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, such as shredders and large chain saws;
- 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, such as mechanical drilling engines (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 sources are derived from a Maricopa County nonroad emission inventory of certain visibility-impairing pollutants (PM_{10}, $PM_{2.5}$, NO_x and SO_x) developed by ENVIRON International Corp. for calendar year 2002 (Environ et al., 2003). ENVIRON prepared the inventory for use and review by the Cap and Trade Oversight Committee (CTOC) formed by the Arizona Department of Environmental Quality (ADEQ). In the inventory prepared for the Cap and Trade Committee, ENVIRON used the EPA NON-ROAD2002 model (Core Version 2.1d March, 2002) to estimate emissions for all categories except aircraft and locomotives. Nonroad modeling for the ENVIRON inventory was based on recent NONROAD modeling performed for the Western Regional Air Partnership (WRAP) for use in the development of a regional haze rule.

Since the modeling done for the CTOC was only annual totals for Maricopa County, additional work was needed to develop estimates for the ozone nonattainment area and for an average ozone season day. Emission calculations for this report differ from the CTOC work in one major area: emission estimates prepared for the CTOC were derived from season average weekday calculations, which were then multiplied by the number of days in each season to produce season totals, and then summed to produce annual emission totals. This approach assumes that activity levels of nonroad equipment are the same on weekdays and weekends.

For this report, ENVIRON re-ran the NONROAD2002 model to produce season totals, which are then summed to produce annual emission totals. The revised method used for this report results in annual emissions levels that are about 15% less than the method used for the CTOC inventory. The method used by ENVIRON for this report takes into account the different activity levels experienced on weekdays versus weekends, which explains the lower annual emissions.

The NONROAD model defines four seasons as follows: spring – March through May, summer – June through August, fall – September through November, and winter – December through February. Since the gasoline oxygen content in Maricopa County changes on September 30, emissions from the fall quarter were calculated for each month separately, and then summed. Seasonal emissions totals are then summed to produce annual emission totals.

The methods used to estimate ozone season-day emissions are described in each section of this chapter. Emission estimates from the summer season (June–July) are assumed to represent emissions in the ozone season (July–September).

Temperature and fuel-related inputs are required for the operation of the NONROAD2002 model. The inputs listed below were used by ENVIRON after ADEQ review:

- Fuel volatility (Reid Vapor Pressure [RVP]), psi: 9.0 in winter, 8.1 in spring, 7.8 in summer and fall.
- Gasoline oxygen content (weight %): 3.36 from October through February, 0.0 otherwise.
- Gasoline sulfur content (ppm): 179 in fall and winter, 115 in spring and summer.
- Diesel sulfur content (ppm): 310 all seasons.
- Temperatures (minimum/average/maximum °F): 39/55/65 winter, 53/72/83 spring, 78/94/104 summer, 57/78/87 fall.

EPA recommends adjusting default NONROAD2002 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. ENVIRON adjusted the NONROAD2002 model defaults in the following manner:

- The NONROAD model uses 1996 as a base year, and then projects emissions for any given year based on growth factors inherent in the model. The default growth factors in the model were zeroed out to reflect base year 1996 equipment population numbers. Arizona-specific growth factors developed for WRAP were then applied to the NONROAD2002 model outputs to produce 2002 year population numbers and associated emissions.
- Equipment population numbers and activity levels for commercial lawn and garden equipment were adjusted based on survey results of the commercial lawn and garden industry performed by ENVIRON as part of the CTOC work. 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 is a considerable decrease in emissions from this category, compared with earlier results using EPA default data.
- Equipment population numbers and activity levels for airport ground support equipment were adjusted based on Maricopa County-specific data provided by the Maricopa Association of Governments (MAG) for the CTOC inventory.

Spatial allocation factors were developed, based on EPA guidance documents, to apportion nonroad emissions to the 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 NONROAD2002 model come from EPA recommendations on weekday and weekend day activity levels for each nonroad equipment category (US EPA, 1999). Table 4.1–1 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 4.1–1. 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 NONROAD2002 model, as discussed above. Emissions are reported by engine type: gasoline 2-stroke, gasoline 4-stroke, diesel, compressed natural gas (CNG), and liquid petroleum gas (LPG). Emissions from CNG and LPG equipment are reported in the gasoline 4-stroke category, as total emissions from these engine types were either trivial or none. County-wide results are shown in Table 4.2–1.

Table 4.2–1. Annual emissions (in tons/yr) from agricultural equipment in Maricopa County.

Source Classification Code (SCC)	Engine type	VOC	NO_x	CO
2260005000	Gasoline 2-stroke	1.04	< 0.005	2.12
2265005000	Gasoline 4-stroke	11.53	6.16	355.26
2270005000	Diesel	58.02	471.30	275.58
Totals:		**70.60**	**477.46**	**632.96**

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 (185,029 acres) to agricultural land inside the county (415,473 acres). See Section 1.5.2 for a discussion of land-use data used.

