COLORADO STATE IMPLEMENTATION PLAN FOR PM_{10}

TECHNICAL SUPPORT DOCUMENT

Adopted April 19, 2001

Denver Metropolitan Nonattainment Area

Emission Inventories and Dispersion Model Results for the Maintenance Plan

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1 Introduction

This document presents technical support methodologies and data by which the Denver area requests redesignation for particulate matter (PM_{10}). Presented are emission inventories and air quality modeling methodologies with results upon which the Denver particulate matter (PM_{10}) redesignation request and maintenance plan are based. Measured air quality data supports Colorado's request that EPA redesignate the Denver metropolitan area to attainment status for the National Ambient Air Quality Standards (NAAQS) for PM_{10}. The Denver metropolitan area has been designated as a PM_{10} nonattainment area since 1987, but has not violated the 24-hour PM_{10} standard since 1993. The Denver PM_{10} nonattainment area is now eligible for redesignation.

2 Background

2.1 National Ambient Air Quality Standards for Fine Particulate

In 1987, the EPA changed the particulate matter standard to include only those particles with an aerodynamic diameter of less than or equal to 10 microns (commonly referred to as PM_{10}). The current PM10 NAAQS allow for a maximum annual average of 50 ug/m^3, and, a 24-hour average of 150 ug/m^3. The 24-hour PM_{10} NAAQS may not be exceeded more than three time over any three year period.

There are both primary and secondary air quality standards. The primary standards are set to protect human health, with a margin of safety to protect the more sensitive persons in the population, such as the very young, elderly and the ill. Secondary standards are set to protect property, materials, aesthetic values and general welfare. For PM_{10}, the national primary and secondary standards are the same. As stated in the Code of Federal Regulations (40 CFR Part 50.6),

The standards are attained when the expected number of days per calendar year with a 24-hour average concentration above 150 ug/m^3 is equal to or less than one (based on 3-year average), and the annual arithmetic mean concentration is less than or equal to 50 ug/m^3 (based on 3-year average) as determined by Appendix K.

2.2 Health Effects of Particulate Matter Less Than 10 Micron in Size

Both fine and coarse particles can accumulate in the respiratory system and are associated with numerous health effects. Coarse particles can aggravate respiratory conditions such as asthma. Exposure to fine particles is associated with several serious health effects, including premature death. Adverse health effects have been associated with exposures to PM over both short periods (such as a day) and longer periods (a year or more).

- When exposed to PM, people with existing heart or lung diseases—such as asthma, chronic obstructive pulmonary disease, congestive heart disease, or ischemic heart disease—are at increased risk of premature death or admission to hospitals or emergency rooms.

- The elderly are also sensitive to PM exposure. They are at increased risk of admission to hospitals or emergency rooms and premature death from heart or lung diseases.

- When exposed to PM, children and people with existing lung disease may not be able to breathe as deeply or vigorously as they normally would, and they may experience symptoms such as coughing and shortness of breath.

- PM can increase susceptibility to respiratory infections and can aggravate existing respiratory diseases, such as asthma and chronic bronchitis, causing more use of medication and more doctor visits.

2.3 Denver PM_{10} Area Designation History

Historically, the particulate matter standard had been frequently violated in the 1970's, 1980's, and early 1990's throughout the Denver metropolitan area. There has only been one exceedance of the 24-hour standard during the 1994 through 2000 period. With the implementation of emission control programs aimed at reducing re-entrained fugitive dust, automobile and industrial emissions, PM_{10} concentrations have stabilized at levels well below the NAAQS.

2.4 Denver Metropolitan Attainment/Maintenance Area

The boundaries of the metro Denver nonattainment area are defined in Colorado's Ambient Air Quality Standards Regulation. Once redesignated, these will become the boundaries of the attainment/maintenance area. The area includes the entire City and County of Denver; those portions of Adams and Arapahoe counties west of Kiowa Creek; all of Douglas County; all of Jefferson County ; and all of Boulder County except Rocky Mountain National Park. Figure 1 presents graphically where the Denver PM_{10} attainment and Maintenance area boundaries are.

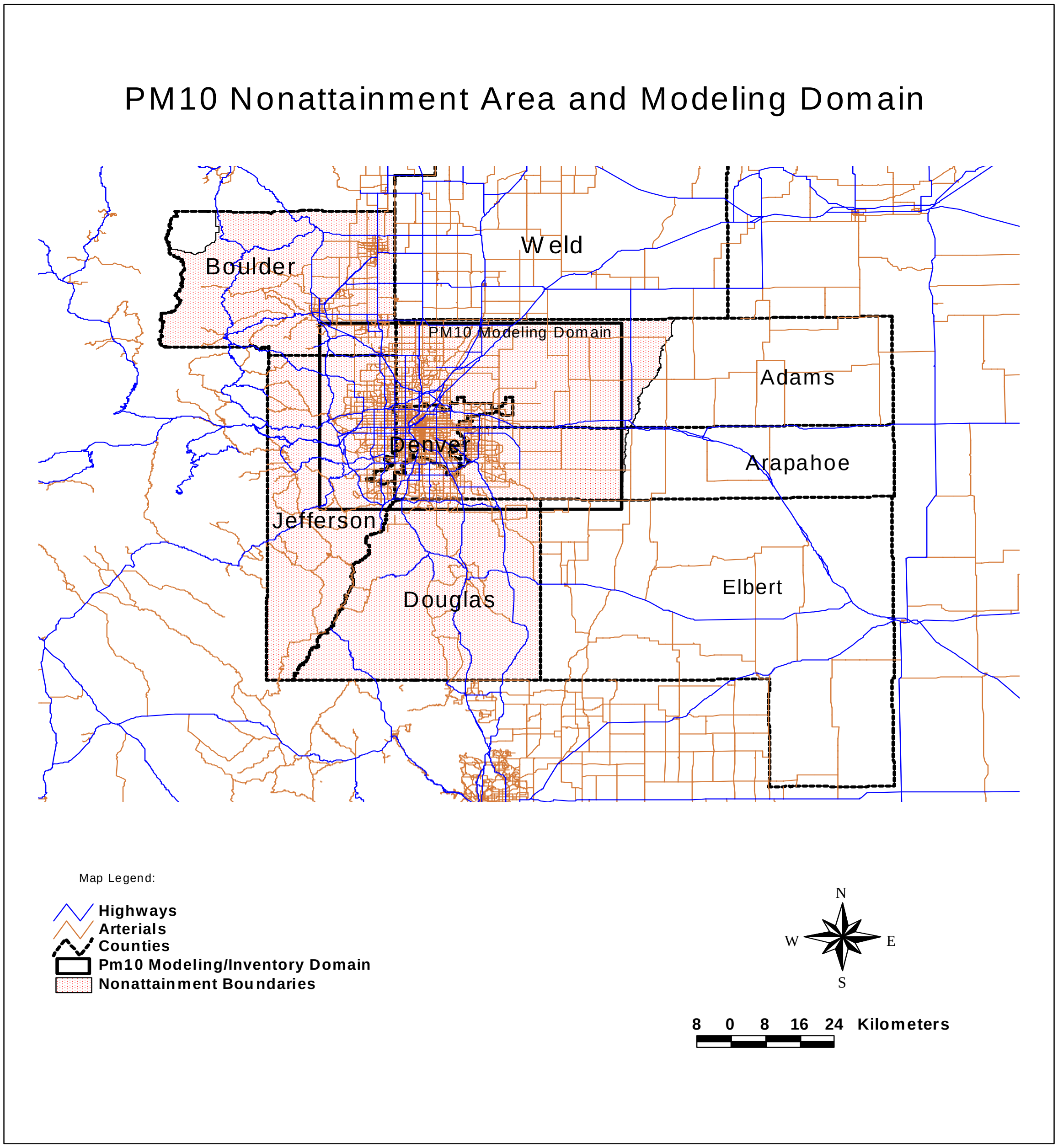

Figure 1. Denver metropolitan area PM10 Dispersion Model and Emission Inventory Domain Depicted within the Nonattainment Area Boundaries.

2.5 Topography, Climate, and Air Quality Meteorology of the Nonattainment Area

The six-county Denver metro area is characterized by a broad valley along the South Platte River. The terrain to the east of the region is dominated by gently rolling plains while the Front Range foothills of the Rocky Mountains dominate the west. The elevation of downtown Denver is 5,280 feet above sea level, with somewhat higher elevations in some suburban areas.

The climate of the Denver metropolitan area is strongly affected by local and regional topographic features. Denver is situated in the plains along the South Platte River Valley approximately 80 kilometers (50 miles) east of the Continental Divide. The Rocky Mountains rise to an elevation of about 3,200 to 4,300 meters (10,500 to 14,200 feet) just to the west of the city.

The meteorological site at Denver's closed Stapleton International Airport is at an elevation of about 1,611 meters (5,285 feet), the meteorological site at the new Denver International Airport is at an elevation of about 1,650 meters (5,412 feet). Greeley, which is north of Denver in the South Platte River Valley, is at an elevation of about 1,400 meters (4,600 feet). About 112 kilometers (70 miles) north of Denver is an east-west rise of land called the Cheyenne Ridge. It is roughly 1,800 –2,000 meters (6,000 to 6,500 feet) in elevation. About 25 miles to the south is another east-west running ridge called the Palmer Divide which rises to 1,800-2,300 meters (5,900 to 7,500 feet). These features form a three-sided basin and work in concert to influence airflow patterns and climate in the Denver metropolitan area, as shown in Figure 2.

On average, Denver experiences low relative humidity, light precipitation, and abundant sunshine. Moisture from the Pacific must travel a long distance and over several high mountain barriers. Gulf moisture must be driven up-slope and against the prevailing westerly winds aloft.

From 8/1/1948 to 12/31/1998, Denver's annual average maximum temperature is 17.9°C (64.2°F), the annual average minimum is 2.6°C (36.6°F), and the normal daily mean temperature is 10.2°C (50.3°F). The city receives an average of 15.6 inches of total precipitation per year and an average total snowfall of 61.9 inches of snowfall. Denver receives an average of 70 percent of the possible sunshine during the year.

The prevailing wind direction in the South Platte River Valley is out of the south. The direction of the prevailing wind is a result of frequent evening, nighttime, and morning drainage wind off of the mountains and the Palmer Divide. These winds are channeled along the Platte River Valley. The other frequent wind direction is from the north. The relatively high frequency of winds from the north is the result of flow up-valley channeled along the Platte River Valley.

Local and regional topography greatly influences not only the climate, but also the dispersion of particulates. In a paper written in 1989[1], W. D. Neff identified five flow regimes which impact the dispersion of the Denver "brown cloud." Of the five, stagnation is the main one associated with elevated concentrations of particulates.

W. D. Neff suggests that "stagnation periods, those with relatively light and variable winds, usually occur following a period of upvalley flow of a cold air mass. In this cycle, large-scale pressure gradient forces cause a layer of cold air that has accumulated in the lowlands to move uphill towards the foothills. As this dense air mass follows the slope, an internal pressure force develops that begins to counteract the external one. For this reason the air mass may slow down as it approaches the mountains and a period of stagnation follows. When the forces involved are fairly weak, this process will be relatively gentle and the period of calm following the return flow may last many hours. However, in cases where the initial motion towards the foothills shows more vigor, the cold air will tend to overshoot and then flow back away from the foothills. In Denver, for example, one often observes a return flow carrying pollutants to the southwest through the city, a short period of relative calm, and then an outflow as the air moves back into the lowlands."[2]

The Air Pollution Control Division has forecast winter season high pollution events for more than a decade. This effort has been supported by significant field study and research by scientists with the National Oceanic and Atmospheric Administration (NOAA) Wave Propagation Laboratory. This research indicates that patterns of flow and their interaction in the region can be complex. Fortunately, these patterns have been well documented and provide a basis for understanding air quality climatology, thus assisting in formulating and evaluating air quality modeling efforts.

