

## 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<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub> and SO<sub>x</sub>) 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 NONROAD2002 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 PM<sub>10</sub> nonattainment area and for an average 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 PM<sub>10</sub> average daily emissions are described in each section of this chapter.

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 PM<sub>10</sub> nonattainment area. The approaches used are described in each section of this chapter.

Temporal allocations (used to calculate PM<sub>10</sub> average-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 average-day emissions.

**Table 4.1–1. Default weekday and weekend day activity allocation fractions.**

<b>Equipment category</b>	<b>Weekday</b>	<b>Weekend day</b>
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.**

<b>Source Classification Code (SCC)</b>	<b>Engine type</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>NH<sub>3</sub></b>
2260005000	Gasoline 2-stroke	0.04	0.04	< 0.005	< 0.005	< 0.005
2265005000	Gasoline 4-stroke	0.08	0.08	6.16	0.06	0.22
2270005000	Diesel	56.78	52.24	471.30	6.53	0.73
<b>Totals:</b>		<b>56.90</b>	<b>52.35</b>	<b>477.46</b>	<b>6.59</b>	<b>0.96</b>

PM<sub>10</sub> 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 (222,124 acres) to agricultural land inside the county (415,473 acres). See Section 1.5.2 for a discussion of land-use data used.

$$\begin{aligned}
 \text{PM}_{10} \text{ nonattainment area emissions from agricultural equipment} &= \text{County PM}_{10} \text{ emissions} \times \text{Agricultural land-use allocation factor} \\
 &= 56.90 \text{ tons} \times 53.46\% \\
 &= 30.42 \text{ tons PM}_{10} / \text{yr}
 \end{aligned}$$

**Table 4.2–2. Annual emissions (in tons/yr) from agricultural equipment in the PM<sub>10</sub> NAA.**

SCC	Engine type	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
2260005000	Gasoline 2-stroke	0.02	0.02	< 0.005	< 0.005	< 0.005
2265005000	Gasoline 4-stroke	0.04	0.04	3.29	0.03	0.12
2270005000	Diesel	30.36	27.93	251.96	3.49	0.39
<b>Totals:</b>		<b>30.42</b>	<b>27.99</b>	<b>255.25</b>	<b>3.52</b>	<b>0.51</b>

County average-day emissions were calculated by multiplying annual 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 (52) in the year (US EPA, 1999), as follows:

$$\begin{aligned}
 \text{Maricopa County PM}_{10} \text{ average-day emissions (lbs/day)} &= \text{Annual PM}_{10} \text{ emissions (tons/year)} \times 2000 \text{ (lb/ton)} \times \text{daily activity allocation factor for agricultural equipment expressed as (week/day)} \div 52 \text{ (weeks per year)} \\
 &= 56.90 \times 2000 \times 0.166667 \div 52 \\
 &= 364.8 \text{ lbs/day}
 \end{aligned}$$

**Table 4.2–3. Typical daily emissions (in lbs/day) from agricultural equipment in Maricopa County.**

SCC	Engine type	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
2260005000	Gasoline 2-stroke	0.3	0.3	< 0.05	< 0.05	< 0.05
2265005000	Gasoline 4-stroke	0.5	0.5	39.5	0.4	1.4
2270005000	Diesel	364.0	334.9	3,021.2	41.9	4.7
<b>Totals:</b>		<b>364.8</b>	<b>335.7</b>	<b>3,060.7</b>	<b>42.3</b>	<b>6.1</b>

PM<sub>10</sub> nonattainment area average-day emissions were calculated by multiplying County average-day emissions by the agricultural land-use allocation factor:

$$\begin{aligned}
 \text{PM}_{10} \text{ nonattainment area average-day emissions} &= \text{Maricopa County PM}_{10} \text{ average-day emissions} \times \text{Agricultural land-use allocation factor} \\
 &= 364.8 \text{ lbs/day} \times 53.46\% \\
 &= 195.0 \text{ lbs/day}
 \end{aligned}$$

**Table 4.2–4. Typical daily emissions (in lbs/day) from agricultural equipment in the PM<sub>10</sub> nonattainment area.**

SCC	Engine type	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
2260005000	Gasoline 2-stroke	0.1	0.1	< 0.05	< 0.05	< 0.05
2265005000	Gasoline 4-stroke	0.3	0.3	21.1	0.2	0.7
2270005000	Diesel	194.6	179.0	1,615.1	22.4	2.5
<b>Totals:</b>		<b>195.0</b>	<b>179.4</b>	<b>1,636.2</b>	<b>22.6</b>	<b>3.2</b>