Ozone nonattainment area emissions from agricultural equipment = County VOC emissions × Agricultural land-use allocation factor

= 70.59 tons × 44.53%

= 31.43 tons VOC/yr

Table 4.2–2. Annual emissions (in tons/yr) from agricultural equipment in the ozone NAA.

SCC	Engine type	VOC	NO_x	CO
2260005000	Gasoline 2-stroke	0.46	<0.005	0.94
2265005000	Gasoline 4-stroke	5.13	2.74	158.20
2270005000	Diesel	25.84	209.87	122.72
Totals:		**31.43**	**212.61**	**281.86**

County season-day emissions were calculated by multiplying summer season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/weekend day activity allocation factor for agricultural equipment listed in Table 4.1–1, and dividing the product by the number of weeks (13) in the ozone season (US EPA, 1999), as follows:

Maricopa County ozone season-day emissions (lbs/day)	= Summer season VOC emissions (tons/season)	× 2000 (lb/ton)	× daily activity allocation factor for agricultural equipment expressed as (weeks/day)	÷ 13 (weeks/season)
	= 24.25	× 2000	× 0.166667	÷ 13
	= 621.8 lbs/day			

Table 4.2–3. Ozone season emissions from agricultural equipment in Maricopa County.

		Seasonal emissions (tons/season)			Season-day emissions (lbs/day)		
SCC	Engine type	VOC	NO_x	CO	VOC	NO_x	CO
2260005000	Gasoline 2-stroke	0.36	<0.005	0.76	9.2	0.1	19.5
2265005000	Gasoline 4-stroke	4.20	1.82	133.49	107.7	46.7	3422.8
2270005000	Diesel	19.69	159.92	93.49	504.9	4100.5	2397.2
Totals:		**24.25**	**161.74**	**227.74**	**621.8**	**4,147.2**	**5,839.5**

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

Ozone nonattainment area season-day emissions	= Maricopa County VOC season-day emissions	×	Agricultural land-use allocation factor
	= 621.8 lbs/day	×	44.53%
	= 276.9 lbs/day		

Table 4.2–4. Ozone season-day emissions (in lbs/day) from agricultural equipment in the ozone NAA.

SCC	Engine type	VOC emissions	NO_x emissions	CO emissions
2260005000	Gasoline 2-stroke	4.1	< 0.05	8.6
2265005000	Gasoline 4-stroke	48.0	20.8	1,524.2
2270005000	Diesel	224.8	1,826.0	1,067.5
Totals:		**276.9**	**1,846.8**	**2,600.3**

4.3 Airport ground support equipment

Annual emissions from airport ground support equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of the number of FAA landing and takeoff operations (LTO) in the nonattainment area to Maricopa County-level totals, as recommended by EIIP guidance (US EPA, 2002). See Section 4.12 for a discussion of aircraft LTO data.

Table 4.3–1. Annual emissions (in tons/yr) from airport ground support equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260008000	Gasoline 2-stroke	0.00	0.00	0.00	0.00	0.00	0.00
2265008000	Gasoline 4-stroke	135.09	92.10	3,447.92	131.71	89.80	3,361.72
2270008000	Diesel	4.48	54.99	23.17	4.37	53.62	22.59
Totals:		**139.57**	**147.09**	**3,471.09**	**136.08**	**143.42**	**3,384.31**

County season-day emissions were calculated by first multiplying Maricopa County annual emissions by 25% to estimate ozone season totals, as airport ground support equipment activity is assumed uniform throughout the year (US EPA, 1999). Ozone season totals were then multiplied by the most conservative weekday/weekend day activity allocation factor for airport ground support equipment (0.1428571) listed in Table 4.1–1, 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 LTOs as described above.

Table 4.3–2. Ozone season-day emissions (in lbs/day) from airport ground support equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260008000	Gasoline 2-stroke	0.0	0.0	0.0	0.0	0.0	0.0
2265008000	Gasoline 4-stroke	742.3	506.0	18,944.6	723.7	493.4	18,471.0
2270008000	Diesel	24.6	302.1	127.3	24.0	294.5	124.1
Totals:		**766.9**	**808.1**	**19,071.9**	**747.7**	**787.9**	**18,595.1**

4.4 Commercial equipment

Annual emissions from commercial equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of industrial employment in the nonattainment area to Maricopa County-level 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.