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[a] a. Neff, W. D., "Meteorological Classifications Used in the 1987-1988 Denver Brown Cloud Study," Preprint Volume of the 6th Joint Conference on Applications of Air Pollution Meteorology," Jan. 30 - Feb 3, 1989, Anaheim, Calif., American Meteorological Society.

a. Neff, W. D., 1989, page 76.[a]

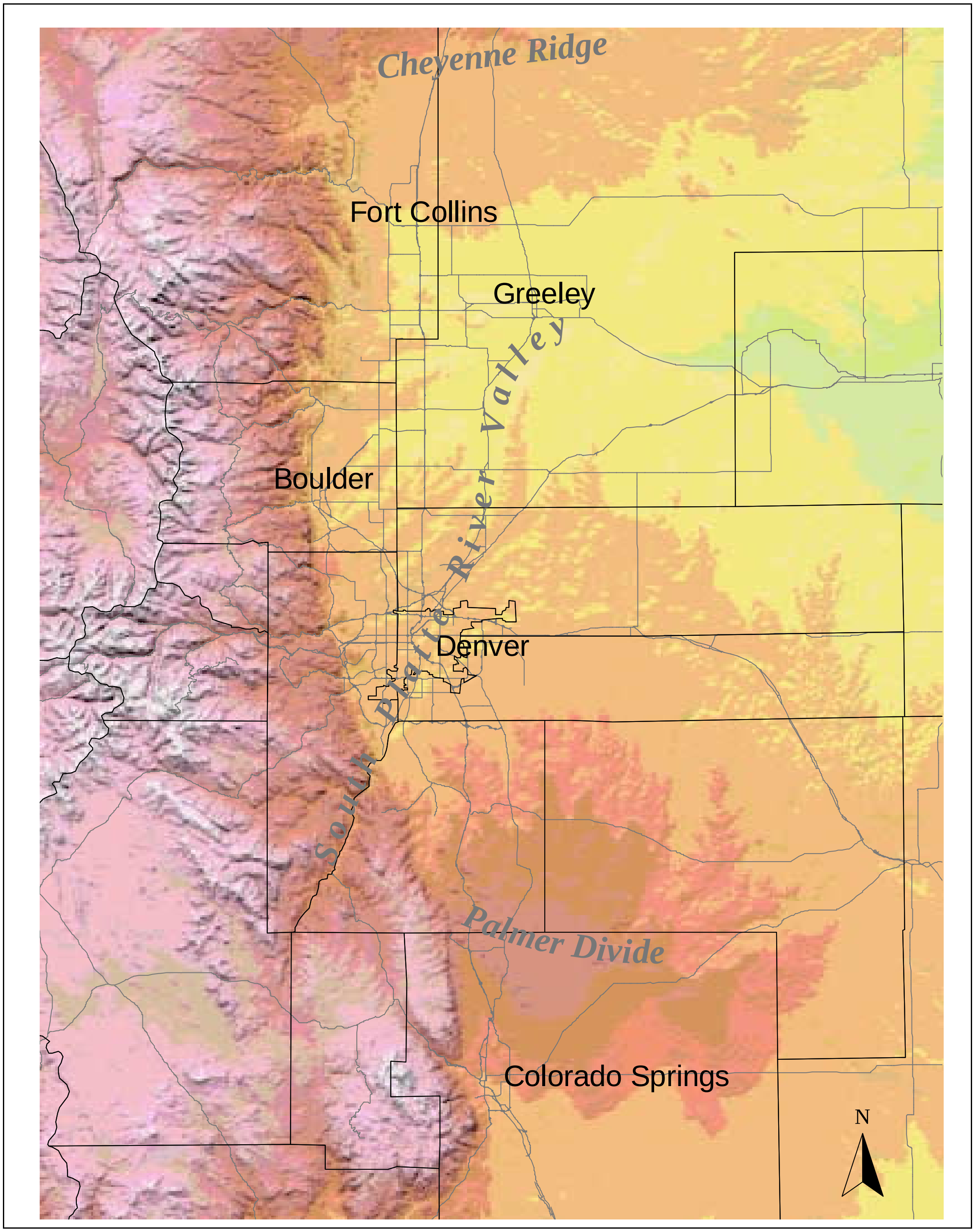

Figure 2. Shaded relief map showing the topography in the Denver area.

2.6 Requirements For Redesignation

Detailed components for redesignation are addressed in a separate document entitled, "Particulate Matter (PM_{10}) Redesignation Request and Maintenance Plan for the Denver Metropolitan Area." Sections 107(d)(3)(D) and (E) of the CAA define five required components of a redesignation request and maintenance plan. Upon submittal and EPA approval of this Maintenance Plan, the Denver metropolitan area will meet all of these criteria.

- The State must show that the area has attained the national standards for particulate matter (PM_{10});
- The State must have a fully approved particulate matter (PM_{10}) State Implementation Plan (SIP);
- The State must demonstrate that the improvement in air quality leading to attainment of the standards is due to permanent and federally enforceable emissions reductions;
- The State must meet all requirements of Section 110 and Part D of the CAA. Section 110 describes general requirements for SIPs, while Part D pertains to general requirements applicable to all nonattainment areas. Refer to **Error! Reference source not found. –** for additional details;
- The State must have a fully approved particulate matter (PM_{10}) maintenance plan that meets the requirements of CAA Section 175A, including a demonstration that the area will maintain the standard for a period of at least 10 years following redesignation by EPA. The plan must also contain contingency measures that could be implemented if a violation of the standard is monitored at any time during the maintenance period.

3 Emission Inventories

This section presents emission inventories for the maintenance plan. Emission inventories are provided for the 1995 attainment year, the 2002, 2003, 2005 and 2010 interim years, and the 2015 maintenance year.

The 1995 emission inventory was developed as part of the attainment SIP and incorporates the projected emissions and control measures in place as part of that plan. These emissions are documented in Volume II of the attainment SIP dated February 1995. In general, most of the emission inventory methodologies that were used for the attainment SIP are used for the maintenance SIP except where noted in the following sections.

The 2002, 2003, 2005, 2010, and 2015 emission inventories include maintenance plan controls and projections of future emission levels from all sources. For most source categories, the 1995 attainment year emissions were proportioned to future years using a surrogate such as population, employment, or households. A brief summary of the methodology used to estimate and project these source categories are presented in the following sections. Details on the methodology used to estimate the various sources can be found in Volume II of the attainment SIP. Any changes to the attainment year emission inventory preparation methodologies that occurred for the maintenance emission inventories will be noted in the subsequent sections.

3.1 Summary of Emission Inventories

Table 3.1-1 summarizes the winter primary PM_{10} inventories used in the approved PM_{10} attainment SIP and projected 2002, 2003, 2005, 2010, and 2015 maintenance year emission inventories used in the dispersion modeling. Table 2 present NO_x and SO_2 emissions inventories that are used in the secondary particulate projected estimates. In the following table and elsewhere in this document, the decimal precision of the results is not intended to imply a level of accuracy.

Table 3.1-1. Primary PM_{10} Emission Inventory for the Denver Modeling Domain

Source Category	*1995 Attainment SIP (tpwd)*	*2002 Interim Year (tpwd)*	*2003 Interim Year (tpwd)*	*2005 Interim Year (tpwd)*	*2010 Interim Year (tpwd)*	*2015 Maintenance Year (tpwd)*
Primary PM_{10}						
Natural Gas	*1.0*	*1.2*	*1.2*	*1.3*	*1.4*	*1.5*
Wood Stove	*1.7*	*1.9*	*1.9*	*2.0*	*2.2*	*2.3*
Fireplace	*2.4*	*1.6*	*1.6*	*1.3*	*1.0*	*0.7*
Airport	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*
Railroad	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Industrial Equipment	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Construction Equipment	*0.4*	*0.3*	*0.3*	*0.2*	*0.3*	*0.3*
Agricultural Wind Erosion	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Open Area Wind Erosion	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Agricultural Tilling	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Construction	*2.9*	*4.0*	*4.0*	*4.1*	*3.9*	*3.7*
Unpaved Roads	*7.9*	*6.9*	*6.9*	*6.9*	*6.9*	*6.9*
On-Road (reentrained dust, sanding, exhaust)	*41.2*	*42.3*	*43.3*	*44.8*	*48.5*	*51.1*
Charbroilers	*1.0*	*1.2*	*1.2*	*1.3*	*1.4*	*1.5*
Minor Point Sources	*5.8*	*7.6*	*7.9*	*8.2*	*8.8*	*9.4*
Major Point Sources	*1.9*	*18.5*	*17.3*	*17.3*	*17.3*	*17.3*
Totals	*66.9*	*86.3*	*86.5*	*88.1*	*92.5*	*95.6*

(1) The precision of the estimates is not intended to imply a level of accuracy.

Table 3.1-2. NOx and SO_2 Emission inventories for the Denver Modeling Domain

	Source Category	1995 Attainment SIP (tpwd)	2002 Interim Year (tpwd)	2003 Interim Year (tpwd)	2005 Interim Year (tpwd)	2010 Interim Year (tpwd)	2015 Maintenance Year (tpwd)
NOx							
	Point Sources	*137.8*	*151.2*	*133.9*	*128.8*	*130.4*	*132.2*
	Natural Gas	*32.7*	*38.9*	*39.9*	*41.9*	*45.8*	*48.8*
	Woodburning	*0.5*	*0.6*	*0.6*	*0.7*	*0.9*	*1.0*
	Airport	*11.4*	*13.7*	*13.9*	*16.8*	*20.6*	*24.2*
	Other non-road	*10.9*	*11.2*	*11.1*	*10.9*	*9.7*	*9.2*
	Mobile Exhaust	*119.4*	*137.7*	*130.4*	*109.6*	*104.0*	*87.8*
Total NOx		*312.7*	*353.3*	*329.8*	*308.7*	*311.4*	*303.3*
SO2							
	Point Sources	*175.5*	*200.2*	*180.5*	*181.1*	*182.0*	*183.1*
	Natural Gas	*0.2*	*0.2*	*0.2*	*0.3*	*0.3*	*0.3*
	Woodburning	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
	Airport	*1.0*	*1.1*	*1.2*	*1.2*	*1.3*	*1.4*
	Other non-road	*0.9*	*1.2*	*1.3*	*1.3*	*1.5*	*1.7*
	Mobile Exhaust	*2.5*	*5.6*	*5.8*	*6.1*	*2.1*	*2.2*
Total SO2		*180.1*	*208.4*	*189.1*	*190.0*	*187.3*	*188.8*

(1) The precision of the estimates is not intended to imply a level of accuracy.

3.2 Demographic and Transportation Data

The demographic data for the modeling domain are presented in Table 3.2-1. The Vehicle Mile Traveled (VMT) estimates are based on the Urban Transportation Planning System (UTPS) model run by the Denver Regional Council of Governments (DRCOG). The most recent demographic and VMT estimates were used from DRCOG's conformity analysis for the fiscally constrained element of the Fiscally-Constrained 2020 Regional Transportation Plan (November 2000).

Table 3.2-1. Demographic Data (Denver PM10 Modeling Domain)

Period	***1995***	***2002***	***2005***	***2010***	***2015***
Population	*1,663,791*	*1,.992,128*	*2,115,292*	*2,273,835*	*2,422,561*
Households	*693,688*	*836,158*	*890,629*	*961,692*	*1,031,744*
Employment	*1,005,129*	*1,180,036*	*1,285,223*	*1,420,487*	*1,504,693*
Daily VMT	*37,220,631*	*51,043,670*	*55,137,245*	*62,712,672*	*66,493,588*

3.3 Projection Surrogates

Table 3.3-1 presents the demographic indicator used to project each source category to future years. Several other factors specific to each source category may also effect the emission inventory change from 1995 to the projected years. For instance, changes in woodburning habits (documented by surveys) have effects beyond demographic growth.

Table 3.3-1. Surrogate Indicators Used for Projecting Emission Inventory Categories

Category	***Surrogate Indicator***
Natural gas	*Households, Employment*
Woodstove	*Households, Surveys*
Fireplace	*Households, Surveys*
Aircraft	*Population Growth*
Locomotive	*Held Constant*
Industrial equipment	*Employment*
Construction equipment.	*Employment*
Wind erosion	*Agricultural land, Held Constant*
Tilling	*Agricultural land, Held Constant*
Construction	*Households, Employment*
Unpaved roads	*Population, Actual data on road segments*
Paved Road Reentrained	*VMT*
Mobile Exhaust	*VMT*
Road Sanding	*VMT*
Charbroilers	*Population*
Minor Point Sources	*Population*
Major Point Source	*Potential to emit-Federal or State Regulatory Limits, Anticipated actual emissions*

3.4 Mobile Source Related PM_{10}, Nitrogen Oxide and Sulfur Oxide Emission Inventories

3.4.1 Denver-Boulder PM_{10} Non-Attainment Area Vehicle Miles Traveled Estimates for 2002 through 2020

The DRCOG 2001-2006 Transportation Improvement Conformity networks were utilized as the basis for the vehicle miles traveled (VMT) estimates. The networks used in this analysis were 01EA, 10OA and 20TA. The VMT in the PM_{10} modeling domain for these networks is as follows:

01EA: 49,745,931
10OA: 62,712,672
20TA: 70,505,342

The 2015 VMT was based on the 10OA and 20TA networks using the following equation:

X = (2020 VMT / 2010 VMT)^ (1/10 years); where X = Compounded annual rate of growth between
2010 and 2020

X = (70,505,342 / 62,712,672) ^.1

X = 1.011781

X^(-5) = .9341 = adjustment factor to use with 2020 network to adjust it to 2015.

2015 VMT = 70,505,342 * .9431 = 66,493,588

Similar calculations were used to estimate the 2015 VMT based on the 10OA and the 01EA networks:

X = (2010 VMT / 2001 VMT)^ (1/9 years) ; where X = Compounded annual rate of growth between
2001 and 2010

X = (62,712,672 / 49,745,931)^(1/9) = 1.0267 growth per year over 9 years

X = 1.0627^(-5) = .8792 = adjustment factor for 2010 to 2005 VMT.

2005 VMT = 62,712,672 * .8792 = 55,137,245

2002 VMT = 1.0627 ^(1)* 49,745,931 = 51,043,670

The speed matrices for the 2005 and 2015 VMT estimates were interpolated directly between the 2001, 2010 and 2020 networks

The VMT in the PM_{10} dispersion model domain are summarized as follows:

Year	VMT
2002	51,043,670
2005	55,137,245
2010	62,712,672
2015	66,493,588
2020	70,505,342

The VMT on the 01EA, 10OA and 20TA networks is summarized by road class and area type in Appendix A.