### 4.3 Airport ground support equipment

Annual emissions from airport ground support equipment (GSE) in Maricopa County were calculated using EPA's NONROAD2002 model, as described in Section 4.1. Annual emissions for the PM<sub>10</sub> nonattainment area for this category were derived by applying the ratio of the number of FAA landings and takeoffs (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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline 4-stroke	0.74	0.69	92.10	0.81	3.32	0.72	0.67	89.80	0.79	3.24
Diesel	3.93	3.62	54.99	0.86	0.09	3.83	3.53	53.62	0.84	0.09
<b>Totals:</b>	<b>4.67</b>	<b>4.31</b>	<b>147.09</b>	<b>1.67</b>	<b>3.41</b>	<b>4.55</b>	<b>4.20</b>	<b>143.42</b>	<b>1.63</b>	<b>3.33</b>

County average-day emissions were calculated by first multiplying Maricopa County annual emissions 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on LTOs as described above. results are shown in Table 4.3–2.

**Table 4.3–2. Typical daily emissions (in lbs/day) from airport ground support equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline 4-stroke	4.1	3.8	506.0	4.5	18.2	4.0	3.7	493.4	4.4	17.7
Diesel	21.6	19.9	302.1	4.7	0.5	21.1	19.4	294.5	4.6	0.5
<b>Totals:</b>	<b>25.7</b>	<b>23.7</b>	<b>808.1</b>	<b>9.2</b>	<b>18.7</b>	<b>25.1</b>	<b>23.1</b>	<b>787.9</b>	<b>9.0</b>	<b>18.2</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	12.43	11.44	1.28	0.11	0.05	12.29	11.32	1.27	0.11	0.05
Gasoline 4-stroke	12.61	11.69	567.59	7.79	20.47	12.47	11.56	561.40	7.70	20.25
Diesel	95.45	87.82	750.57	11.38	1.17	94.41	86.86	742.39	11.26	1.16
<b>Totals:</b>	<b>120.50</b>	<b>110.95</b>	<b>1,319.44</b>	<b>19.28</b>	<b>21.68</b>	<b>119.17</b>	<b>109.74</b>	<b>1,305.06</b>	<b>19.07</b>	<b>21.46</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on industrial employment ratios as described above.

**Table 4.4–2. Typical daily emissions (in lbs/day) from commercial equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	79.7	73.3	8.2	0.7	0.3	78.8	72.5	8.1	0.7	0.3
Gasoline 4-stroke	80.8	74.9	3,638.4	49.9	131.2	79.9	74.1	3,598.7	49.4	129.8
Diesel	611.9	562.9	4,811.3	72.9	7.5	605.2	556.8	4,758.9	72.1	7.4
<b>Totals:</b>	<b>772.4</b>	<b>711.1</b>	<b>8,457.9</b>	<b>123.5</b>	<b>139.0</b>	<b>763.9</b>	<b>703.4</b>	<b>8,365.7</b>	<b>122.2</b>	<b>137.5</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	28.34	26.07	6.28	0.20	0.23	28.10	25.85	6.23	0.20	0.23
Gasoline 4-stroke	2.33	2.16	114.49	1.46	4.13	2.31	2.14	113.51	1.45	4.09
Diesel	828.67	762.37	9,713.92	152.39	15.12	821.54	755.81	9,630.38	151.08	14.99
<b>Totals:</b>	<b>859.34</b>	<b>790.60</b>	<b>9,834.69</b>	<b>154.05</b>	<b>19.47</b>	<b>851.95</b>	<b>783.80</b>	<b>9,750.12</b>	<b>152.73</b>	<b>19.31</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on population ratios as described above.

**Table 4.5–2. Typical daily emissions (in lbs/day) from construction and mining equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	181.7	167.1	40.3	1.3	1.5	180.1	165.7	40.0	1.3	1.5
Gasoline 4-stroke	14.9	13.8	733.9	9.4	26.5	14.8	13.7	727.6	9.3	26.3
Diesel	5,312.0	4,887.0	62,268.7	976.9	96.9	5,266.3	4,845.0	61,733.2	968.5	96.1
<b>Totals:</b>	<b>5,508.6</b>	<b>5,067.9</b>	<b>63,042.9</b>	<b>987.6</b>	<b>124.9</b>	<b>5,461.2</b>	<b>5,024.4</b>	<b>62,500.8</b>	<b>979.1</b>	<b>123.9</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.17	0.15	0.02	< 0.005	< 0.005	0.17	0.15	0.02	< 0.005	< 0.005
Gasoline 4-stroke	10.90	10.77	2,108.32	3.49	76.03	10.78	10.65	2,085.34	3.45	75.20
Diesel	96.15	88.46	1,066.46	18.95	1.66	95.10	87.50	1,054.84	18.74	1.64
<b>Totals:</b>	<b>107.22</b>	<b>99.38</b>	<b>3,174.80</b>	<b>22.45</b>	<b>77.69</b>	<b>106.05</b>	<b>98.30</b>	<b>3,140.20</b>	<b>22.19</b>	<b>76.84</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on industrial employment ratios as described above.