Table 4.4–1. Annual emissions (in tons/yr) from commercial equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260006000	Gasoline 2-stroke	269.92	1.28	557.16	264.76	1.26	546.52
2265006000	Gasoline 4-stroke	1,352.35	567.59	44,729.37	1,326.52	556.75	43,875.04
2270006000	Diesel	136.64	750.57	511.02	134.03	736.23	501.26
Totals:		**1,758.91**	**1319.44**	**45,797.55**	**1,725.31**	**1,294.24**	**44,922.82**

County season-day emissions were calculated by multiplying Maricopa County summer season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/ weekend day activity allocation factor for commercial equipment (0.1666667) listed in Table 4.1–1, 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 4.4–2. Ozone season-day emissions (in lbs/day) from commercial equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260006000	Gasoline 2-stroke	1,755.6	6.4	3,928.5	1,722.1	6.3	3,853.5
2265006000	Gasoline 4-stroke	9,814.9	2,981.5	332,839.0	9,627.4	2,924.6	326,481.8
2270006000	Diesel	875.9	4,811.3	3,276.2	859.2	4,719.4	3,213.6
Totals:		**12,446.4**	**7,799.2**	**340,043.7**	**12,208.7**	**7,650.3**	**333,548.9**

4.5 Construction and mining equipment

Annual emissions from construction and mining equipment in Maricopa County were calculated using EPA's NONROAD2002 model as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County-level totals as a conservative estimate, as 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.

Table 4.5–1. Annual emissions (in tons/yr) from construction and mining equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260002000	Gasoline 2-stroke	468.57	6.28	1,170.13	459.62	6.16	1,147.78
2265002000	Gasoline 4-stroke	236.59	114.49	9,139.37	232.07	112.30	8,964.81
2270002000	Diesel	1,081.31	9,713.92	5,275.07	1,060.66	9,528.38	5,174.32
Totals:		**1,786.47**	**9,834.69**	**15,584.58**	**1,752.35**	**9,646.84**	**15,286.91**

County season-day emissions were calculated by multiplying Maricopa County summer season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/ weekend day activity allocation factor for construction/mining equipment (0.1666667) listed in Table 4.1–1, 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 ratios as described above.

Table 4.5–2. Ozone season-day emissions (in lbs/day) from construction and mining equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260002000	Gasoline 2-stroke	4,005.6	43.6	10,746.7	3,929.1	42.8	10,541.4
2265002000	Gasoline 4-stroke	2,171.3	801.3	88,000.8	2,129.8	786.0	86,320.0
2270002000	Diesel	9,159.7	82,270.8	44,681.3	8,984.7	80,699.4	43,827.9
Totals:		**15,336.6**	**83,115.7**	**143,428.8**	**15,043.6**	**81,528.2**	**140,689.3**

4.6 Industrial equipment

Annual emissions from industrial equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of industrial employment in the nonattainment area to Maricopa County-level totals as a conservative estimate, as the number of employees in manufacturing recommended by EIIP guidance (US EPA, 2002) was not available. See Section 1.5.1 for a discussion of the industrial employment data used.

Table 4.6–1. Annual emissions (in tons/yr) from industrial equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260003000	Gasoline 2-stroke	3.44	0.02	7.23	3.37	.02	7.09
2265003000	Gasoline 4-stroke	240.98	2,108.32	14,638.82	236.38	2,068.05	14,359.2
2270003000	Diesel	117.57	1,066.46	489.42	115.32	1,046.09	480.07
Totals:		**361.99**	**3,174.80**	**15,135.47**	**355.07**	**3,114.16**	**14,846.36**

County season-day emissions were calculated by multiplying Maricopa County summer season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/ weekend day activity allocation factor for industrial equipment (0.1666667) listed in Table 4.1–1, 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 4.6–2. Ozone season-day emissions (in lbs/day) from industrial equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260003000	Gasoline 2-stroke	22.3	0.1	51.0	21.9	0.1	50.0
2265003000	Gasoline 4-stroke	1,682.0	13,226.6	100,889.9	1,649.9	12,974.0	98,962.9
2270003000	Diesel	753.6	6,835.4	3137.4	739.2	6,704.8	3,077.5
Totals:		**2,457.9**	**20,062.1**	**104,078.3**	**2,411.0**	**19,678.9**	**102,090.4**

4.7 Lawn and garden equipment

Annual emissions from lawn and garden equipment in Maricopa County were calculated using EPA's NONROAD2002 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 ozone nonattainment area for this category were derived by applying the ratio of housing units in the nonattainment area to Maricopa County-level totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.1 for a discussion of the housing data used.

Table 4.7–1. Annual emissions (in tons/yr) from lawn and garden equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260004000	Gasoline 2-stroke	2,179.10	13.04	4,677.47	2,139.44	12.80	4,592.34
2265004000	Gasoline 4-stroke	2,309.44	463.63	72,476.35	2,267.41	455.19	71,157.28
2270004000	Diesel	34.64	218.81	119.31	34.01	214.83	117.14
Totals:		**4,523.18**	**695.48**	**77,273.13**	**4,440.86**	**682.82**	**75,866.76**

County season-day emissions were calculated by multiplying Maricopa County summer season ozone emissions (generated by the NONROAD2002 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 4.1–1, 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 housing units as described above.