3.4.2 Mobile Source Related PM_{10}, Nitrogen Oxide and Sulfur Oxide Emission Inventory Estimates for 2015

The following table summarizes the 2015 mobile source related emission inventories described in this section:

Road Dust PM10 (t/d)	Sanding PM10(t/d)	Tailpipe PM10(t/d)	Tailpipe NOx(t/d)	Tailpipe SOx(t/d)
41.078	6.788	3.21	87.78	2.22

3.4.2.1 Road Dust and Sanding Emission Inventories:

Per the PM_{10} SIP, the annual averaged sanding emission factor is .0896 g/mile. The wintertime sanding emissions are increased by a factor of 1.76. To account for reduced VMT during the winter the sanding and road dust emissions are decreased by a factor of .937. These 'seasonal' adjustments are consistent with emission inventory calculations in the PM_{10} SIP.

The assumptions concerning contribution of sanding to road dust emissions and the effectiveness of sweeping control measures have changed since the PM10 SIP technical analysis was completed. Based on an analysis conducted by the Colorado Department of Transportation documented in the report Street Sanding & Sweeping (Cowherd, 1998), 64% of wintertime paved road dust is attributable to street sanding and 36% is attributable to other sources. This estimate is consistent with data collected by the Regional Air Quality Council (RAQC) and documented in the report Emission Benefit Study (AlphaTRAC, Inc., August, 1999). The RAQC Emission Benefit Study also provided updated information on the effectiveness of street sweeping equipment. The study showed that mechanical and the use of a combination of sweeping equipment reduces wintertime street sand and paved road dust emission by 37% and that vacuum and Regenerative Air sweeping equipment reduces emissions by 61%. The 64%/36% split between sanding and other contributors to road dust emissions replaces the 33.8%/66.2% split used in the inventory calculations for the SIP. The revised sweeping equipment effectiveness is also applied as appropriate by the various municipalities to determine the level of PM_{10} control associated with sand application reductions and remedial sweeping activities.

The road dust and sanding emission factors used in the PM_{10} SIP were also used in this technical analysis for the redesignation request. The re-entrained emissions factors are as follows:

Road Dust Emission Factors

					Sanding
Road Class	Area type	AM Peak	PM Peak	Off Peak	AM/PM/OFF
1	1	0.477	0.4935	0.457	0.0896
1	2	0.477	0.4935	0.457	0.0896
1	3	0.5129	0.5142	0.5126	0.0896
1	4	0.5109	0.5109	0.4762	0.0896
1	5	0.2752	0.3281	0.329	0.0896
2	1	0.4771	0.4935	0.4571	0.0896
2	2	0.4771	0.4935	0.4571	0.0896
2	3	0.5116	0.5472	0.5106	0.0896
2	4	0.457	0.4739	0.4729	0.0896
2	5	0.4022	0.4731	0.4203	0.0896
3	1	0.7724	0.7735	0.7729	0.0896
3	2	0.7592	0.7919	0.7944	0.0896
3	3	0.7943	0.811	0.8108	0.0896
3	4	0.7915	0.8093	0.7924	0.0896
3	5	0.7906	0.8279	0.752	0.0896
4	1	1.6596	1.6605	1.6616	0.0896
4	2	1.6487	1.681	1.684	0.0896
4	3	1.702	1.7192	1.6844	0.0896
4	4	1.6842	1.6999	1.6835	0.0896
4	5	1.6808	1.7181	1.6423	0.0896
5	1	1.657	1.6585	1.657	0.0896
5	2	1.6434	1.6753	1.6785	0.0896
5	3	1.676	1.7317	1.7313	0.0896
5	4	1.7307	1.7149	1.7295	0.0896
5	5	1.6759	1.7132	1.6374	0.0896
6	1	0.6164	0.6323	0.5966	0.0896
6	2	0.6164	0.6323	0.5966	0.0896
6	3	0.6524	0.6536	0.6521	0.0896
6	4	0.6505	0.6506	0.6159	0.0896
6	5	0.4156	0.4682	0.4694	0.0896
8	1	1.6527	1.6546	1.6527	0
8	2	1.6382	1.671	1.6731	0
8	3	1.6716	1.7271	1.7259	0
8	4	1.7245	1.7086	1.7231	0
8	5	1.6689	1.707	1.6304	0

Area types: 1=CBD, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural
Road Classes: 1=Freeway, 2=Maj. Regional, 3=Pr. Arterial, 4=Min. Arterial, 5=Collector, 6=Ramp, 8=Local

Summary of Uncontrolled Road Dust and Sanding Emissions

Area Type	Road Class	AM Peak	PM Peak	OFF Peak	Total Tons/day	AM Peak	PM Peak	OFF Peak	Total Tons/Day
	2	0.001	0.001	0.000	0.00	0.000	0.000	0.000	0.00
	3	0.040	0.099	0.130	0.27	0.008	0.020	0.026	0.06
	4	0.051	0.125	0.167	0.34	0.005	0.012	0.016	0.03
	5	0.017	0.043	0.029	0.09	0.002	0.004	0.003	0.01
	8	0.012	0.032	0.043	0.09	0.000	0.000	0.000	0.00
1		0.122	0.300	0.369	0.79	0.015	0.037	0.045	0.10
	1	0.221	0.549	0.813	1.58	0.073	0.175	0.280	0.53
	2	0.022	0.053	0.077	0.15	0.007	0.017	0.027	0.05
	3	0.183	0.472	0.632	1.29	0.038	0.094	0.125	0.26
	4	0.106	0.270	0.301	0.68	0.010	0.025	0.028	0.06
	5	0.096	0.215	0.161	0.47	0.009	0.020	0.015	0.04
	6	0.011	0.026	0.035	0.07	0.003	0.007	0.009	0.02
	8	0.092	0.236	0.315	0.64	0.000	0.000	0.000	0.00
2		0.731	1.821	2.334	4.89	0.141	0.338	0.485	0.96
	1	0.647	1.592	2.546	4.79	0.199	0.488	0.783	1.47
	2	0.051	0.136	0.192	0.38	0.016	0.039	0.059	0.11
	3	1.208	2.989	3.780	7.98	0.240	0.581	0.735	1.56
	4	0.651	1.543	1.655	3.85	0.060	0.142	0.155	0.36
	5	0.502	1.016	0.612	2.13	0.047	0.093	0.056	0.20
	6	0.037	0.090	0.131	0.26	0.009	0.022	0.032	0.06
	8	0.549	1.533	2.040	4.12	0.000	0.000	0.000	0.00
3		3.646	8.899	10.956	23.50	0.571	1.364	1.820	3.76
	1	0.961	2.336	2.841	6.14	0.297	0.721	0.941	1.96
	2	0.097	0.246	0.342	0.69	0.034	0.082	0.114	0.23
	3	1.215	3.099	4.268	8.58	0.242	0.604	0.849	1.70
	4	0.800	1.919	2.146	4.86	0.075	0.178	0.201	0.45
	5	0.668	1.328	1.058	3.05	0.061	0.122	0.096	0.28
	6	0.042	0.100	0.124	0.27	0.010	0.024	0.032	0.07
	8	0.616	1.757	2.403	4.78	0.000	0.000	0.000	0.00
4		4.400	10.785	13.182	28.37	0.718	1.731	2.234	4.68
	1	0.059	0.159	0.222	0.44	0.034	0.077	0.107	0.22
	2	0.005	0.013	0.017	0.04	0.002	0.004	0.006	0.01
	3	0.063	0.143	0.152	0.36	0.013	0.027	0.032	0.07
	4	0.037	0.067	0.070	0.17	0.003	0.006	0.007	0.02
	5	0.178	0.349	0.365	0.89	0.017	0.032	0.035	0.08
	6	0.001	0.004	0.005	0.01	0.001	0.001	0.002	0.00
	8	0.060	0.158	0.198	0.42	0.000	0.000	0.000	0.00
5		0.404	0.893	1.029	2.33	0.069	0.148	0.188	0.41
		9.304	22.698	27.869	59.87	1.515	3.618	4.772	9.91

Area types: 1=CBD,2=Fringe,3=Urban,4=Suburban,5=Rural
Road Classes: 1=Freeway,2=Maj. Regional,3=Pr. Arterial,4=Min. Arterial,
5=Collector,6=Ramp,8=Local

The suite of controls applied to the 2002, 2005, 2010 and 2015 road dust and sanding emissions are as follows:

Area	Geographical description of Area	Road Dust and Sanding Emissions Reduction*
1	Denver Central Business District	72%
2	I-25 between 6th Avenue and University Blvd.	54%
3	Area bounded by Louisiana Ave, Federal Blvd., 38th Avenue and Downing Ave.	50%
4	Foothills areas as defined in Regulation 16	20%
5	Metropolitan area not covered in areas above	30%

*Agencies are required to meet the specified level of emission reduction by a combination of reduced sand application and sweeping.

The 2015 uncontrolled and controlled road dust and sanding emissions summarized by control area are summarized as follows:

Area	Geographical description of Area	Uncontrolled Road Dust (tons/day)	Controlled Road Dust (tons/day)	Uncontrolled Sanding (tons/day)	Controlled Sanding (tons/day)
1	Denver Central Business District	.358	.100	.039	.011
2	I-25 between 6th Avenue and University Blvd.	.793	.365	.204	.094
3	Area bounded by Louisiana Ave, Federal Blvd., 38th Avenue and Downing Ave.	2.831	1.415	.465	.233
4	Foothills areas as defined in Regulation 16	.754	.604	.130	.104
5	Metropolitan area not covered in areas above	55.134	38.594	9.066	6.347
	Totals	59.870	41.078	9.905	6.788

3.4.2.2 2015 Mobile Source Nitrogen Oxide Emission Inventory

The EPA mobile emission factor model, Mobile5b, was utilized for the calculation of the nitrogen oxide emissions for mobile sources. The control strategies included in the mobile5 input files mirror the strategies that resulted from the Denver-Boulder Carbon Monoxide Redesignation Request. The Mobile5b input and output files are included in Appendix B. The emission factors and inventory totals are summarized in the following tables.

2015 Mobile5b Nitrogen Oxide Emission Factors (grams/mile)

RO CL	AREA TYPE	AM PD 1	AM PD 2	AM PD 3	PM PD 1	PM PD 2	PM PD 3	OFF PD 1	OFF PD 2	OFF PD 3	OFF PD 4
1	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	1.60	1.57	1.58	1.61	1.56	1.56	2.21	2.14	1.98	1.82
1	3	1.52	1.48	1.48	1.51	1.45	1.45	2.16	2.06	1.89	1.69
1	4	1.60	1.55	1.54	1.61	1.53	1.51	2.21	2.14	2.02	1.88
1	5	3.17	2.72	2.55	3.07	2.43	2.29	3.62	3.56	3.38	3.04
2	1	1.60	1.59	1.57	1.58	1.58	1.58	0.00	0.00	0.00	0.00
2	2	1.58	1.63	1.74	1.56	1.59	1.68	1.75	1.73	1.72	1.72
2	3	1.52	1.51	1.52	1.44	1.43	1.44	1.64	1.64	1.62	1.60
2	4	1.73	1.72	1.74	1.72	1.70	1.71	1.81	1.80	1.78	1.77
2	5	1.96	1.91	1.89	1.72	1.68	1.66	2.00	2.00	1.99	1.98
3	1	1.55	1.64	1.76	1.71	1.82	1.95	1.68	1.68	1.68	1.69
3	2	1.67	1.70	1.80	1.63	1.65	1.74	1.59	1.59	1.59	1.58
3	3	1.54	1.55	1.57	1.52	1.52	1.54	1.51	1.51	1.50	1.50
3	4	1.58	1.57	1.58	1.47	1.46	1.46	1.69	1.68	1.66	1.65
3	5	1.52	1.50	1.49	1.47	1.45	1.43	1.86	1.84	1.83	1.81
4	1	1.57	1.64	1.75	1.72	1.85	1.98	1.68	1.69	1.69	1.69
4	2	1.68	1.73	1.83	1.63	1.68	1.76	1.58	1.58	1.58	1.58
4	3	1.60	1.60	1.62	1.54	1.53	1.55	1.65	1.65	1.64	1.64
4	4	1.66	1.65	1.66	1.55	1.53	1.54	1.68	1.67	1.67	1.67
4	5	1.53	1.51	1.49	1.47	1.46	1.45	1.81	1.81	1.80	1.80
5	1	1.58	1.62	1.67	1.74	1.79	1.86	1.67	1.68	1.69	1.70
5	2	1.62	1.67	1.74	1.64	1.68	1.74	1.54	1.54	1.55	1.55
5	3	1.65	1.66	1.70	1.39	1.38	1.39	1.42	1.42	1.42	1.42
5	4	1.47	1.47	1.46	1.47	1.46	1.46	1.42	1.42	1.42	1.42
5	5	1.64	1.64	1.64	1.47	1.47	1.46	1.81	1.81	1.81	1.80
6	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2	1.66	1.67	1.70	1.63	1.64	1.66	1.61	1.60	1.59	1.59
6	3	1.54	1.54	1.55	1.52	1.52	1.53	1.52	1.51	1.50	1.50
6	4	1.57	1.57	1.58	1.46	1.46	1.46	1.63	1.63	1.62	1.62
6	5	1.49	1.49	1.49	1.44	1.43	1.43	1.76	1.76	1.75	1.75
8	1	1.72	1.72	1.72	1.90	1.90	1.90	1.87	1.87	1.87	1.87
8	2	1.73	1.73	1.73	1.75	1.75	1.75	1.66	1.66	1.66	1.66
8	3	1.63	1.63	1.63	1.37	1.37	1.37	1.35	1.35	1.35	1.35
8	4	1.40	1.40	1.40	1.40	1.40	1.40	1.39	1.39	1.39	1.39
8	5	1.71	1.71	1.71	1.52	1.52	1.52	1.88	1.88	1.88	1.88