**Table 4.6–2. Typical daily emissions (in lbs/day) from industrial equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	1.1	1.0	0.1	< 0.05	< 0.05	1.1	1.0	0.1	< 0.05	< 0.05
Gasoline 4-stroke	69.9	69.0	13,514.9	22.4	487.4	69.1	68.2	13,367.6	22.2	482.1
Diesel	616.6	567.1	6,836.3	121.5	10.6	609.9	560.9	6,761.8	120.2	10.5
<b>Totals:</b>	<b>687.6</b>	<b>637.1</b>	<b>20,351.3</b>	<b>143.9</b>	<b>498.0</b>	<b>680.1</b>	<b>630.1</b>	<b>20,129.5</b>	<b>142.4</b>	<b>492.6</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	100.27	92.24	13.04	0.85	0.47	99.45	91.48	12.93	0.84	0.47
Gasoline 4-stroke	18.57	17.10	463.63	10.76	16.73	18.42	16.96	459.83	10.67	16.59
Diesel	22.75	20.93	218.81	3.59	0.34	22.56	20.76	217.02	3.56	0.34
<b>Totals:</b>	<b>141.59</b>	<b>130.27</b>	<b>695.48</b>	<b>15.20</b>	<b>17.54</b>	<b>140.43</b>	<b>129.20</b>	<b>689.78</b>	<b>15.07</b>	<b>17.40</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on housing units as described above.

**Table 4.7–2. Typical daily emissions (in lbs/day) from lawn and garden equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	696.3	640.6	86.7	6.0	2.9	690.6	635.3	86.0	6.0	2.9
Gasoline 4-stroke	138.3	127.3	2,853.1	80.3	123.8	137.2	126.3	2,829.7	79.6	122.8
Diesel	140.0	128.8	1,346.5	22.1	2.1	138.9	127.7	1,335.5	21.9	2.1
<b>Totals:</b>	<b>974.6</b>	<b>896.7</b>	<b>4,286.3</b>	<b>108.4</b>	<b>128.8</b>	<b>966.7</b>	<b>889.3</b>	<b>4,251.2</b>	<b>107.5</b>	<b>127.8</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.85	0.78	0.20	0.01	0.01	0.84	0.77	0.20	0.01	0.01
Gasoline 4-stroke	0.02	0.02	0.60	0.02	0.02	0.02	0.02	0.59	0.02	0.02
Diesel	2.38	2.19	37.94	0.69	0.06	2.36	2.17	37.61	0.68	0.06
<b>Totals:</b>	<b>3.25</b>	<b>2.99</b>	<b>38.74</b>	<b>0.71</b>	<b>0.09</b>	<b>3.22</b>	<b>2.96</b>	<b>38.40</b>	<b>0.70</b>	<b>0.09</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area season-day emissions were calculated based on population as described above.

**Table 4.8–2. Typical daily emissions (in lbs/day) from logging equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	5.4	5.0	1.3	0.1	0.1	5.4	5.0	1.3	0.1	0.1
Gasoline 4-stroke	0.1	0.1	3.8	0.1	0.1	0.1	0.1	3.8	0.1	0.1
Diesel	15.3	14.0	243.2	4.4	0.4	15.2	13.9	241.1	4.4	0.4
<b>Totals:</b>	<b>20.8</b>	<b>19.1</b>	<b>248.3</b>	<b>4.6</b>	<b>0.6</b>	<b>20.7</b>	<b>19.0</b>	<b>246.2</b>	<b>4.6</b>	<b>0.6</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	26.76	24.62	11.60	0.43	0.42	12.92	11.89	5.60	0.21	0.20
Gasoline 4-stroke	0.18	0.16	15.90	0.21	0.57	0.09	0.08	7.68	0.10	0.28
Diesel	0.29	0.27	15.52	0.23	0.02	0.14	0.13	7.49	0.11	0.01
<b>Totals:</b>	<b>27.23</b>	<b>25.05</b>	<b>43.01</b>	<b>0.88</b>	<b>1.02</b>	<b>13.15</b>	<b>12.10</b>	<b>20.77</b>	<b>0.42</b>	<b>0.49</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on water surface area as described above.