Table 4.7–2. Ozone season-day emissions (in lbs/day) from lawn and garden equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260004000	Gasoline 2-stroke	21,657.8	93.4	49,010.7	21,263.6	91.7	48,118.7
2265004000	Gasoline 4-stroke	24,477.7	3,686.6	801,025.2	24,032.2	3,619.5	786,446.5
2270004000	Diesel	289.2	1,827.4	996.4	283.9	1,794.1	978.3
Totals:		**46,424.7**	**5,607.4**	**851,032.3**	**45,579.7**	**5,505.3**	**835,543.5**

4.8 Logging equipment

Annual emissions from logging equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Logging equipment includes equipment such as large chain saws and shredders used by such entities such as city parks departments and large landscaping companies. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County-level totals as a conservative estimate, as the number of employees in logging recommended by EIIP guidance was not available (US EPA, 2002). See Section 1.5.1 for a discussion of the population figures used.

Table 4.8–1. Annual emissions (in tons/yr) from logging equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260007000	Gasoline 2-stroke	14.46	0.20	34.30	14.18	0.20	33.64
2265007000	Gasoline 4-stroke	3.81	0.60	90.02	3.74	0.59	88.30
2270007000	Diesel	2.66	37.94	12.23	2.61	37.22	12.00
Totals:		**20.94**	**38.74**	**136.54**	**20.53**	**38.01**	**133.94**

County season-day emissions were calculated by multiplying Maricopa County summer-season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/weekend day activity allocation factor for logging equipment (0.1666667) listed in Table 4.1–1, 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 4.8–2. Ozone season-day emissions (in lbs/day) from logging equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260007000	Gasoline 2-stroke	93.6	1.0	241.9	91.8	1.0	237.3
2265007000	Gasoline 4-stroke	25.7	2.7	671.3	25.2	2.6	658.5
2270007000	Diesel	17.1	243.3	78.4	16.8	238.7	76.9
Totals:		**136.4**	**247.0**	**991.6**	**133.8**	**242.3**	**972.7**

4.9 Pleasure craft

Annual emissions from pleasure craft equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of water surface area in the nonattainment area to Maricopa County-level totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.2 for a discussion of the land-use data used.

Table 4.9–1. Annual emissions (in tons/yr) from pleasure craft equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2282005000	Gasoline 2-stroke	552.32	11.60	982.10	189.45	3.98	336.86
2282010000	Gasoline 4-stroke	47.25	15.90	439.26	16.21	5.45	150.67
2282020000	Diesel	0.63	15.52	2.55	0.22	5.32	0.87
Totals:		**600.20**	**43.01**	**1,423.91**	**205.88**	**14.75**	**488.40**

County season-day emissions were calculated by multiplying Maricopa County summer-season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/ weekend day activity allocation factor for pleasure craft (0.3500000) listed in Table 4.1–1, 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 water surface area as described above.

Table 4.9–2. Ozone season-day emissions (in lbs/day) from pleasure craft equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2282005000	Gasoline 2-stroke	14,218.0	264.0	26,686.0	4,876.8	90.6	9,153.3
2282010000	Gasoline 4-stroke	1,194.1	336.3	12,373.7	409.6	115.4	4,244.2
2282020000	Diesel	16.4	401.4	65.9	5.6	137.7	22.6
Totals:		**15,428.5**	**1,001.7**	**39,125.6**	**5,292.0**	**343.7**	**13,420.1**

4.10 Railway maintenance equipment

Annual emissions from railway maintenance equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County-level totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.1 for a discussion of the population data used.

Table 4.10–1. Annual emissions (in tons/yr) from railway maintenance equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2285003015	Gasoline 2-stroke	0.00	0.00	0.00	0.00	0.00	0.00
2285004015	Gasoline 4-stroke	1.11	0.39	43.99	1.09	0.38	43.15
2285002015	Diesel	4.00	19.96	17.29	3.92	19.58	16.96
Totals:		**5.10**	**20.35**	**61.28**	**5.01**	**19.96**	**60.11**

County season-day emissions were calculated by multiplying Maricopa County summer season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/ weekend day activity allocation factor for railway maintenance equipment (0.1800000) listed in Table 4.1–1, 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 4.10–2. Ozone season-day emissions (in lbs/day) from railway maintenance equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2285003015	Gasoline 2-stroke	0.0	0.0	0.0	0.0	0.0	0.0
2285004015	Gasoline 4-stroke	8.8	2.0	353.9	8.6	2.0	347.1
2285002015	Diesel	27.7	138.2	119.7	27.2	135.6	117.4
Totals:		**36.5**	**140.2**	**473.6**	**35.8**	**137.6**	**464.5**

4.11 Recreational equipment

Annual emissions from recreational equipment in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the ozone nonattainment area for this category were derived by applying the ratio of passive open space, golf courses and vacant land use in the nonattainment area to Maricopa County-level totals as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.2 for a discussion of the land-use data used.