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local
Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

2015 Nitrogen Oxide AM and PM Peak Emission Inventories (tons/day)

AREA TYPE	CLASS	AM1	AM2	AM3	AM TOTAL	PM1	PM2	PM3	PM TOTAL
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.04	0.02	0.03	0.09	0.15	0.06	0.04	0.24
	4	0.02	0.01	0.02	0.05	0.09	0.04	0.02	0.14
	5	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.05
	8	0.01	0.00	0.00	0.01	0.02	0.01	0.01	0.04
1		0.07	0.05	0.06	0.18	0.28	0.12	0.07	0.48
	1	0.37	0.20	0.22	0.79	1.26	0.41	0.22	1.89
	2	0.04	0.02	0.02	0.08	0.12	0.04	0.02	0.18
	3	0.19	0.11	0.14	0.44	0.65	0.25	0.15	1.05
	4	0.05	0.03	0.04	0.12	0.17	0.07	0.04	0.28
	5	0.03	0.03	0.04	0.11	0.11	0.07	0.05	0.23
	6	0.01	0.01	0.01	0.03	0.05	0.02	0.01	0.07
	8	0.04	0.03	0.03	0.10	0.16	0.06	0.04	0.26
2		0.74	0.43	0.50	1.67	2.52	0.92	0.53	3.97
	1	0.95	0.51	0.55	2.02	3.28	1.07	0.57	4.92
	2	0.07	0.04	0.05	0.16	0.25	0.09	0.05	0.38
	3	1.09	0.66	0.76	2.52	3.72	1.45	0.82	5.99
	4	0.27	0.18	0.21	0.66	0.87	0.38	0.22	1.47
	5	0.15	0.15	0.24	0.54	0.36	0.29	0.22	0.87
	6	0.04	0.02	0.03	0.09	0.14	0.05	0.03	0.22
	8	0.25	0.15	0.17	0.57	0.80	0.32	0.18	1.30
3		2.83	1.72	2.00	6.56	9.42	3.64	2.10	15.16
	1	1.40	0.82	0.93	3.15	4.84	1.83	1.02	7.69
	2	0.17	0.10	0.12	0.39	0.60	0.22	0.12	0.95
	3	1.14	0.68	0.77	2.58	3.78	1.42	0.79	5.99
	4	0.34	0.23	0.28	0.84	1.08	0.49	0.29	1.86
	5	0.20	0.17	0.23	0.60	0.57	0.37	0.26	1.21
	6	0.05	0.03	0.03	0.11	0.15	0.06	0.03	0.24
	8	0.23	0.14	0.16	0.53	0.95	0.38	0.22	1.54
4		3.53	2.17	2.52	8.22	11.96	4.77	2.75	19.48
	1	0.32	0.16	0.17	0.66	0.97	0.31	0.17	1.45
	2	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.05
	3	0.05	0.03	0.04	0.13	0.16	0.07	0.04	0.27
	4	0.01	0.01	0.01	0.03	0.03	0.02	0.01	0.06
	5	0.07	0.05	0.07	0.19	0.17	0.09	0.06	0.32
	6	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01
	8	0.03	0.02	0.02	0.07	0.09	0.04	0.02	0.15
5		0.49	0.28	0.33	1.10	1.47	0.54	0.31	2.32
		7.66	4.65	5.41	17.72	25.66	9.99	5.76	41.40

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local
Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

2015 Nitrogen Oxide OFF Peak and Grand Total Emission Inventories (tons/day)

AREA TYPE	ROAD CLASS	OP1	OP2	OP3	OP4 OFF	TOTAL	GRAND TOTAL
	2	0.00	0.00	0.00	0.00	0.00	0.01
	3	0.06	0.07	0.14	0.04	0.30	0.64
	4	0.03	0.04	0.08	0.02	0.18	0.38
	5	0.01	0.01	0.01	0.00	0.03	0.10
	8	0.01	0.01	0.02	0.01	0.05	0.10
1		0.11	0.13	0.26	0.07	0.57	1.22
	1	0.86	0.97	1.67	0.39	3.89	6.56
	2	0.07	0.07	0.14	0.03	0.31	0.57
	3	0.26	0.31	0.61	0.16	1.35	2.84
	4	0.05	0.07	0.14	0.04	0.30	0.71
	5	0.03	0.03	0.07	0.02	0.16	0.49
	6	0.02	0.02	0.04	0.01	0.10	0.20
	8	0.07	0.08	0.15	0.04	0.33	0.70
2		1.36	1.56	2.82	0.70	6.44	12.08
	1	2.38	2.61	4.42	1.00	10.41	17.35
	2	0.13	0.16	0.29	0.07	0.65	1.20
	3	1.43	1.71	3.40	0.94	7.48	15.99
	4	0.31	0.38	0.80	0.23	1.72	3.85
	5	0.09	0.12	0.25	0.08	0.54	1.94
	6	0.07	0.08	0.14	0.04	0.32	0.64
	8	0.33	0.39	0.77	0.21	1.70	3.57
3		4.75	5.45	10.07	2.57	22.83	44.55
	1	2.61	3.14	5.89	1.50	13.15	24.00
	2	0.25	0.32	0.63	0.17	1.38	2.73
	3	1.98	2.24	4.25	1.13	9.60	18.17
	4	0.45	0.51	1.02	0.29	2.27	4.97
	5	0.17	0.20	0.42	0.13	0.93	2.74
	6	0.07	0.08	0.16	0.04	0.35	0.70
	8	0.41	0.48	0.93	0.25	2.07	4.14
4		5.94	6.98	13.31	3.52	29.75	57.45
	1	0.50	0.59	1.11	0.27	2.47	4.58
	2	0.02	0.02	0.04	0.01	0.09	0.17
	3	0.08	0.09	0.18	0.05	0.39	0.79
	4	0.02	0.02	0.03	0.01	0.08	0.18
	5	0.08	0.10	0.20	0.05	0.43	0.94
	6	0.00	0.01	0.01	0.00	0.02	0.04
	8	0.05	0.06	0.11	0.03	0.24	0.46
5		0.75	0.88	1.67	0.43	3.73	7.15
		12.90	15.00	28.12	7.30	63.32	122.44

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local

Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

The results of this inventory were adjusted to account for the Tier II / Low Sulfur regulations. The methodology described in Mobile5 Information Sheet #8 was used to make the Tier II / Low Sulfur adjustments. The basis of the Tier II / Low Sulfur adjustment is a gram per mile adjustment applied to various vehicle types. The following table summarizes the calculations:

Vehicle Type	**2015 VMT**	**Grams/Mile Adjustment**	**NOx Reduction**
LDGV	38,057,784	.458	-19.213
LDGT1	15,128,592	.497	-8.288
LDGT2	6,835,286	.814	-6.133
HDGV	1,753,188	.35	-.676
LDDT	131,662	0.000	.000
LDDV	305,071	0.036	-.348
HDGV	4,232,004	0.000	.000
TOTAL	66,492,588		-34.659

The nitrogen oxide emission inventory for 2015 adjusted for Tier II / Low Sulfur regulations is 87.78 tons per day (122.440 tons/day – 34.659 tons/day).

3.4.2.3 2015 Mobile Source PM_{10} and Sulfur Dioxide Emission Inventory

The EPA mobile particulate emission factor model PART5 was utilized for the calculation of the PM_{10} and sulfur dioxide emission factors. An EPA memorandum, Development of On-Highway Inventory Adjustment Factors used in the Tier 2 Final Rule Air Quality Analysis, (John Koupal and Gary Dolce, Office of Mobile Sources, October 18, 1999) was used to adjust emission factors resultant from PART5 to account for Tier II/ Low sulfur regulation. This memo details vehicle type specific gram per mile reductions for PM_{10} and SO_2 in the years 2007 and 2030. Values for 2015 were interpolated from the 2007 and 2030 values. These reductions were applied to the each area type, road class and time of day by vehicle type. The composite emission factor was then re-calculated. The following table lists the multiplicative adjustment that were applied to each vehicle type:

Vehicle Type	2015 PM_{10} Multiplicative Adjustment	2015 SO_2 Multiplicative Adjustment
LDGV	.416	.088
LDGT1	.339	.088
LDGT2	.357	.088
HDGV	.767	.088
LDDV	.577	1.000
LDDT	.559	1.000
All other vehicle types	1.000	1.000

The following tables summarize estimates of the 2015 PM_{10} and SO_2 emission factors and emission inventories:

2015 Tailpipe PM_{10} Emission Factors

RO CL	AREA TYPE	AM PD 1	AM PD 2	AM PD 3	PM PD 1	PM PD 2	PM PD 3	OFF PD 1	OFF PD 2	OFF PD 3	OFF PD 4
1	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	2	0.054	0.054	0.054	0.051	0.051	0.051	0.059	0.059	0.059	0.059
1	3	0.046	0.046	0.046	0.045	0.045	0.046	0.048	0.048	0.048	0.048
1	4	0.048	0.048	0.048	0.047	0.047	0.047	0.053	0.053	0.053	0.053
1	5	0.100	0.100	0.100	0.085	0.085	0.085	0.088	0.088	0.088	0.088
2	1	0.054	0.054	0.054	0.051	0.051	0.051	0.000	0.000	0.000	0.000
2	2	0.054	0.054	0.054	0.051	0.051	0.051	0.059	0.059	0.058	0.058
2	3	0.047	0.047	0.047	0.040	0.040	0.040	0.048	0.048	0.048	0.048
2	4	0.060	0.060	0.060	0.053	0.054	0.053	0.056	0.056	0.056	0.056
2	5	0.072	0.072	0.072	0.056	0.056	0.056	0.067	0.067	0.067	0.067
3	1	0.049	0.049	0.049	0.051	0.051	0.051	0.051	0.051	0.051	0.051
3	2	0.053	0.053	0.053	0.048	0.048	0.048	0.045	0.045	0.045	0.045
3	3	0.046	0.046	0.046	0.044	0.044	0.044	0.041	0.041	0.041	0.041
3	4	0.047	0.047	0.047	0.043	0.043	0.043	0.048	0.048	0.048	0.048
3	5	0.048	0.048	0.048	0.040	0.040	0.040	0.056	0.056	0.056	0.056
4	1	0.049	0.049	0.049	0.051	0.051	0.051	0.051	0.051	0.051	0.051
4	2	0.053	0.053	0.053	0.048	0.048	0.048	0.045	0.045	0.045	0.046
4	3	0.042	0.042	0.042	0.037	0.037	0.037	0.045	0.045	0.045	0.045
4	4	0.045	0.046	0.046	0.042	0.042	0.042	0.046	0.046	0.046	0.046
5		0.048	0.048	0.048	0.040	0.040	0.040	0.056	0.056	0.056	0.051
5	1	0.049	0.049	0.049	0.051	0.051	0.051	0.051	0.051	0.051	0.051
5	2	0.053	0.053	0.053	0.048	0.048	0.048	0.046	0.046	0.046	0.046
5	3	0.047	0.047	0.047	0.035	0.035	0.035	0.035	0.035	0.035	0.035
5	4	0.035	0.035	0.035	0.037	0.038	0.037	0.035	0.035	0.035	0.035
5	5	0.048	0.048	0.048	0.040	0.040	0.040	0.056	0.056	0.056	0.056
6	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	2	0.053	0.053	0.053	0.048	0.048	0.048	0.045	0.045	0.045	0.045
6	3	0.046	0.046	0.046	0.044	0.044	0.044	0.041	0.041	0.041	0.041
6	4	0.047	0.047	0.047	0.043	0.043	0.043	0.048	0.048	0.048	0.048
6	5	0.048	0.048	0.048	0.040	0.040	0.040	0.056	0.056	0.056	0.056
7	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	1	0.049	0.049	0.049	0.051	0.051	0.051	0.051	0.051	0.051	0.051
8	2	0.053	0.053	0.053	0.048	0.048	0.048	0.046	0.046	0.046	0.046
8	3	0.047	0.047	0.047	0.035	0.035	0.035	0.035	0.035	0.035	0.035
8	4	0.035	0.035	0.035	0.037	0.037	0.037	0.035	0.035	0.035	0.035
8	5	0.048	0.048	0.048	0.040	0.040	0.040	0.056	0.056	0.056	0.056

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial 5=Collector, 6=Ramp, 7=Frontage, 8=Local

Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

2015 Tailpipe SO_2 EMISSION FACTORS

RO CL	AREA TYPE	AM PD 1	AM PD 2	AM PD 3	PM PD 1	PM PD 2	PM PD 3	OFF PD 1	OFF PD 2	OFF PD 3	OFF PD 4
1	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	2	0.039	0.040	0.040	0.037	0.037	0.037	0.044	0.044	0.044	0.044
1	3	0.032	0.032	0.032	0.031	0.031	0.031	0.034	0.034	0.034	0.034
1	4	0.033	0.033	0.033	0.032	0.032	0.032	0.039	0.039	0.039	0.039
1	5	0.087	0.087	0.087	0.072	0.072	0.072	0.074	0.074	0.074	0.074
2	1	0.039	0.039	0.040	0.037	0.037	0.037	0.000	0.000	0.000	0.000
2	2	0.040	0.040	0.040	0.037	0.037	0.037	0.044	0.044	0.044	0.045
2	3	0.033	0.033	0.033	0.026	0.026	0.026	0.034	0.034	0.034	0.034
2	4	0.046	0.046	0.046	0.039	0.039	0.039	0.042	0.042	0.042	0.042
2	5	0.058	0.058	0.058	0.042	0.042	0.042	0.053	0.053	0.053	0.053
3	1	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036
3	2	0.038	0.038	0.038	0.034	0.034	0.034	0.031	0.031	0.031	0.031
3	3	0.031	0.031	0.031	0.029	0.029	0.029	0.027	0.027	0.027	0.027
3	4	0.033	0.033	0.033	0.029	0.029	0.029	0.034	0.034	0.034	0.034
3	5	0.033	0.033	0.033	0.026	0.026	0.026	0.042	0.042	0.042	0.042
4	1	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036
4	2	0.038	0.038	0.038	0.034	0.034	0.034	0.031	0.031	0.031	0.031
4	3	0.027	0.027	0.027	0.023	0.023	0.023	0.031	0.031	0.031	0.031
4	4	0.031	0.031	0.031	0.028	0.028	0.028	0.031	0.031	0.031	0.031
4	5	0.033	0.033	0.033	0.026	0.026	0.026	0.042	0.042	0.042	0.042
5	1	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036
5	2	0.038	0.038	0.038	0.034	0.034	0.034	0.031	0.031	0.031	0.031
5	3	0.032	0.032	0.032	0.020	0.020	0.020	0.020	0.020	0.020	0.020
5	4	0.020	0.020	0.020	0.023	0.023	0.023	0.020	0.020	0.020	0.020
5	5	0.033	0.033	0.033	0.026	0.026	0.026	0.042	0.042	0.042	0.042
6	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	2	0.038	0.038	0.038	0.034	0.034	0.034	0.031	0.031	0.031	0.031
6	3	0.031	0.031	0.031	0.029	0.029	0.029	0.027	0.027	0.027	0.027
6	4	0.033	0.033	0.033	0.029	0.029	0.029	0.034	0.034	0.034	0.034
6	5	0.033	0.033	0.033	0.026	0.026	0.026	0.042	0.042	0.042	0.042
7	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	1	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036
8	2	0.038	0.038	0.038	0.034	0.034	0.034	0.031	0.031	0.031	0.031
8	3	0.032	0.032	0.032	0.020	0.020	0.020	0.020	0.020	0.020	0.020
8	4	0.020	0.020	0.020	0.023	0.023	0.023	0.020	0.020	0.020	0.020
8	5	0.033	0.033	0.033	0.026	0.026	0.026	0.042	0.042	0.042	0.042

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local
Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

2015 AM Peak and PM Peak Emission PM_{10} Inventory Totals

AREA TYPE	CLASS	AM1	AM2	AM3	AM TOTAL	PM1	PM2	PM3	PM TOTAL
	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.001	0.001	0.001	0.003	0.004	0.002	0.001	0.007
	4	0.001	0.000	0.000	0.002	0.003	0.001	0.001	0.004
	5	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.001
	8	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001
		-------	-------	-------	-------	-------	-------	-------	-------
1		0.002	0.001	0.002	0.005	0.008	0.003	0.002	0.014
	1	0.012	0.007	0.007	0.027	0.040	0.013	0.007	0.060
	2	0.001	0.001	0.001	0.003	0.004	0.001	0.001	0.006
	3	0.006	0.004	0.004	0.014	0.019	0.007	0.004	0.031
	4	0.002	0.001	0.001	0.004	0.005	0.002	0.001	0.008
	5	0.001	0.001	0.001	0.003	0.003	0.002	0.001	0.007
	6	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.002
	8	0.001	0.001	0.001	0.003	0.004	0.002	0.001	0.007
		-------	-------	-------	-------	-------	-------	-------	-------
2		0.024	0.014	0.016	0.054	0.077	0.028	0.016	0.121
	1	0.029	0.016	0.017	0.062	0.099	0.033	0.018	0.150
	2	0.002	0.001	0.001	0.005	0.007	0.002	0.001	0.011
	3	0.033	0.020	0.022	0.075	0.107	0.042	0.024	0.173
	4	0.007	0.005	0.005	0.017	0.021	0.009	0.005	0.036
	5	0.004	0.004	0.006	0.015	0.009	0.007	0.006	0.022
	6	0.001	0.001	0.001	0.003	0.004	0.002	0.001	0.006
	8	0.007	0.004	0.005	0.016	0.020	0.008	0.005	0.033
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3		0.084	0.051	0.059	0.194	0.268	0.104	0.059	0.431
	1	0.042	0.025	0.029	0.096	0.140	0.056	0.032	0.228
	2	0.006	0.004	0.004	0.014	0.019	0.007	0.004	0.030
	3	0.034	0.020	0.023	0.077	0.111	0.042	0.023	0.176
	4	0.009	0.006	0.008	0.023	0.029	0.014	0.008	0.051
	5	0.005	0.004	0.006	0.014	0.015	0.010	0.007	0.031
	6	0.001	0.001	0.001	0.003	0.004	0.002	0.001	0.007
	8	0.006	0.004	0.004	0.013	0.025	0.010	0.006	0.041
		-------	-------	-------	-------	-------	-------	-------	-------
4		0.103	0.064	0.074	0.241	0.343	0.140	0.081	0.563
	1	0.010	0.006	0.007	0.023	0.027	0.011	0.006	0.044
	2	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.002
	3	0.002	0.001	0.001	0.004	0.004	0.002	0.001	0.007
	4	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.002
	5	0.002	0.001	0.002	0.005	0.005	0.002	0.002	0.009
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.001	0.000	0.001	0.002	0.002	0.001	0.001	0.004
		-------	-------	-------	-------	-------	-------	-------	-------
5		0.015	0.010	0.012	0.037	0.041	0.017	0.010	0.068
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		0.228	0.140	0.162	0.530	0.737	0.292	0.168	1.197

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local
Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

2015 Off Peak Total and Grand Total PM_{10} Emission Inventory

AREA TYPE	ROAD CLASS	OP1	OP2	OP3	OP4	TOTAL OFF	GRAND TOTAL
	2	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.002	0.002	0.004	0.001	0.009	0.019
	4	0.001	0.001	0.002	0.001	0.005	0.011
	5	0.000	0.000	0.000	0.000	0.001	0.003
	8	0.000	0.000	0.001	0.000	0.001	0.003
		-------	-------	-------	-------	-------	-------
1		0.003	0.004	0.008	0.002	0.017	0.036
	1	0.023	0.027	0.049	0.012	0.111	0.198
	2	0.002	0.003	0.005	0.001	0.011	0.019
	3	0.007	0.009	0.018	0.005	0.039	0.083
	4	0.002	0.002	0.004	0.001	0.009	0.021
	5	0.001	0.001	0.002	0.001	0.005	0.015
	6	0.001	0.001	0.001	0.000	0.003	0.006
	8	0.002	0.002	0.004	0.001	0.009	0.020
		-------	-------	-------	-------	-------	-------
2		0.037	0.044	0.083	0.022	0.186	0.361
	1	0.053	0.061	0.112	0.028	0.255	0.467
	2	0.004	0.005	0.009	0.002	0.019	0.035
	3	0.039	0.047	0.093	0.026	0.205	0.453
	4	0.009	0.011	0.022	0.006	0.048	0.101
	5	0.002	0.003	0.006	0.002	0.013	0.050
	6	0.002	0.002	0.004	0.001	0.009	0.018
	8	0.009	0.010	0.020	0.005	0.044	0.094
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3		0.117	0.138	0.266	0.071	0.593	1.218
	1	0.063	0.078	0.156	0.043	0.340	0.664
	2	0.008	0.010	0.020	0.005	0.043	0.086
	3	0.056	0.064	0.123	0.033	0.276	0.529
	4	0.012	0.014	0.028	0.008	0.063	0.137
	5	0.004	0.005	0.010	0.003	0.023	0.068
	6	0.002	0.002	0.005	0.001	0.010	0.021
	8	0.010	0.012	0.023	0.006	0.052	0.107
		-------	-------	-------	-------	-------	-------
4		0.156	0.186	0.365	0.100	0.807	1.611
	1	0.012	0.015	0.029	0.008	0.063	0.130
	2	0.001	0.001	0.001	0.000	0.003	0.006
	3	0.002	0.003	0.005	0.002	0.012	0.024
	4	0.001	0.001	0.001	0.000	0.003	0.005
	5	0.003	0.003	0.006	0.002	0.013	0.028
	6	0.000	0.000	0.000	0.000	0.001	0.001
	8	0.001	0.002	0.003	0.001	0.007	0.013
		-------	-------	-------	-------	-------	-------
5		0.020	0.023	0.046	0.013	0.102	0.207
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		0.333	0.395	0.768	0.208	1.705	3.432

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local
Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

2015 AM Peak and PM Peak Emission SO2 Inventory Totals

AREA TYPE	CLASS	AM1	AM2	AM3	AM TOTAL	PM1	PM2	PM3	PM TOTAL
	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.001	0.000	0.001	0.002	0.003	0.001	0.001	0.005
	4	0.000	0.000	0.000	0.001	0.002	0.001	0.000	0.003
	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
		-------	-------	-------	-------	-------	-------	-------	-------
1		0.002	0.001	0.001	0.004	0.006	0.002	0.001	0.009
	1	0.009	0.005	0.005	0.018	0.027	0.009	0.005	0.041
	2	0.001	0.000	0.001	0.002	0.003	0.001	0.000	0.004
	3	0.004	0.002	0.003	0.009	0.013	0.005	0.003	0.020
	4	0.001	0.001	0.001	0.002	0.003	0.001	0.001	0.005
	5	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.004
	6	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.001
	8	0.001	0.001	0.001	0.002	0.003	0.001	0.001	0.005
		-------	-------	-------	-------	-------	-------	-------	-------
2		0.017	0.010	0.011	0.037	0.051	0.019	0.010	0.080
	1	0.019	0.010	0.011	0.040	0.063	0.021	0.011	0.096
	2	0.001	0.001	0.001	0.003	0.004	0.001	0.001	0.006
	3	0.021	0.013	0.014	0.048	0.068	0.026	0.015	0.109
	4	0.004	0.003	0.003	0.011	0.012	0.005	0.003	0.020
	5	0.003	0.003	0.004	0.010	0.005	0.004	0.003	0.012
	6	0.001	0.000	0.001	0.002	0.003	0.001	0.001	0.004
	8	0.005	0.003	0.003	0.011	0.011	0.004	0.002	0.018
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3		0.053	0.032	0.037	0.123	0.165	0.064	0.036	0.265
	1	0.027	0.017	0.019	0.063	0.091	0.036	0.021	0.148
	2	0.004	0.003	0.003	0.010	0.013	0.005	0.003	0.020
	3	0.022	0.013	0.015	0.050	0.069	0.026	0.015	0.109
	4	0.006	0.004	0.005	0.015	0.018	0.008	0.005	0.031
	5	0.003	0.002	0.003	0.008	0.008	0.005	0.004	0.018
	6	0.001	0.001	0.001	0.002	0.003	0.001	0.001	0.004
	8	0.003	0.002	0.002	0.007	0.014	0.006	0.003	0.023
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4		0.066	0.041	0.047	0.155	0.216	0.088	0.050	0.354
	1	0.008	0.005	0.006	0.019	0.021	0.009	0.005	0.035
	2	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.001
	3	0.001	0.001	0.001	0.003	0.003	0.001	0.001	0.004
	4	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001
	5	0.001	0.001	0.001	0.004	0.003	0.001	0.001	0.005
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.002
		-------	-------	-------	-------	-------	-------	-------	-------
5		0.012	0.007	0.009	0.028	0.030	0.012	0.007	0.049
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		0.149	0.091	0.105	0.346	0.468	0.185	0.106	0.758

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local
Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