**Table 4.9–2. Typical daily emissions (in lbs/day) from pleasure craft equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	360.2	331.4	156.2	5.8	5.7	173.9	160.0	75.4	2.8	2.8
Gasoline 4-stroke	2.4	2.2	214.0	2.8	7.7	1.2	1.1	103.3	1.4	3.7
Diesel	3.9	3.6	208.9	3.1	0.3	1.9	1.7	100.9	1.5	0.1
<b>Totals:</b>	<b>366.5</b>	<b>337.2</b>	<b>579.1</b>	<b>11.7</b>	<b>13.7</b>	<b>177.0</b>	<b>162.8</b>	<b>279.6</b>	<b>5.7</b>	<b>6.6</b>

#### 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 PM<sub>10</sub> 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline 4-stroke	0.01	0.01	0.39	0.01	0.01	0.01	0.01	0.39	0.01	0.01
Diesel	3.04	2.80	19.96	0.26	0.03	3.01	2.78	19.79	0.26	0.03
<b>Totals:</b>	<b>3.05</b>	<b>2.81</b>	<b>20.35</b>	<b>0.27</b>	<b>0.05</b>	<b>3.02</b>	<b>2.79</b>	<b>20.18</b>	<b>0.27</b>	<b>0.05</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on the population ratio as described above.

**Table 4.10–2. Typical daily emissions (in lbs/day) from railway maintenance equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline 4-stroke	0.1	0.1	2.7	0.1	0.1	0.1	0.1	2.7	0.1	0.1
Diesel	21.0	19.4	138.2	1.8	0.2	20.8	19.2	137.0	1.8	0.2
<b>Totals:</b>	<b>21.1</b>	<b>19.5</b>	<b>140.9</b>	<b>1.9</b>	<b>0.3</b>	<b>20.9</b>	<b>19.3</b>	<b>139.7</b>	<b>1.9</b>	<b>0.3</b>

#### 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 PM<sub>10</sub> 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 EIPP 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.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	0.29	0.27	4.95	0.24	0.18	0.06	0.05	0.99	0.05	0.04
Gasoline 4-stroke	2.03	1.87	47.92	1.90	1.73	0.41	0.37	9.59	0.38	0.35
Diesel	2.21	2.03	10.47	0.15	0.02	0.44	0.41	2.10	0.03	<0.005
<b>Totals:</b>	<b>4.53</b>	<b>4.17</b>	<b>63.34</b>	<b>2.29</b>	<b>1.92</b>	<b>0.91</b>	<b>0.83</b>	<b>12.68</b>	<b>0.46</b>	<b>0.39</b>

County average-day emissions were calculated by multiplying Maricopa County annual 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 (52) in the year (US EPA, 1999). PM<sub>10</sub> nonattainment area average-day emissions were calculated based on land use as described above.

**Table 4.11–2. Typical daily emissions (in lbs/day) from recreational equipment.**

Engine type	Maricopa County					PM <sub>10</sub> nonattainment area				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Gasoline 2-stroke	2.5	2.3	42.3	2.1	1.5	0.5	0.5	8.5	0.4	0.3
Gasoline 4-stroke	17.4	16.0	409.6	16.2	14.8	3.5	3.2	82.0	3.2	3.0
Diesel	18.9	17.4	89.5	1.3	0.1	3.8	3.5	17.9	0.3	<0.05
<b>Totals:</b>	<b>38.8</b>	<b>35.7</b>	<b>541.4</b>	<b>19.6</b>	<b>16.5</b>	<b>7.8</b>	<b>7.2</b>	<b>108.4</b>	<b>3.9</b>	<b>3.3</b>

#### 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 4.11) 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. Since the EDMS model results do not calculate PM<sub>10</sub> or PM<sub>2.5</sub> values, a ratio was calculated based on the NEI default emission factors between NO<sub>x</sub> and PM<sub>10</sub> as well as NO<sub>x</sub> and PM<sub>2.5</sub>. This ratio was then applied to the EDMS output results for NO<sub>x</sub> to derive PM<sub>10</sub> and PM<sub>2.5</sub> emission factors. [ *NOTE: Refer to the Errata sheet that accompanies this document for details on how PM<sub>10</sub> and PM<sub>2.5</sub> emissions for air carriers have been calculated.* ]

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

Aircraft type	Abbreviation	SCC	NO <sub>x</sub>	SO <sub>x</sub>	NO <sub>x</sub> :PM		PM <sub>10</sub>	PM <sub>2.5</sub>
					ratio	ratio		
Air Taxi	AT	2275060000	0.158	0.015	3.8185	2.6329	0.603	0.416
General Aviation	GA	2275050000	0.065	0.010	3.6415	2.4923	0.237	0.162
Military	ML	2275001000	0.158	0.015	3.8185	2.6329	0.603	0.416

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 Sky ranch 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 Sky ranch, 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 air craft 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.