Table 4.11–1. Annual emissions (in tons/yr) from recreational equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260001000	Gasoline 2-stroke	679.09	4.95	971.01	68.52	0.50	97.97
2265001000	Gasoline 4-stroke	202.67	47.92	8,803.03	20.45	4.84	888.23
2270001000	Diesel	3.49	10.47	14.16	0.35	1.06	1.43
Totals:		**885.25**	**63.35**	**9,788.20**	**89.32**	**6.40**	**987.63**

County season-day emissions were calculated by multiplying Maricopa County summer-season ozone emissions (generated by the NONROAD2002 model) by the most conservative weekday/weekend day activity allocation factor for recreational equipment (0.2222222) listed in Table 4.1–1, 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 4.11–2. Ozone season-day emissions (in lbs/day) from recreational equipment.

		Maricopa County			Nonattainment area		
SCC	**Engine type**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
2260001000	Gasoline 2-stroke	8,656.4	53.0	13,092.8	873.4	5.3	1,321.1
2265001000	Gasoline 4-stroke	2,751.3	470.9	124,149.3	277.6	47.5	12,526.7
2270001000	Diesel	44.1	132.2	178.9	4.4	13.3	18.1
Total		**11,451.8**	**656.1**	**137,421.0**	**1,155.4**	**66.1**	**13,865.9**

4.12 Aircraft

A survey of all 16 airports in Maricopa County was conducted to collect data on the total number of landing and take-off operations (LTO's) as well as fleet mix to determine the types of aircraft used and idle times to calculate annual emissions. Of these airports, three locations (Buckeye Municipal Airport, Gila Bend Municipal Airport and Wickenburg Municipal Airport) are outside of the nonattainment area. Data provided by many airports were in the form of the US Federal Aviation Administration's (FAA) monthly reporting Form 7230-1, which documents the traffic flow in four major activity categories: air carrier, air taxi, general aviation and military.

Emissions were derived from both computer modeling and National Emissions Inventory (NEI) default emission factors. For airports that provided complete survey data, the FAA's latest airport Emissions and Dispersion Modeling Software (EDMS 4.1) was used to calculate emissions. Parameters required to apply this model include annual LTO figures, fleet mix of types of aircraft in each activity category, and average idle-in and idle-out times.

For those airports that provided only partial data, the EDMS model could not be used to calculate emissions. Instead, NEI default emission factors were used to calculate emissions. Examples of missing data were detailed fleet mix data or unknown idle times. For airports that did not respond to the survey, LTO figures and fleet mix were derived from an online database that provides free detailed aeronautical information on airports at http://www.airnav.com. The "Airport Operational Statistics" section of this database contains data on average daily aircraft operations at the airport by aircraft type (air carrier, air taxi, general aviation and military). These data were multiplied by 365 to derive annual LTO totals and was used to grow LTO's and fleet mix. Since the EDMS model requires specific aircraft types to run and the Airport Operational Statistics only provide general aircraft type information, the NEI default emission factors shown in Table 4.12–1 were applied to these activity data to calculate emissions.

Table 4.12–1. NEI default emission factors (lbs/LTO), by aircraft type.

Aircraft type	Abbreviation	SCC	HC	HC:VOC conversion factor	VOC	NO_x	CO
Air Taxi	AT	2275060000	1.234	0.9914	1.223	0.158	28.130
General Aviation	GA	2275050000	0.394	0.9708	0.382	0.065	12.014
Military	ML	2275001000	1.234	1.1046	1.363	0.158	28.130

Table 4.12–2 summarizes the data received from each airport, and the approach used (using the EDMS model or default emission factors from the 1999 NEI) to calculate emissions from each airport.

The following provides an example of how aircraft emissions were calculated using EDMS for Skyranch at Carefree, a small, general-aviation only airport with a mix of aircraft 12,500 lbs or less. Since the EDMS model requires an exact LTO value for each airframe considered in the model, and since the survey did not require respondents to supply exact LTO counts for each individual airframe, an averaging method was used. EDMS was run to produce an composite emission factor for an airport based on the most common type of aircraft using that facility. For Skyranch, a composite profile was created by selecting within EDMS 12 aircraft types likely to utilize the airport, based on data provided by the airport survey and follow-up correspondence. These 12 aircraft types are: Cessna 150, Commanche, Robin R 2160, Socata Tampico, Cessna 172 Skyhawk, Piper PA-28, Robin R 3000, Socata Tobago, Cherokee six, Robin DR 400, Rockwell Commander, and Spencer S-12 Air Car.

The EDMS model was run with the above 12 aircraft types and for ease of calculation each aircraft was allocated 2000 LTO/year. It was then necessary to divide the lbs/LTO result by the 12 representative aircraft used to derive an emission factor for an "average" aircraft LTO.

For example, the model run with the 12 aircraft types resulted in total CO emissions of 211.69 tons (assuming each of the 12 aircraft types had 2000 LTOs each during the period).

Table 4.12–2. 2002 airport activity data, emission calculation methods, and emission factors.