Off Peak Total and Grand Total SO_2 Emission Inventory

AREA TYPE	ROAD CLASS	OP1	OP2	OP3	OP4	TOTAL OFF	GRAND TOTAL
	2	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.001	0.001	0.003	0.001	0.006	0.013
	4	0.001	0.001	0.002	0.000	0.004	0.007
	5	0.000	0.000	0.000	0.000	0.001	0.002
	8	0.000	0.000	0.000	0.000	0.001	0.002
		-------	-------	-------	-------	-------	-------
1		0.002	0.003	0.005	0.001	0.011	0.024
	1	0.016	0.019	0.035	0.009	0.079	0.138
	2	0.002	0.002	0.003	0.001	0.008	0.013
	3	0.005	0.006	0.011	0.003	0.025	0.054
	4	0.001	0.001	0.003	0.001	0.006	0.013
	5	0.001	0.001	0.001	0.000	0.003	0.010
	6	0.000	0.000	0.001	0.000	0.002	0.004
	8	0.001	0.001	0.003	0.001	0.006	0.013
		-------	-------	-------	-------	-------	-------
2		0.026	0.030	0.057	0.015	0.127	0.245
	1	0.035	0.040	0.074	0.019	0.167	0.303
	2	0.002	0.003	0.006	0.001	0.013	0.022
	3	0.024	0.028	0.056	0.016	0.124	0.280
	4	0.005	0.007	0.014	0.004	0.030	0.061
	5	0.001	0.002	0.003	0.001	0.007	0.028
	6	0.001	0.001	0.002	0.001	0.005	0.011
	8	0.005	0.005	0.011	0.003	0.024	0.052
		-------	-------	-------	-------	-------	-------
3		0.073	0.086	0.166	0.044	0.370	0.757
	1	0.043	0.054	0.107	0.029	0.233	0.444
	2	0.006	0.007	0.014	0.004	0.030	0.061
	3	0.037	0.042	0.081	0.022	0.181	0.341
	4	0.008	0.009	0.018	0.005	0.040	0.086
	5	0.002	0.003	0.006	0.002	0.012	0.038
	6	0.001	0.002	0.003	0.001	0.007	0.013
	8	0.006	0.007	0.013	0.003	0.028	0.059
		-------	-------	-------	-------	-------	-------
4		0.103	0.123	0.241	0.066	0.533	1.042
	1	0.010	0.012	0.023	0.006	0.050	0.104
	2	0.000	0.001	0.001	0.000	0.002	0.004
	3	0.002	0.002	0.004	0.001	0.008	0.016
	4	0.000	0.000	0.001	0.000	0.002	0.004
	5	0.002	0.002	0.004	0.001	0.009	0.018
	6	0.000	0.000	0.000	0.000	0.000	0.001
	8	0.001	0.001	0.002	0.001	0.005	0.009
		-------	-------	-------	-------	-------	-------
5		0.015	0.018	0.035	0.010	0.078	0.155
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	0.219	0.259	0.504	0.136	1.119	2.223	

Road Class: 1=Freeway, 2=Major Regional, 3=Principal Arterial, 4=Minor Arterial
5=Collector, 6=Ramp, 7=Frontage, 8=Local

Area Types: 1=Central Business District, 2=Fringe, 3=Urban, 4=Suburban, 5=Rural

3.4.3 Interim Year Emission Inventories

Mobile source emission inventories for 2002, 2005 and 2010 were also developed for the maintenance demonstration RAM dispersion modeling analysis to assure that the proposed control strategies maintained the PM_{10} NAAQS for years between 2002 and 2015. The following table summarizes the mobile source emission inventory estimates for all years in the analysis

	Road Dust PM_{10} (t/d)	Sanding PM_{10}(t/d)	Tailpipe PM_{10}(t/d)	Tailpipe NOx(t/d)	Tailpipe SO_2(t/d)
2002	32.168	5.196	4.95	137.7	5.63
2005	34.242	5.632	4.96	109.6	6.10
2010	38.947	6.405	3.13	104.02	2.06
2015	41.078	6.788	3.21	87.78	2.22

A. Interim Year Road Dust, Sanding and tailpipe PM_{10} Emission Inventories

The 2015 suite of road dust and sanding emission control strategies applies to all analysis years. Inventory estimate methodology is identical to the 2015 road dust and sanding emission inventories. The inventories are summarized as follows:

2002

REGION	Total VMT	Uncontrolled Sand	Controlled Sand	Uncontrolled Road Dust	Controlled Road Dust
1	46,166,980	6.848	4.793	42.641	29.849
2	205,640	0.032	0.009	0.290	0.081
3	1,186,604	0.192	0.089	0.764	0.351
4	2,732,011	0.424	0.297	2.570	1.799
5	752,435	0.116	0.093	0.753	0.602
	---------------	-------	-------	-------	--------
	51,043,670	7.612	5.280	47.016	32.682

2005

REGION	Total VMT	Uncontrolled Sand	Controlled Sand	Uncontrolled Road Dust	Controlled Road Dust
1	50,580,310	7.517	5.262	45.936	32.155
2	206,088	0.032	0.009	0.288	0.081
3	1,139,350	0.185	0.085	0.719	0.331
4	2,607,856	0.404	0.202	2.449	1.224
5	603,392	0.092	0.074	0.564	0.451
	---------------	-------	-------	-------	--------
	55,136,997	8.230	5.632	49.955	34.242

2010

REGION	Total VMT	Uncontrolled Sand	Controlled Sand	Uncontrolled Road Dust	Controlled Road Dust
1	57,529,925	8.550	5.985	52.248	36.573
2	234,404	0.036	0.010	0.327	0.092
3	1,295,894	0.210	0.097	0.818	0.376
4	2,966,169	0.459	0.230	2.785	1.392
5	686,297	0.105	0.084	0.641	0.513
	---------------	-------	-------	-------	--------
	62,712,690	9.361	6.405	56.819	38.947

3.4.3.1 Interim Year Nitrogen Oxide Emission Inventories

The following table summarizes the assumptions used for the 2002, 2005 and 2010 Nitrogen Oxide emission inventories:

Year	I/M Program Parameters	Other Controls	Inventory (ton/day)
2002	No cut-point controls on I/M 240 program	None	137.7
2005	2.5 g/mi cut-point on I/M 240 program; 60% RSD program	Tier II/Low Sulfur (-12.2 tons)	109.6
2010	1.5 g/mi cut-point on I/M 240 program; 80% RSD program	Tier II/Low Sulfur (-27.3 tons/day)	104.0

Appendix C contains the Mobile5b descriptive output for one scenario and the resultant emission factors for all area types, road classes and peak periods in tabular format. The emission factors tabulated in Appendix C result in emissions inventories of 121.8 and 131.3 tons/day for 2005 and 2010, respectively. The inventories in the above table have the Tier II/Low Sulfur adjustment removed from the inventory.

3.4.3.2 Interim Year PM_{10} and Sulfur Dioxide Emission Inventories

The EPA mobile particulate emission factor model PART5 was utilized for the calculation of the PM_{10} and sulfur dioxide emission factors. No adjustments were made to the 2002 and 2005 emission factors. An adjustment to the 2010 emission factors was made using the same methodology as the adjustment made to the 2015 PM_{10} and sulfur dioxide emission factors. Appendix D contains the 2002, 2005 and 2010 emission factor tables for these pollutants. The 2010 emission factor table in Appendix D has the emission factors resultant from the adjustment methodology. The following table summarizes the multiplicative adjustment for 2010:

Vehicle Type	2010 PM_{10} Multiplicative Adjustment	2010 SO_2 Multiplicative Adjustment
LDGV	.415	.088
LDGT1	.341	.088
LDGT2	.365	.088
HDGV	.767	.088
LDDV	.732	1.000
LDDT	.710	1.000
All other vehicle types	1.000	1.000

3.5 Major Stationary Point Sources

Point source modeling procedure and inventory development differ for major and minor stationary sources of PM_{10}, NO_x, and SO_2.

A major stationary source is a stationary source that emits, or has the potential to emit, 100 tons per year (tpy) or more of any pollutant regulated under the Federal Act for which the area is nonattainment. A stationary source that emits, or has the potential to emit, 100 tpy of a precursor of the pollutant for which the area is nonattainment is considered a major stationary source (NO_x and SO_2 are considered precursors for PM_{10} in the Denver Metro PM_{10} nonattainment area).

For demonstrating compliance with a 24-hr averaging period, consistent with EPA's Guideline on Air Quality Models, point sources at major stationary sources are modeled at maximum allowable short-term emissions, which are emission rates based on maximum actual or design capacity, physical and operational design, continuous operation for all hours of averaging period, and any federally enforceable short-term limitations on emissions. To be considered federally enforceable, short-term limitations must be contained in a permit issued under an EPA-approved permit program, an EPA-approved state regulation or plan, or in a federal regulation.

The methodology for developing the point source emission inventory of major stationary sources follows the estimations provided in Title V (T5) Operating Permit technical reviews and applications. Maximum allowable hourly emission rates were developed from maximum design rates, emission limits in regulations, and potential-to-emit (PTE) estimations.

The point source emission inventory of major stationary sources is used for modeling 2002, 2003, 2005, 2010, 2015 maintenance years. Since Public Service Company of Colorado (PSCo) will retire Arapahoe Station Units 1 and 2 by January 1, 2003, per voluntary agreement between PSCo and the State of Colorado, these units are omitted from the inventories for 2003 and later years.

3.5.1 Development of PM_{10} Emission Inventory

Major PM_{10} stationary sources located in the modeling domain are as follows: Conoco Denver Refinery, PSCo-Arapahoe Station, PSCo-Cherokee Station, PSCo-Zuni Station, Robinson Brick, Trigen-Colorado Energy Corporation, and UDS Refinery.

Only the point sources from the major stationary sources of PM_{10} were included in the point source modeling (Table 3.5-1)). Non-point source PM_{10} emissions from these sources have been included in the RAM modeling as area source emissions.

Table 3.5-1. Major Stationary PM10 Source Point Summary

Major Stationary PM_{10} Source	**Point Source**
Conoco Denver Refinery	Asphalt Heater H-16 Asphalt Heater H-18 Asphalt Unit (Crude Heater) Asphalt Unit (Vacuum Heater) Asphalt Unit Flare B-4 Boiler B-6 Boiler B-8 Boiler DHDS (Feed Heater) FCCU (Feed Preheater) FCCU Regenerator GOHDS (Fractionator Heater) GOHDS (Reactor Charge Heater) Main Plant Flare NDS (Desulfurizer Heater) No. 1 Sulfur Recovery Unit (H-25, Claus Incinerator) No. 2 Sulfur Recovery Unit and Tail Gas Unit Reformer – Inactive H-8 Reformer – Inactive H-12 Reformer (Charge and Reheaters) H-28, H-29, H-30 Rerun (Rerun Charge Heater) SCTU (Crude Fractionator Heater) SCTU (Tar Stripper Charge Heater) SCTU (Vacuum Charge Heater) Sour Crude (Crude Heater) Sour Crude (Vacuum Heater)
PSCo-Arapahoe Station	Unit 1 (Boiler) Unit 2 (Boiler) Unit 3 (Boiler) Unit 4 (Boiler) Unit 5 (Turbine) Unit 6 (Turbine)
PSCo-Cherokee Station	Unit 1 (Boiler) Unit 2 (Boiler) Unit 3 (Boiler) Unit 4 (Boiler)
PSCo-Zuni Station	Unit 1A (Boiler) Unit 1B (Boiler) Unit 2 (Boiler)
Robinson Brick	Rotary Dryer Tunnel Dryer/Kiln Tunnel Dryer/Kiln Rotary Calciner
Trigen-Colorado Energy Corporation	Boiler 1 Boiler 2 Boiler 3 Boiler 4 Boiler 5

Major Stationary PM_{10} Source	Point Source
UDS Refinery	Crude Heater Vacuum Heater Reformer Heater FCCU Preheater FCCU Regenerator Black Oil Heater Boiler #1 Boiler #2 Boiler #3 Refinery Flare Rail Car Flare SRU Plant

3.5.1.1 PM Emission Limitation

Particulate Matter (PM) Emission Limitation for fuel burning equipment, as set in Colorado Regulation No. 1 (Reg. 1) Section III.A, is summarized in Table 3.5-2, (see Appendix E.1). This limitation applies to each fuel burning unit regardless of fuel type. This limitation is considered highly conservative for units that burn natural gas, such as the boilers at Zuni (required by Reg. 1 Section VIII.A for the winter season).

Table 3.5-2. Reg. 1 PM Limitation for Fuel Burning Equipment

Heat Input Design Capacity (HC) (10^6 BTU/hr)	*Allowable PM Emission Limitation (lb/10^6 Btu)*
≤ 1	0.5
$1 < HC \leq 500$	$0.5(HC \text{ in } 10^6 \text{ BTU/hr})^{-0.26}$
> 500	0.1

The maximum allowable hourly PM_{10} emission rates for the boiler units at the PSCo-Arapahoe Station, PSCo-Cherokee Station, PSCo-Zuni Station, and Trigen Colorado Energy Corporation are determined from the limitation described above. The Reg. 1 PM limitation for fuel burning equipment applies to all sources, grandfathered and permitted.

PM Emission Limitation for manufacturing processes, as set in Reg. 1 Section III.C, are summarized in Table 3.5-3, (see Appendix E.1).

Table 3.5-3. Reg. 1 PM Limitation for Manufacturing Processes

Process Weight Rates (P) (ton/hr)	*Allowable PM Emission Limitation (lb/hr)*
≤ 30 ton/hr	$3.59(P \text{ in ton/hr})^{0.62}$
> 30 ton/hr	$17.31(P \text{ in ton/hr})^{0.16}$

PM Limitation for manufacturing processes is applicable for the point sources at Robinson Brick. The Reg. 1 PM limitation for manufacturing processes applies to all sources, grandfathered and permitted.

3.5.1.2 Cumulative Mass Percent of PM emissions less than 10 µm

EPA's Compilation of Air Pollutant Emissions Factors (AP-42) has cumulative particle size distributions for some source types (see Appendix E.2). The mass fraction of PM_{10} in PM is used to determine the maximum allowable PM_{10} emissions from maximum allowable PM emissions, as limited by Reg. 1. *Table 3.5-4* lists the mass fractions and the point sources they were applied to.