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

Airport name	Activity category	2002 LTOs	LTO data source <sup>1</sup>	Emission calculation method <sup>2</sup>	Lbs/LTO			
					PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>
Arizona Army National Guard	ML	780	reported	NEI default	0.603	0.416	0.158	0.015
Buckeye Municipal Airport <sup>3</sup>	GA	16,796	reported	EDMS	0.160	0.110	0.044	0.002
Chandler Municipal Airport	AT	914	reported	NEI default	0.603	0.416	0.158	0.015
	GA	80,689	reported	NEI default	0.237	0.162	0.065	0.010
	ML	10	reported	NEI default	0.603	0.416	0.158	0.015
Falcon Field	AT	1,319	AirNav	NEI default	0.603	0.416	0.158	0.015
	GA	125,350	AirNav	NEI default	0.237	0.162	0.065	0.010
	ML	5,278	AirNav	NEI default	0.603	0.416	0.158	0.015
Gila Bend Municipal Airport <sup>3</sup>	GA	522	AirNav	NEI default	0.236	0.162	0.065	0.010
Glendale Municipal Airport	GA	59,352	reported	NEI default	0.237	0.162	0.065	0.010
Luke Air Force Base	ML	61,225	reported	EDMS	41.650	28.739	10.906	0.387
Phoenix Deer Valley Airport	AT	2,495	reported	NEI default	0.603	0.416	0.158	0.015
	GA	192,254	reported	NEI default	0.237	0.162	0.065	0.010
	ML	37	reported	NEI default	0.603	0.416	0.158	0.015
Phoenix Goodyear Airport	AC	131	reported	EDMS	1.48	1.45	37.718	1.887
	AT	270	reported	NEI default	0.603	0.416	0.158	0.015
	GA	68,317	reported	NEI default	0.237	0.162	0.065	0.010
	ML	569	reported	NEI default	0.603	0.416	0.158	0.015
Phoenix Sky Harbor Int'l.	AC	187,125	reported	EDMS	1.28	1.25	40.201	2.933
	AT	57,570	reported	EDMS	5.266	3.634	1.379	0.145
	GA	26,204	reported	EDMS	0.062	0.042	0.017	0.001
	ML	1,987	reported	EDMS	1.264	0.872	0.331	0.012
Pleasant Valley Airport	GA	19,302	reported	EDMS	1.205	0.824	0.331	0.059
Scottsdale Airport	AT	5,026	reported	NEI default	0.603	0.416	0.158	0.015
	GA	92,365	reported	NEI default	0.237	0.162	0.065	0.010
	ML	291	reported	NEI default	0.603	0.416	0.158	0.015
Skyranch at Carefree	GA	2,453	reported	EDMS	0.160	0.110	0.044	0.002
Stellar Airpark	GA	22,000	reported	NEI default	0.236	0.162	0.065	0.010
Wickenburg Mun. Airport <sup>3</sup>	AT	179	AirNav	NEI default	0.603	0.416	0.158	0.015
	GA	8,495	AirNav	NEI default	0.236	0.162	0.065	0.010
	ML	268	AirNav	NEI default	0.603	0.416	0.158	0.015
Williams Gateway Airport	AC	421	reported	EDMS	1.08	1.05	18.067	1.346
	AT	3,104	reported	EDMS	5.266	3.634	1.379	0.145
	GA	79,731	reported	EDMS	0.163	0.112	0.045	0.002
	ML	5,990	reported	EDMS	20.240	13.966	5.300	0.195

1. “reported” = using 2002 survey results supplied by the airport,  
“AirNav” = using available data on average daily LTOs from [www.airnav.com](http://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.

For example, the model run with the 12 aircraft types resulted in total NO<sub>x</sub> emissions of 0.532 tons (assuming each of the 12 aircraft types had 2000 LTOs each during the period).

$$\begin{aligned} \text{Composite NO}_x \text{ emission factor (lb/LTO)} &= \Sigma \text{ modeled NO}_x \text{ emissions (tons/yr)} \times 1 \text{ yr} / 24,000 \text{ LTOs} \times 2000 \text{ lb/ton} \\ &= 0.044 \text{ lb NO}_x \text{ /LTO} \end{aligned}$$

This composite emission factor was then multiplied by the actual number of LTOs at the airport to derive an annual NO<sub>x</sub> emissions total:

$$\begin{aligned} \text{NO}_x \text{ emissions (lb/ yr)} &= 2,453 \text{ LTO/yr} \times 0.044 \text{ lb NO}_x \text{ /LTO} \\ &= 107.9 \text{ lb NO}_x \text{ /yr} \end{aligned}$$

The above approach was used to calculate NO<sub>x</sub> and SO<sub>x</sub> directly from the EDMS model. Emissions of PM<sub>10</sub> and PM<sub>2.5</sub> were derived by applying the appropriate NO<sub>x</sub>:PM<sub>10</sub> and NO<sub>x</sub>:PM<sub>2.5</sub> ratios listed in Table 4.12–1.

For all airports, activity is presumed to occur evenly over a 7-day week and average daily emissions were calculated by dividing annual totals by 365 days per year. Table 4.12–3 lists the total annual emissions and average daily emissions, for each airport and aircraft type.