Airport name	Activity category	2002 LTOs	LTO data source[1]	Emission calculation method[2]	Lbs/LTO VOC	Lbs/LTO NO_x	Lbs/LTO CO
Arizona Army National Guard	ML	780	reported	NEI default	1.363	0.158	28.130
Buckeye Municipal Airport[3]	GA	16,796	reported	EDMS	0.249	0.044	17.641
Chandler Municipal Airport	AT	914	reported	NEI default	1.223	0.158	28.130
	GA	80,689	reported	NEI default	0.382	0.065	12.014
	ML	10	reported	NEI default	1.363	0.158	28.130
Falcon Field	AT	1,319	AirNav	NEI default	1.223	0.158	28.130
	GA	125,350	AirNav	NEI default	0.382	0.065	12.014
	ML	5,278	AirNav	NEI default	1.363	0.158	28.130
Gila Bend Municipal Airport[3]	GA	522	AirNav	NEI default	0.382	0.065	12.014
Glendale Municipal Airport	GA	59,352	reported	NEI default	0.382	0.065	12.014
Luke Air Force Base	ML	61,225	reported	EDMS	3.245	10.906	13.827
Phoenix Deer Valley Airport	AT	2,495	reported	NEI default	1.223	0.158	28.130
	GA	192,254	reported	NEI default	0.382	0.065	12.014
	ML	37	reported	NEI default	1.363	0.158	28.130
Phoenix Goodyear Airport	AC	131	reported	EDMS	2.531	37.718	7.615
	AT	270	reported	NEI default	1.223	0.158	28.130
	GA	68,317	reported	NEI default	0.382	0.065	12.014
	ML	569	reported	NEI default	1.363	0.158	28.130
Phoenix Sky Harbor Int'l.	AC	187,125	reported	EDMS	17.444	40.201	43.267
	AT	57,570	reported	EDMS	1.271	1.379	14.996
	GA	26,204	reported	EDMS	0.104	0.017	6.838
	ML	1,987	reported	EDMS	0.072	0.331	0.643
Pleasant Valley Airport	GA	19,302	reported	EDMS	0.015	0.331	0.529
Scottsdale Airport	AT	5,026	reported	NEI default	1.223	0.158	28.130
	GA	92,365	reported	NEI default	0.382	0.065	12.014
	ML	291	reported	NEI default	1.363	0.158	28.130
Skyranch at Carefree	GA	2,453	reported	EDMS	0.249	0.044	17.641
Stellar Airpark	GA	22,000	reported	NEI default	0.382	0.065	12.014
Wickenburg Municipal Airport[3]	AT	179	AirNav	NEI default	1.223	0.158	28.130
	GA	8,495	AirNav	NEI default	0.382	0.065	12.014
	ML	268	AirNav	NEI default	1.363	0.158	28.130
Williams Gateway Airport	AC	421	reported	EDMS	2.409	18.067	6.960
	AT	3,104	reported	EDMS	1.271	1.379	14.996
	GA	79,731	reported	EDMS	0.277	0.045	18.234
	ML	5,990	reported	EDMS	1.152	5.300	10.288

1. "reported" = using 2002 survey results supplied by the airport,
   "AirNav" = using available data on average daily LTOs from www.airnav.com.
2. "EDMS" = emission factors were based on EDMS model calculations,
   "NEI default" = NEI default emission factors Table 4.12–1 were used.
3. Airport is outside the nonattainment area.

Composite CO emission factor (lb/LTO) = Σ modeled CO emissions (tons/yr) × 1 yr ÷ 24,000 LTOs × 2000 lb/ton
= 17.64 lb CO/LTO

This composite emission factor was then multiplied by the actual number of LTOs at the airport to derive an annual CO emissions total:

CO emissions (lb/ yr) = 2,453 LTO/yr × 17.64 lb CO/LTO
= 43,272.88 lb CO/yr

The above approach was used to calculate CO, HC (hydrocarbons), NO_x and SO_x directly from the EDMS model. Emissions of VOC were derived by applying the appropriate HC:VOC factor listed in Table 4.12–1.

Table 4.12–2 lists the emission factors used. Table 4.12–3 lists the total annual emissions and ozone season-day emissions, for each airport and aircraft type. For all airports, activity is presumed to occur evenly over a 7-day week. To develop seasonal allocation factors, Phoenix Sky Harbor International Airport's distribution of LTO's for air carrier activity was used. Seasonal activity for the ozone season (July – September) is thus calculated as (15,985 + 16,243 + 15,283 ÷ 187,125 = 25%).

Table 4.12–3. Annual and ozone season-day emissions, by airport and aircraft type.