Table 3.5-4. Cumulative Mass % of PM emissions less than 10 µm

Source Type	Point Source	Cumulative Mass % of PM emissions < 10 µm
Dry Bottom Boilers burning pulverized bituminous and subbituminous coal, w/ ESP[1]	Arapahoe: Units 1, 2	67
Dry Bottom Boilers burning pulverized bituminous and subbituminous coal, w/ baghouse[1]	Arapahoe: Units 3, 4 Cherokee: Units 1, 2, 3, 4	92
Utility Boilers firing residual oil, uncontrolled[2]	Zuni: Units 1A, 1B, 2	71
Rotary Dryer[3]	Robinson Brick: S001	24
Rotary Calciner[3]	Robinson Brick: S006	34

[1]AP-42, Table 1.1-6 (9/98).
[2]AP-42, Table 1.3-4 (9/98).
[3]AP-42, Table 11.25-8 (1/95).

3.5.1.3 Potential to Emit

Maximum hourly PM_{10} emissions for the point sources at the refineries are based on the estimations submitted in their T5 applications. The PTE estimations were calculated with emission factors. These estimations are summarized in Section 3.5.1.4 and attached in Appendix E.3, Conoco Refinery and UDS Refinery.

Maximum hourly PM_{10} emission rates for the turbines at PSCo-Arapahoe Station are the maximum short-term emission rates reported in their construction permit application (see Appendix E.3, PSCo - Arapahoe).

3.5.1.4 PM_{10} Emission Inventory

Hourly emission rates (ER) based on limitations in Reg. 1 are calculated in the following manner:

For fuel burning equipment:

$$\text{ER}\left(\frac{\text{lb PM}_{10}}{\text{hr}}\right) = \text{Design Rate}\left(\frac{\text{mmBtu}}{\text{hr}}\right) \times \text{Reg.1 Limit}\left(\frac{\text{lb PM}}{\text{mmBtu}}\right) \times \text{Cumulative Mass \%}\left(\frac{\text{lb PM}_{10}}{\text{lb PM}}\right)$$

For manufacturing processes:

$$\text{ER}\left(\frac{\text{lb PM}_{10}}{\text{hr}}\right) = \text{Reg.1 Limit}\left(\frac{\text{lb PM}}{\text{hr}}\right) \times \text{Cumulative Mass \%}\left(\frac{\text{lb PM}_{10}}{\text{lb PM}}\right)$$

Hourly emission rates based on emission factors (EF) are calculated in the following manner:

For fuel burning equipment:

$$ER\left(\frac{\text{lb PM}_{10}}{\text{hr}}\right) = EF\left(\frac{\text{lb PM}_{10}}{\text{mmscf}}\right) \times \text{Heating Value}\left(\frac{\text{mmscf}}{\text{mmBtu}}\right) \times \text{ Design Rate}\left(\frac{\text{mmBtu}}{\text{hr}}\right)$$

$$ER\left(\frac{\text{lb PM}_{10}}{\text{hr}}\right) = \text{Fuel Use}\left(\frac{\text{barrel or mmscf}}{\text{yr}}\right) \times EF\left(\frac{\text{lb PM}_{10}}{\text{barrel or mmscf}}\right) \times \text{Operation}\left(\frac{\text{yr}}{\text{8760 hr}}\right)$$

$$ER\left(\frac{\text{lb PM}_{10}}{\text{hr}}\right) = \text{Throughput}\left(\frac{10^6\ \text{ft}^3}{\text{yr}}\right) \times EF\left(\frac{\mu\text{g}}{\text{L}}\right) \times \text{Operation}\left(\frac{\text{yr}}{\text{8760 hr}}\right) \times \frac{0.0624\ \text{lb} \cdot \text{L}}{\mu\text{g} \cdot 10^6\ \text{ft}^3}$$

Table 3.5-5 through Table 3.5-11 summarizes the emission inventory calculations for the major PM_{10} stationary sources (see Appendix E.4 for supporting documentation).

Table 3.5-5. Conoco Refinery PM10 Point Source Emissions

Conoco Refinery							
Point	*Feed Rate (10^3 barrels/yr)*	*PM_{10} EF (lb/10^3 barrels)*	*Fuel Use (mmscf/yr)*	*PM_{10} EF (lb /mmscf)*	*Operation hr/yr*	*PM_{10} ER (lb/hr)*	*PM_{10} ER (g/s)*
FCCU	*7300*	*50.8*			*8760*	*42.33*	*5.33*
Heater 31			*206.39*	*13.7*	*8760*	*0.32*	*0.04*
Heater 32			*331.13*	*13.7*	*8760*	*0.52*	*0.07*
Heater 6			*126.14*	*13.7*	*8760*	*0.20*	*0.02*
Heater 8			*145.42*	*13.7*	*8760*	*0.23*	*0.03*
Heater 10			*298.02*	*13.7*	*8760*	*0.47*	*0.06*
Heater 11			*260.7*	*13.7*	*8760*	*0.41*	*0.05*
Heater 33			*67.28*	*12*	*8760*	*0.09*	*0.01*
Heater 12			*258.77*	*13.7*	*8760*	*0.40*	*0.05*
Heater 37			*501.42*	*13.7*	*8760*	*0.78*	*0.10*
Heater 17			*511.58*	*13.7*	*8760*	*0.80*	*0.10*
Heater 13			*59.57*	*12*	*8760*	*0.08*	*0.01*
Heater 19			*255.62*	*13.7*	*8760*	*0.40*	*0.05*
Heater 20			*122.64*	*13.7*	*8760*	*0.19*	*0.02*
Heater 22			*523.5*	*13.7*	*8760*	*0.82*	*0.10*
Boiler 4			*1138.8*	*3*	*8760*	*0.39*	*0.05*
Boiler 6			*972.36*	*3*	*8760*	*0.33*	*0.04*
Boiler 8			*1410.36*	*3*	*8760*	*0.48*	*0.06*
Heater 18			*52.56*	*12*	*8760*	*0.07*	*0.01*
Heater 16			*52.56*	*12*	*8760*	*0.07*	*0.01*
SRU1			*0*	*0*	*8760*	*0.00*	*0.00*
Heater 27			*669.96*	*13.7*	*8760*	*1.05*	*0.13*
Heaters 28, 29, 30			*776.14*	*13.7*	*8760*	*1.21*	*0.15*
Total						*52*	*7*

Table 3.5-6. PSCo-Arapahoe Station PM_{10} Point Source Emissions

PSCO-Arapahoe Station					
Point	*Design Rate (mmBtu/hr)*	*Reg. 1 PM Limit (lb/mmBtu)*	*Fraction PM_{10}/PM*	*PM_{10} ER (lb/hr)*	*PM_{10} ER (g/s)*
Unit 1 (2002 only)	*754.8*	*0.1*	*0.67*	*50.57*	*6.37*
Unit 2 (2002 only)	*754.8*	*0.1*	*0.67*	*50.57*	*6.37*
Unit 3	*754.8*	*0.1*	*0.92*	*69.44*	*8.75*
Unit 4	*1709*	*0.1*	*0.92*	*157.23*	*19.81*
*Unit 5**				*3.00*	*0.38*
*Unit 6**				*3.00*	*0.38*
2002 Total				*334*	*42*
2003+ Total				*233*	*29*

*Maximum short-term emission rate noted in construction permit application

Table 3.5-7. PSCo-Cherokee Station PM_{10} Point Source Emissions

PSCO-Cherokee Station					
Point	Design Rate (mmBtu/hr)	Reg. 1 PM Limit (lb/mmBtu)	Fraction PM_{10}/PM	PM_{10} ER (lb/hr)	PM_{10} ER (g/s)
Unit 1	1392	0.1	0.92	128.06	16.14
Unit 2	1392	0.1	0.92	128.06	16.14
Unit 3	1877	0.1	0.92	172.68	21.76
Unit 4	3520	0.1	0.92	323.84	40.80
Total				753	95

Table 3.5-8. PSCo-Zuni Station PM_{10} Point Source Emissions

PSCO-Zuni Station					
Point	Design Rate (mmBtu/hr)	Reg. 1 PM Limit (lb/mmBtu)	Fraction PM_{10}/PM	PM_{10} ER (lb/hr)	PM_{10} ER (g/s)
Unit 1A	450	0.102	0.71	32.59	4.11
Unit 1B	200	0.126	0.71	17.89	2.25
Unit 2	1075	0.1	0.71	76.33	9.62
Total				127	16

Table 3.5-9. Robinson Brick PM_{10} Point Source Emissions

Robinson Brick						
Point	P = Short-Term Process Rate (dry ton/hr)	Reg. 1 Limit PM = $17.31P^{0.16}$ (lb/hr)	Reg. 1 Limit PM = $3.59P^{0.62}$ (lb/hr)	Fraction PM_{10}/PM	PM_{10} ER (lb/hr)	PM_{10} ER (g/s)
S001: Rotary Dryer	35	30.57		0.24	7.34	0.92
S002,S003,S004,S005: Tunnel Dryer(2), Kiln(2)	13.4		17.9	1	17.9	2.26
S006: Rotary Calciner	10		14.97	0.34	5.09	0.64
Total					30	4

Table 3.5-10. Trigen-Colorado Energy Corporation PM_{10} Point Source Emissions

Trigen-Colorado Energy Corporation					
Point	*Design Rate (mmBtu/hr)*	*Reg. 1 PM Limit (lb/mmBtu)*	*Fraction PM_{10}/PM*	*PM_{10} ER (lb/hr)*	*PM_{10} ER (g/s)*
Boiler 1	*288*	*0.11*	*1*	*31.68*	*3.99*
Boiler 2	*288*	*0.11*	*1*	*31.68*	*3.99*
Boiler 3	*225*	*0.12*	*1*	*27.00*	*3.40*
Boiler 4	*360*	*0.1*	*1*	*36.00*	*4.54*
Boiler 5	*650*	*0.1*	*1*	*65.00*	*8.19*
Total				*191*	*24*

Table 3.5-11. UDS Refinery PM_{10} Point Source Emissions

UDS Refinery											
Point	*Coke Production (lb/hr)*	*lb PM_{10}/ 10^3 lb Coke Produced*	*Design Rate (mmBtu/hr)*	*PM_{10} EF (lb/ mmscf)*	*PM_{10} EF (µg/L)*	*Flare Throughput (10^6 ft^3/yr)*	*(lb-L)/ (µg-10^6 ft^3)*	*mmscf per mmBtu*	*Operation (hr/yr)*	*PM_{10} ER (lb/hr)*	*PM_{10} ER (g/s)*
FCCU	*5788.7*	*7.88*								*45.61*	*5.75*
Crude Heater			*88*	*13.7*				*0.0010*		*1.21*	*0.15*
Vacuum Heater			*31*	*13.7*				*0.0010*		*0.42*	*0.05*
Reformer Heater			*161*	*13.7*				*0.0010*		*2.21*	*0.28*
FCC Preheater			*75*	*13.7*				*0.0022*		*2.28*	*0.29*
SRU Incinerator			*2.4*	*12*				*0.0010*		*0.03*	*0.004*
Black Oil Heater			*8.1*	*5*				*0.0010*		*0.04*	*0.01*
Utilities (Boiler 1, 2, 3)			*225*	*13.7*				*0.0010*		*3.08*	*0.39*
Refinery Flare					*137*	*212.5*	*0.0624*		*8760*	*0.21*	*0.03*
LPG Loading-Unloading and Flare										*0.00*	*0.00*
Total										*55*	*7*

3.5.1.5 Fugitive Sources at Major PM10 Sources

Fugitive dust sources at major PM_{10} facilities were modeled using the RAM model as area sources. Table 3.5-12 presents a summary of fugitive emissions from the major PM_{10} facilities in the modeling domain from 1995 actual emissions data. These emission rates were grown to the maintenance years based on demographic data for modeling purposes. Fugitive emissions at these facilities include coal/ash handling, paved/unpaved roads, cooling towers, and grain handing.

