions.

Area	VOC		NO _x		CO	
	kg/day	lbs/day	kg/day	lbs/day	kg/day	lbs/day
Maricopa County	406,355.7	895,860.0	4,172.6	9,199.0	55,422.8	122,186.2
8-hr ozone NAA	283,221.1	624,395.0	2,826.6	6,231.7	28,387.8	62,584.2

Table 6.5–2. Annual biogenic emissions.

Area	VOC		NO _x		CO	
	tonnes [*] /yr	tons [*] /yr	tonnes/yr	tons/yr	tonnes/yr	tons/yr
Maricopa County	72,316.20	79,714.87	707.17	779.52	10,476.94	11,548.84
8-hr ozone NAA	50,178.11	55,311.84	478.25	527.18	5,383.74	5,934.55

* "Tonne" denotes metric ton, and "ton" denotes short (or English) ton

6.6 References

- Guenther, A., 2006a. User's Guide to Processing Driving Variables for Model of Emissions of Gases and Aerosols from Nature (MEGAN).
- Guenther, A., 2006b. User's Guide to the Model of Emissions of Gases and Aerosols from Nature (MEGAN) Version MEGAN-VBA-2.0.
- Guenther, A., 2007. Corrigendum to "Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature)" *Atmos. Chem. Phys.*, 6, 3181–3210, 2006, *Atmos. Chem. Phys.*, 7, 4327-4327.
- Guenther, A., T. Karl, P. Harley, C. Wiedinmyer, P. I. Palmer, and C. Geron, 2006. Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature), *Atmos. Chem. Phys.*, 6, 1-30.
- Guenther, A., X. Jiang, C. L. Heald, T Sakulyanontvittaya, T. Duhl, L. K. Emmons, and X. Wang, 2012. The model of emissions of gases and aerosols from nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions, *Geosci. Model Dev. Discuss.*, 5, 1503-1560.
- Jiang, X., A. Guenther, and T. Duhl, 2011. MEGAN version 2.10 User's Guide.