	Activity	Tons/yr			Lbs/day		
Facility	**category[1]**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
Arizona Army Natl. Guard	ML	0.53	0.06	10.97	2.9	0.3	60.3
Chandler Municipal Airport	AT	0.56	0.07	12.86	3.1	0.4	70.6
	GA	15.43	2.62	484.70	84.8	14.4	2,663.2
	ML	0.01	0.00	0.14	0.0	0.0	0.8
Falcon Field	AT	0.81	0.10	18.55	4.4	0.6	101.9
	GA	23.97	4.07	752.98	131.7	22.4	4,137.2
	ML	3.60	0.42	74.24	19.8	2.3	407.9
Glendale Municipal Airport	GA	11.35	1.93	356.53	62.4	10.6	1,958.9
Luke Air Force Base	ML	99.33	333.86	423.28	545.8	1,834.4	2,325.7
Phoenix Deer Valley Airport	AT	1.53	0.20	35.09	8.4	1.1	192.8
	GA	36.77	6.25	1,154.87	202.0	34.3	6,345.4
	ML	0.02	0.00	0.39	0.1	0.0	2.2
Phoenix Goodyear Airport	AC	0.17	2.47	0.50	0.9	13.6	2.7
	AT	0.17	0.02	3.80	0.9	0.1	20.9
	GA	13.07	2.22	410.38	71.8	12.2	2,254.8
	ML	0.39	0.04	8.00	2.1	0.2	44.0
Phoenix Sky Harbor Int'l.	AC	1,632.11	3,761.31	4,048.17	8,967.6	20,666.5	22,242.7
	AT	36.59	39.69	431.66	201.0	218.1	2,371.8
	GA	1.36	0.22	89.59	7.5	1.2	492.3
	ML	0.07	0.33	0.64	0.4	1.8	3.5
Pleasant Valley Airport	GA	0.14	3.19	5.11	0.8	17.6	28.1
Scottsdale Airport	AT	3.07	0.40	70.69	16.9	2.2	388.4
	GA	17.66	3.00	554.84	97.1	16.5	3,048.6
	ML	0.20	0.02	4.09	1.1	0.1	22.5
Skyranch at Carefree	GA	0.31	0.05	21.64	1.7	0.3	118.9
Stellar Airpark	GA	4.21	0.72	132.15	23.1	3.9	726.1
Williams Gateway Airport	AC	0.51	3.80	1.47	2.8	20.9	8.0
	AT	1.97	2.14	23.27	10.8	11.8	127.9
	GA	11.03	1.79	726.91	60.6	9.9	3,994.0
	ML	3.45	15.87	30.81	19.0	87.2	169.3
Ozone nonattainment area totals:		**1,920.37**	**4,186.89**	**9,888.43**	**10,551.5**	**23,004.9**	**54,332.0**
Airports outside the nonattainment area:							
Buckeye Municipal Airport	GA	2.10	0.37	148.15	11.5	2.0	814.0
Gila Bend Municipal Airport	GA	0.10	0.02	3.14	0.6	0.1	17.2
Wickenburg Mun. Airport	AT	0.11	0.01	2.52	0.6	0.1	13.8
	GA	1.62	0.28	51.03	8.9	1.5	280.4
	ML	0.18	0.02	3.77	1.0	0.1	20.7
Maricopa County totals:		**1,924.48**	**4,187.59**	**10,097.03**	**10,574.1**	**23,008.7**	**55,478.2**

1. AC = air carrier, GA = general aviation, AT = air taxi, ML = military.

4.13 Locomotives

Annual emissions from locomotives were calculated based on diesel fuel usage provided by Burlington Northern/Santa Fe Railway (BNSF) and Union Pacific Railway (UP). Railway operations from these companies fall into two categories: Class I haul lines and yard/switching operations (no Class II or Class III haul lines operated in Maricopa County in 2002). Annual emissions from Class I haul operations and yard/ switching operations were calculated by multiplying diesel fuel usage by EPA emission factors for VOC, NO_x, and CO (US EPA, 1997).

VOC Emissions from UP Class I haul lines = Diesel fuel used (gals) × EPA emission factor (lbs/gal) for VOC ÷ 2000 lbs/ton

= 9,204,320 gallons × 0.022 lbs/gal ÷ 2000 lbs/ton

= 101.25 tons of VOC/yr

Table 4.13–1. Fuel use, emission factors, and annual emissions from locomotives in Maricopa County.

Locomotive type	Diesel fuel used (gals)	Emission factor (lbs/gal)			Emissions (tons/yr)		
		VOC	NO_x	CO	VOC	NO_x	CO
BNSF Class I haul line	824,339	0.022	0.595	0.059	9.07	245.24	24.32
UP Class I haul line	9,204,320	0.022	0.595	0.059	101.25	2,738.29	271.53
BNSF yard/switch operations	824,900	0.046	0.798	0.084	18.97	329.14	34.65
UP yard/switch operations	329,960	0.046	0.798	0.084	7.59	131.65	13.86
Totals:	**11,183,519**				**136.88**	**3,444.32**	**344.35**

Ozone nonattainment area emissions were calculated by multiplying Maricopa County emissions by the percentage of track miles inside the ozone nonattainment area, determined by GIS mapping:

Ozone nonattainment area emissions from UP Class I haul lines = County VOC emissions × Percentage of track in the nonattainment area

= 101.25 tons of VOC/yr × 37.95%

= 38.42 tons of VOC/yr

Table 4.13–2. Annual emissions (in tons/yr) from locomotives in the ozone NAA.