**Table 4.12–3. Annual and typical daily emissions, by airport and aircraft type.**

Facility	Category <sup>1</sup>	Tons/yr				Lbs/day			
		PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>
Arizona Army Natl. Guard	ML	0.24	0.16	0.06	0.01	1.3	0.9	0.3	0.0
Chandler Municipal Airport	AT	0.28	0.19	0.07	0.01	1.5	1.0	0.4	0.0
	GA	9.55	6.53	2.62	0.40	52.3	35.8	14.4	2.2
	ML	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Falcon Field	AT	0.40	0.27	0.10	0.01	2.2	1.5	0.6	0.1
	GA	14.84	10.15	4.07	0.63	81.3	55.6	22.3	3.4
	ML	1.59	1.10	0.42	0.04	8.7	6.0	2.3	0.2
Glendale Municipal Airport	GA	7.02	4.81	1.93	0.30	38.5	26.3	10.6	1.6
Luke Air Force Base	ML	1,275.01	879.76	333.86	11.85	6,986.4	4,820.6	1,829.4	64.9
Phoenix Deer Valley Airpt.	AT	0.75	0.52	0.20	0.02	4.1	2.8	1.1	0.1
	GA	22.75	15.57	6.25	0.96	124.7	85.3	34.2	5.3
	ML	0.01	0.01	0.00	0.00	0.0	0.0	0.0	0.0
Phoenix Goodyear Airport	AC	0.10	0.09	2.47	0.12	0.5	0.5	13.5	0.7
	AT	0.08	0.06	0.02	0.00	0.4	0.3	0.1	0.0
	GA	8.09	5.53	2.22	0.34	44.3	30.3	12.2	1.9
	ML	0.17	0.12	0.04	0.00	0.9	0.6	0.2	0.0
Phoenix Sky Harbor Int'l.	AC	119.76	116.95	3,761.31	274.42	656.2	640.8	20,609.9	1,503.7
	AT	151.59	104.60	39.69	4.17	830.6	573.1	217.5	22.9
	GA	0.81	0.55	0.22	0.01	4.4	3.0	1.2	0.1
	ML	1.26	0.87	0.33	0.01	6.9	4.7	1.8	0.1
Pleasant Valley Airport	GA	11.63	7.96	3.19	0.57	63.7	43.6	17.5	3.1
Scottsdale Airport	AT	1.52	1.05	0.40	0.04	8.3	5.7	2.2	0.2
	GA	10.93	7.48	3.00	0.46	59.9	41.0	16.4	2.5
	ML	0.09	0.06	0.02	0.00	0.5	0.3	0.1	0.0
Skyranch at Carefree	GA	0.20	0.13	0.05	0.00	1.1	0.7	0.3	0.0
Stellar Airpark	GA	2.60	1.78	0.72	0.11	14.3	9.8	3.9	0.6
Williams Gateway Airport	AC	0.23	0.22	3.80	0.28	1.2	1.2	20.8	1.6
	AT	8.17	5.64	2.14	0.23	44.8	30.9	11.7	1.2
	GA	6.53	4.47	1.79	0.08	35.8	24.5	9.8	0.4
	ML	60.62	41.83	15.87	0.58	332.2	229.2	87.0	3.2
<b>PM<sub>10</sub> nonattainment area totals:</b>		<b>1,716.82</b>	<b>1,218.47</b>	<b>4,186.89</b>	<b>295.66</b>	<b>9,407.2</b>	<b>6,676.6</b>	<b>22,941.9</b>	<b>1,620.1</b>

Airports outside the nonattainment area:

Buckeye Mun. Airport	GA	1.35	0.92	0.37	0.02	7.4	5.0	2.0	0.1
Gila Bend Mun. Airport	GA	0.06	0.04	0.02	0.00	0.3	0.2	0.1	0.0
Wickenburg Mun. Airport	AT	0.05	0.04	0.01	0.00	0.3	0.2	0.1	0.0
	GA	1.01	0.69	0.28	0.04	5.5	3.8	1.5	0.2
	ML	0.08	0.06	0.02	0.00	0.4	0.3	0.1	0.0
<b>Maricopa County totals:</b>		<b>1,719.37</b>	<b>1,220.22</b>	<b>4,187.66</b>	<b>295.81</b>	<b>9,421.2</b>	<b>6,686.1</b>	<b>22,946.1</b>	<b>1,620.9</b>

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 the emission factors listed in Table 4.13–1.

**Table 4.13–1. Emission factors for locomotives.**

Activity type	Emission factors (lbs/gal diesel)				
	PM <sub>10</sub> <sup>(1)</sup>	PM <sub>2.5</sub> <sup>(1)</sup>	NO <sub>x</sub> <sup>(1)</sup>	SO <sub>x</sub> <sup>(2)</sup>	NH <sub>3</sub> <sup>(3)</sup>
Class I haul line	0.015	0.013	0.595	0.036	0.00095
Yard/switch operations	0.020	0.019	0.798	0.036	0.00095

Sources: (1) EPA, 1997. (2) EPA, 1992. (3) EPA, 1998.

The example below illustrates how emissions were calculated for each locomotive activity type. Fuel use reported by railroads, and emission totals are summarized in Table 4.13–2.

$$\begin{aligned}
 \text{PM}_{10} \text{ emissions from UP Class I haul lines} &= \text{Diesel fuel used (gals)} \times \text{EPA emission factor (lbs/gal) for PM}_{10} \div 2000 \text{ lbs/ton} \\
 &= 9,204,320 \text{ gallons} \times 0.015 \text{ lbs/gal} \div 2000 \text{ lbs/ton} \\
 &= 69.03 \text{ tons PM}_{10}/\text{yr}
 \end{aligned}$$

**Table 4.13–2. Fuel use and annual emissions from locomotives in Maricopa County.**

Locomotive type	Diesel fuel used (gals)	Annual emissions (tons/yr)				
		PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
BNSF Class I haul line	824,339	6.18	5.36	245.24	14.84	0.39
UP Class I haul line	9,204,320	69.03	59.83	2,738.29	165.68	4.37
BNSF yard/switch operations	824,900	8.25	7.84	329.14	14.85	0.39
UP yard/switch operations	329,960	3.30	3.13	131.65	5.94	0.16
<b>Totals:</b>	<b>11,183,519</b>	<b>86.76</b>	<b>76.16</b>	<b>3,444.32</b>	<b>201.30</b>	<b>5.31</b>

PM<sub>10</sub> nonattainment area emissions were calculated by multiplying Maricopa County emissions by the percentage of track miles inside the PM<sub>10</sub> nonattainment area, determined by GIS mapping:

$$\begin{aligned}
 \text{PM}_{10} \text{ nonattainment area emissions from UP Class I haul lines} &= \text{County PM}_{10} \text{ emissions} \times \text{Percentage of track in the nonattainment area} \\
 &= 69.03 \text{ tons PM}_{10}/\text{yr} \times 44.27\% \\
 &= 30.56 \text{ tons PM}_{10}/\text{yr}
 \end{aligned}$$

**Table 4.13–3. Annual emissions (in tons/yr) from locomotives in the PM<sub>10</sub> NAA.**

Locomotive type	Track in nonattainment area (%)	Annual emissions (tons/yr)				
		PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
BNSF Class I haul line	44.27	2.74	2.37	108.57	6.57	0.17
UP Class I haul line	44.27	30.56	26.49	1,212.24	73.35	1.94
BNSF yard/switch operations	100.00	8.25	7.84	329.14	14.85	0.39
UP yard/switch operations	100.00	3.30	3.13	131.65	5.94	0.16
<b>Totals:</b>		<b>44.85</b>	<b>39.83</b>	<b>1,781.60</b>	<b>100.70</b>	<b>2.66</b>

PM<sub>10</sub> typical daily emissions for both the county (shown in Table 4.13–4) and the PM<sub>10</sub> nonattainment area (Table 4.13–5) were calculated by dividing annual totals by 365 days per year, as locomotive activity is assumed to be uniform throughout the year.

$$\begin{aligned}
 \text{PM}_{10} \text{ typical daily} &= \text{Annual PM}_{10} \text{ emissions (tons)} \times 2000 \text{ lbs/ton} \div 365 \text{ days} \\
 \text{emissions from haul lines} &= 69.03 \text{ tons} \times 2000 \text{ lbs/ton} \div 365 \text{ days} \\
 &= 378.3 \text{ lbs PM}_{10} / \text{day}
 \end{aligned}$$

**Table 4.13–4. Typical daily emissions (in lbs/day) from locomotives in Maricopa County.**

Locomotive type	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
BNSF Class I haul line	33.9	29.4	1,343.8	81.3	2.1
UP Class I haul line	378.3	327.8	15,004.3	907.8	24.0
BNSF yard/switch operations	45.2	42.9	1,803.5	81.4	2.1
UP yard/switch operations	18.1	17.2	721.4	32.5	0.9
<b>Totals:</b>	<b>475.4</b>	<b>417.3</b>	<b>18,873.0</b>	<b>1,103.0</b>	<b>29.1</b>

**Table 4.13–5. Typical daily emissions (in lbs/day) from locomotives in the PM<sub>10</sub> nonattainment area.**

Locomotive type	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
BNSF Class I haul line	15.0	13.0	594.9	36.0	0.9
UP Class I haul line	167.5	145.1	6,642.4	401.9	10.6
BNSF yard/switch operations	45.2	42.9	1,803.5	81.4	2.1
UP yard/switch operations	18.1	17.2	721.4	32.5	0.9
<b>Totals:</b>	<b>245.7</b>	<b>218.2</b>	<b>9,762.2</b>	<b>551.8</b>	<b>14.6</b>

#### 4.14 Summary of all nonroad mobile source emissions

Table 4.14–1 summarizes annual and daily emissions of PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>x</sub> and NH<sub>3</sub> from nonroad mobile sources in Maricopa County respectively. Table 4.14–2 shows annual and typical daily emissions for these pollutants for the PM<sub>10</sub> nonattainment area.