Locomotive type	Track in nonattainment area (%)	VOC	NO_x	CO
BNSF Class I haul line	37.95	3.44	93.07	9.23
UP Class I haul line	37.95	38.42	1,039.18	103.04
BNSF yard/switch operations	100.00	18.97	329.14	34.65
UP yard/switch operations	100.00	7.59	131.65	13.86
Totals:		**68.43**	**1,593.04**	**160.78**

Ozone season-day emissions for both the county and the ozone nonattainment area were calculated by dividing annual totals by 365 days per year, as locomotive activity is assumed to be uniform throughout the year.

Ozone season-day emissions from haul lines = Annual VOC emissions (tons) × 2000 lbs/ton ÷ 365 days

= 110.32 tons × 2000 lbs/ton ÷ 365 days

= 604.5 lbs/day

Table 4.13–3. Ozone season-day emissions (in lbs/day) from locomotives.

	Maricopa County			Nonattainment area		
Locomotive type	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
BNSF Class I haul line	49.7	1,343.8	133.2	18.9	510.0	50.6
UP Class I haul line	554.8	15,004.3	1,487.8	210.5	5,694.1	564.6
BNSF yard/switch operations	104.0	1,803.5	189.8	104.0	1,803.5	189.8
UP yard/switch operations	41.6	721.4	75.9	41.6	721.4	75.9
Totals:	**750.0**	**18,873.0**	**1,886.8**	**374.9**	**8,729.0**	**881.0**

4.14 Summary of all nonroad mobile source emissions

Tables 4.14–1 and 4.14–2 summarize annual and ozone season-day emissions of VOC, NO_x and CO from nonroad mobile sources in Maricopa county and the ozone nonattainment area, respectively.

Table 4.14–1. Annual and season-day emissions from nonroad mobile sources in Maricopa County.

	Annual emissions (tons/yr)			Typical daily emissions (lbs/day)		
Equipment category	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
Agricultural	70.60	477.46	632.96	621.8	4,147.2	5,839.5
Airport ground support equip.	139.57	147.09	3,471.09	766.9	808.1	19,071.9
Commercial	1,758.91	1,319.44	45,797.55	12,446.4	7,799.2	340,043.7
Construction & mining	1,786.47	9,834.69	15,584.58	15,336.6	83,115.7	143,428.8
Industrial	361.99	3,174.80	15,135.47	2,457.9	20,062.1	104,078.3
Lawn & garden	4,523.18	695.48	77,273.13	46,424.7	5,607.4	851,032.3
Logging	20.94	38.74	136.54	136.4	247.0	991.6
Pleasure craft	600.20	43.01	1,423.91	15,428.5	1,001.7	39,125.6
Railway maintenance	5.10	20.35	61.28	36.5	140.2	473.6
Recreational	885.25	63.35	9,788.20	11,451.8	656.1	137,421.0
Aircraft	1,924.48	4,187.59	10,097.03	10,574.1	23,008.7	55,478.2
Locomotives	136.88	3,444.32	344.35	750.0	18,873.0	1,886.8
Totals:	**12,213.57**	**23,446.32**	**179,746.09**	**116,431.6**	**165,466.4**	**1,698,871.3**

Table 4.14–2. Annual and season-day emissions from nonroad mobile sources in the ozone NAA.

	Annual emissions (tons/yr)			Typical daily emissions (lbs/day)		
Equipment category	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
Agricultural	31.43	212.61	281.86	276.9	1,846.8	2,600.3
Airport ground support equip.	136.08	143.42	3,384.31	747.7	787.9	18,595.1
Commercial	1,725.31	1,294.24	44,922.82	12,208.7	7,650.3	333,548.9
Construction & mining	1,752.35	9,646.84	15,286.91	15,043.6	81,528.2	140,689.3
Industrial	355.07	3,114.16	14,846.36	2,411.0	19,678.9	102,090.4
Lawn & garden	4,440.86	682.82	75,866.76	45,579.7	5,505.3	835,543.5
Logging	20.53	38.01	133.94	133.8	242.3	972.7
Pleasure craft	205.88	14.75	488.40	5,292.0	343.7	13,420.1
Railway maintenance	5.01	19.96	60.11	35.8	137.6	464.5
Recreational	89.32	6.40	987.63	1,155.4	66.1	13,865.9
Aircraft	1,920.37	4,186.89	9,888.43	10,551.5	23,004.9	54,332.0
Locomotives	68.43	1,593.04	160.78	374.9	8,729.0	881.0
TOTALS:	**10,750.64**	**20,953.14**	**166,308.31**	**93,811.0**	**149,521.0**	**1,517,003.7**

4.15 Quality assurance procedures

Established procedures were used to check, and correct when necessary, the off-road 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.

4.16 References

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