**Table 4.14–1. Annual and typical daily emissions from nonroad mobile sources in Maricopa County.**

Category	Annual emissions (tons/yr)					Typical daily emissions (lbs/day)				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Agricultural	56.90	52.35	477.46	6.59	0.96	364.8	335.7	3,060.7	42.3	6.1
Airport ground support	4.67	4.31	147.09	1.67	3.41	25.7	23.7	808.1	9.2	18.7
Commercial	120.50	110.95	1,319.44	19.28	21.68	772.4	711.1	8,457.9	123.5	139.0
Construction & mining	859.34	790.60	9,834.69	154.05	19.47	5,508.6	5,067.9	63,042.9	987.6	124.9
Industrial	107.22	99.38	3,174.80	22.45	77.69	687.6	637.1	20,351.3	143.9	498.0
Lawn & garden	141.59	130.27	695.48	15.20	17.54	974.6	896.7	4,286.3	108.4	128.8
Logging	3.25	2.99	38.74	0.71	0.09	20.8	19.1	248.3	4.6	0.6
Pleasure craft	27.23	25.06	43.01	0.88	1.02	366.5	337.2	579.1	11.7	13.7
Railway maintenance	3.05	2.81	20.35	0.27	0.05	21.1	19.5	140.9	1.9	0.3
Recreational	4.53	4.17	63.35	2.29	1.92	38.8	35.7	541.4	19.6	16.5
Aircraft	1,719.37	1,220.22	4,187.66	295.81	0.00	9,421.2	6,686.1	22,946.1	1,620.5	0.0
Locomotives	86.76	76.16	3,444.32	201.30	5.31	475.4	417.3	18,873.0	1,103.0	29.1
<b>Totals:</b>	<b>3,134.41</b>	<b>2,519.27</b>	<b>23,446.39</b>	<b>720.50</b>	<b>149.14</b>	<b>18,677.5</b>	<b>15,187.1</b>	<b>143,336.0</b>	<b>4,176.6</b>	<b>975.7</b>

**Table 4.14–2. Annual and typical daily emissions from nonroad mobile sources in the PM<sub>10</sub> NAA.**

Category	Annual emissions (tons/yr)					Typical daily emissions (lbs/day)				
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>x</sub>	NH <sub>3</sub>
Agricultural	30.42	27.99	255.25	3.52	0.51	195.0	179.4	1,636.2	22.6	3.2
Airport ground support	4.55	4.20	143.42	1.63	3.33	25.1	23.1	787.9	9.0	18.2
Commercial	119.17	109.74	1,305.06	19.07	21.46	763.9	703.4	8,365.7	122.2	267.6
Construction & mining	851.95	783.80	9,750.12	152.73	19.31	5,461.2	5,024.4	62,500.8	979.1	123.9
Industrial	106.05	98.30	3,140.20	22.19	76.84	680.1	630.1	20,129.5	142.4	492.6
Lawn & garden	140.43	129.20	689.78	15.07	17.40	966.7	889.3	4,251.2	107.5	127.8
Logging	3.22	2.96	38.40	0.70	0.09	20.7	19.0	246.2	4.6	0.6
Pleasure craft	13.15	12.10	20.77	0.42	0.49	177.0	162.8	279.6	5.7	6.6
Railway maintenance	3.02	2.79	20.18	0.27	0.05	20.9	19.3	139.7	1.9	0.3
Recreational	0.91	0.83	12.68	0.46	0.39	7.8	7.2	108.4	3.9	3.3
Aircraft	1,716.82	1,218.47	4,186.89	295.66	0.00	9,407.2	6,676.6	22,941.9	1,620.1	0.0
Locomotives	44.85	39.83	1,781.60	100.70	2.66	245.7	218.2	9,762.2	551.8	14.6
<b>Totals:</b>	<b>3,034.54</b>	<b>2,430.21</b>	<b>21,344.35</b>	<b>612.42</b>	<b>142.53</b>	<b>17,971.3</b>	<b>14,552.8</b>	<b>131,149.3</b>	<b>3,570.8</b>	<b>1,058.7</b>

#### 4.15 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.

#### 4.16 References

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