Table 3.5-12. Fugitive PM10 Emissions at Major Facilities Using the RAM Model

Plant	Process	Emissions (tpy)	Emissions (tpd)
CHEROKEE	COAL HANDLING/STORAGE	24.00	0.07
	FLY ASH HANDLING/STORAGE	11.00	0.03
	PAVED/UNPAVED ROADS	11.20	0.03
	COOLING TOWERS	7.00	0.02
	Subtotal	53.20	0.15
ARAPAHOE	COAL HANDLING/STORAGE	36.90	0.10
ROCKY MOUNTAIN BOTTLE CO	FUG. LIGHT PETRO.OIL MIST	1.30	0.00
ROBINSON BRICK CO PIONEER MINE	OPEN PIT CLAY MINING	1.58	1.58
COORS BREWING	ASH HANDLING SYSTEM	8.50	0.02
	COAL HANDLING - #5 BOILER	0.11	0.00
	COAL UNLOADING	0.01	0.00
	COAL CONVEY TO BOILER #3	0.00	0.00
	STARCH HANDLING	1.27	0.00
	RICE UNLOADING	0.63	0.00
	MCINTYRE GRAIN SILOS	0.80	0.00
	MALTING OPERATION	1.05	0.00
	MALTHOUSE GRAIN HANDLING	2.70	0.01
	RAW MAT MILLING/BATCHING	1.70	0.00
	SPENT GRAIN DYRING SYSTEM	2.41	0.01
	MALTHOUSE	0.00	0.00
	PWTP COOLING TOWER	0.32	0.00
	FAB SHOP BOILERS	0.02	0.00
	BREWERY COOLING TOWERS	2.90	0.01
	DIESEL AIR COMPRESSOR	0.15	0.00
	CEMENT BATCH PLANT	0.40	0.00
	DRY BYPRODUCT PELLET SYS	25.90	0.07
	PACKAGING RAIL TUNNELS	0.47	0.00
	CEMENT BATCH PLANT BOILER	0.00	0.00
	DIATOMACEOUS EARTH HANDLG	0.04	0.00
	YEAST DRYING PLANT	0.63	0.00
	PACKAGING HOT MELT APPLIC	0.70	0.00
	CO4 NATURAL GAS USE	0.09	0.00
	BUILDING 21 COOLING TOWER	1.08	0.00
	BUILDING 30 COOLING TOWER	2.12	0.01
	BLDG 32 COOLING TOWER	0.32	0.00
	TRIM SCRAP CYCLONES	7.50	0.02

Plant	*Process*	*Emissions (tpy)*	*Emissions (tpd)*
	DECO SCRAP CYCLONE 6	*0.10*	*0.00*
	WELLNESS CENTER BOILER	*0.02*	*0.00*
	DIESEL FUEL	*0.00*	*0.00*
	ABRASIVE RECYCLNG-PROCESS	*0.42*	*0.00*
	Subtotal	*53.73*	*0.15*
Trigen-Golden Facility	*RAIL CAR-DUMPER TO HOPPERS*	*51.60*	*0.14*
	CONVEYOR TO UNIT 5 SILOS	*22.70*	*0.06*
	CONVEYOR TO UNIT 3 SILOS	*0.02*	*0.00*
	CYCLONES	*47.70*	*0.13*
	BIN VENT	*0.22*	*0.00*
	FLY ASH LOADOUT	*0.02*	*0.00*
	DIESEL ENGINE	*0.14*	*0.00*
	Subtotal	*122.40*	*0.34*
	Total Fugitive Emissions	*215.38*	*0.47*

3.5.2 Development of Secondary PM10 Emission Inventory

As in the attainment SIP modeling protocol, major stationary sources of NO_x and SO_2 are treated as background sources where such sources are modeled with anticipated actual emissions if two criteria are met:

(1) The difference between modeling at anticipated actual versus maximum allowable emission rates for any excluded source must be less than a de minimis level of 1 $\mu g/m^3$ secondary PM_{10} (using the secondary particulate roll-forward model described in Section 4.3, and;
(2) The cumulative difference for all excluded sources must be no more than 2 $\mu g/m^3$.

The criteria above are evaluated using daily 1995 SIP anticipated actual emissions and daily maximum allowable emission rates for the 2015 maintenance year. Major stationary sources that do not meet these criteria are included in the secondary PM_{10} concentration determination using their maximum allowable emissions of NO_x and SO_2. For the attainment SIP, this methodology resulted in five sources modeled at maximum allowable emissions: PSCo-Arapahoe Station, PSCo-Cherokee Station, PSCo-Valmont Station, Trigen-Colorado Energy Corporation, and Rocky Mountain Bottle Company.

Major NO_x and SO_2 stationary sources located in the modeling domain are listed in Table 3.5-13 (see Appendix E.2) below. Though not in the modeling domain, PSCo-Valmont Station is included in Table 3.5-13 because of the attainment SIP modeling protocol requirement to account for their secondary PM_{10} emissions. The GSA Federal

Center, not identified as a major source, was included in Table 3.5-13 because it was part of the attainment SIP evaluation for modeling secondary PM_{10} sources at actual emissions.

In its approval of the Denver PM_{10} nonattainment area SIP, EPA incorporated by reference permits for Purina Mills and Electron Corporation. However, these source permits reflect that Purina and Electron are minor sources - i.e., have emissions less than 100 tons per year of PM_{10}. Accordingly, the State modeled these sources at their actual emissions plus a growth factor for purposes of the nonattainment area SIP attainment demonstration. Although these sources have potentials to emit greater than 100 tons per year, they are no different than other synthetic minor sources in the Denver area that were modeled at actual emissions plus a growth factor in the original nonattainment area SIP, and there is no reason the permits for these sources need to be specifically incorporated by reference into the SIP. Thus, the maintenance plan removes the permits for Purina Mills and Electron Corporation from the SIP, and lists them as possible contingency measures should the NAAQS be violated.

Annual source PTE estimates, used to determine daily allowable emission rates, were extracted from T5 applications and technical reviews, and updated calculations based on newer emission factors (see Appendix E.2). The PTE listed below for PSCo-Denver Steam, PSCo-Valmont Station, PSCo-Zuni Station, and Trigen-Colorado Energy Corporation reflect the restriction in Reg. 1 Section VIII.A which requires these facilities to use natural gas as the primary fuel in units capable of burning either gas or oil between November 1 and March 1 and allows the use of fuel oil as backup fuel under certain circumstances during this period (see Appendix E.1). The PTE for PSCo-Arapahoe Station takes into account of retirement of Units 1 and 2 in January 1, 2003.

Table 3.5-13. Major Stationary Secondary PM_{10} Sources (2015 emissions)

Major Stationary Secondary PM_{10} Source	***PTE (tpy)***	
	NO_x	***SO_2***
Amoco – Wattenberg	*345*	
Buckley AFB	*352*	*123*
CIG – Watkins	*994*	
Conoco Denver Refinery	*1,734*	*3,498*
Gates Rubber Co.	*379*	
GSA Federal Center	*30*	
HS Resources – Brighton	*525*	
Metro Wastewater		*245*
NARCo – Mitchell	*150*	
NARCo – Radar	*178*	
NARCo – State	*156*	
NARCo – Third Creek	*248*	
PSCo – Arapahoe Station	*7,770*	*10,224*
PSCo – Cherokee Station	*21,382*	*34,683*
PSCo - Denver Steam Plant (gas-fired)	*585*	
PSCo – Valmont Station (gas-fired)	*4,474*	*8,890*
PSCo - Zuni Station (gas-fired)	*2,116*	
Rocky Flats	*183*	
Rocky Mountain Bottle Company	*424*	*369*

Major Stationary Secondary PM_{10} Source	***PTE (tpy)***	
	NO_x	***SO_2***
Trigen-Colorado Energy Corporation (gas-fired)	*3,962*	*6,959*
TXI Operations, LP – Western Aggregates	*219*	*239*
UDS Refinery	*359*	*1,047*

The five sources modeled at maximum allowable emissions in the attainment SIP are not part of the criteria evaluation because of the intention to model them at maximum allowable emissions for the maintenance plan. However, their emissions (1995 SIP Allow) are listed in the upper portion of Table 3.5-14to determine the emission (tpd)-to-concentration ($\mu g/m^3$) multiplier, per the roll-forward method. For the excluded sources, the annual source 2015 PTE are divided by 365 days to determine daily allowable emission rates. The difference between 2015 daily allowable emission rates (2015 Allow) and attainment SIP anticipated actual emission rates (1995 SIP Actual) for the excluded sources are determined and used to evaluate the criteria above (see Table 3.5-14).

Table 3.5-14. Evaluation for Modeling Secondary PM_{10} Sources at Actual Emissions

1995 SIP Secondary PM_{10} Source Modeled at Maximum Allowable	**1995 SIP Allow NO_x (tpd)**	**1995 SIP Allow SO_2 (tpd)**					
PSCo Cherokee Station	55.7	83.6					
PSCo Arapahoe Station	28.9	36.0					
PSCo Valmont Station	9.6	24.7					
Trigen-Colorado Energy Corp.	13.2	19.1					
Rocky Mountain Bottle Co.	1.7	1.0					
Excluded Secondary PM_{10} Source Modeled at Actual+Growth	**1995 SIP Actual NO_x (tpd)**	**1995 SIP Actual SO_2 (tpd)**	**2015 Allow NO_x (tpd)**	**2015 Allow SO_2 (tpd)**	**Evaluation: Allow minus Actual Emissions (tpd)**	**Evaluation: Allow minus Actual Conc. ($\mu g/m^3$)**	**Evaluation: Conc. Difference < 1 $\mu g/m^3$?**
Amoco Wattenburg	1.3	0.1	0.9	0.1	-0.4		Yes
Buckley AFB	0.8	0.1	1.0	0.3	0.4	0.0	Yes
CIG Watkins	2.8	0.0	2.7	0.0	-0.1		Yes
Conoco Refinery	1.9	6.5	4.8	9.6	5.9	0.6	Yes
Gates Rubber	0.8	0.0	1.0	0.0	0.2	0.0	Yes
GSA Federal Center	0.5	0.7	0.1	0.0	-1.1		Yes
H.S. Resources Brighton Station**			1.4	0.0	1.4	0.1	Yes
Metro Wastewater	0.1	0.0	0.0	0.7	0.6	0.1	Yes
NARCo Mitchell Station**			0.4	0.0	0.4	0.0	Yes
NARCo Radar Station	0.2	0.0	0.5	0.0	0.3	0.0	Yes
NARCo State Station**			0.4	0.0	0.4	0.0	Yes
NARCo Third Creek Station	1.3	0.0	0.7	0.0	-0.6		Yes
PSCo Denver Steam Plant	0.9	0.0	1.6	0.0	0.7	0.1	Yes
PSCo Zuni*	0.7	0.0	5.8	0.0	5.1	0.5	Yes
Rocky Flats	0.2	0.1	0.5	0.0	0.2	0.0	Yes
TXI Western Aggregate	0.3	0.0	0.6	0.7	1.0	0.1	Yes
UDS Refinery	1.2	3.6	1.0	2.9	-1.0		Yes
Remaining minor point sources	5.4	0.0	Cumulative Difference			1.6	Each Conc. Difference < 1 $\mu g/m^3$
Allowable Point Subtotal	109.1	164.4	Less than 2 $\mu g/m^3$?			Yes	
Actual Point Subtotal	18.4	11.1	***Criteria 2 met***				***Criteria 1 met***
Point Source Subtotal*	137.8	175.5					
Area Sources Subtotal	55.5	2.1					
Mobile Source Subtotal	119.4	2.5					
Total	312.7	180.1					
TOTAL Secondary Emissions (tpd)		492.8					
Secondary Concentration ($\mu g/m^3$)		46.1					
Multiplier ($\mu g/m^3$ per tpd)		0.0935					

*It appears PSCo Zuni was erroneously modeled at maximum allowable (11 tpd NO_x) in the 1995 SIP, but is modeled at actual emissions in 2001 maintenance plan. The 1995 point source subtotal reflects Zuni at maximum allowable.

**These sources were not contained in 1995 list of sources.

As illustrated above, the criteria have been met for the excluded secondary PM_{10} sources modeled at actual plus growth listed in Table 3.5-14. Therefore, the same five major stationary secondary PM_{10} sources modeled at maximum allowable emissions for the 1995 attainment SIP will be modeled at maximum allowable emissions for this maintenance plan. Table 3.5-15 lists the point sources associated with these sources.

Table 3.5-15. Secondary PM_{10} Source Point Summary

Secondary PM_{10} Source	***Point Source***
PSCo-Arapahoe Station	*Unit 1 (Boiler)* *Unit 2 (Boiler)* *Unit 3 (Boiler)* *Unit 4 (Boiler)* *Unit 5 (Turbine)* *Unit 6 (Turbine)*
PSCo-Cherokee Station	*Unit 1 (Boiler)* *Unit 2 (Boiler)* *Unit 3 (Boiler)* *Unit 4 (Boiler)*
PSCo-Valmont Station	*Unit 5 (Boiler)* *Unit 6 (Turbine)* *Unit 7 (Turbine)* *Unit 8 (Turbine)*
Rocky Mountain Bottle Company	*Furnace 1* *Furnace 2* *Furnace 3* *IS Bottle Making Machines*
Trigen-Colorado Energy Corporation	*Boiler 1* *Boiler 2* *Boiler 3* *Boiler 4* *Boiler 5*

3.5.2.1 NO_x and SO_2 Emission Limitations

Table 3.5-16 summarizes the NO_x and SO_2 limitations applicable to the point sources above. For sources subject to multiple limitations, the most restrictive limit is reported. The regulations providing the limits in Table 3.5-16 are discussed below.

Reg. 1 contains numerous NO_x and SO_2 emission limitations that apply to the sources of interest. Section VI provides SO_2 emission limitations for sources constructed or modified prior to August 11, 1977, except sources listed in Section VII. Section VI limitations are based on a 3-hr rolling average. Trigen-Colorado Energy Corporation Boilers 3, 4, and 5 are subject to Section VI. Section VII provides NO_x and/or SO_2 emission limitations for select units at electric generating stations owned and operated by PSCo. The NO_x limitations are based on a 30-day rolling average. The SO_2 limitations are based on a 3-hr rolling average, with one exception that is based on an annual average which is noted in the table. Section VII affects PSCo-Valmont Station Unit 5 and all units at PSCo-Arapahoe Station and PSCo-Cherokee Station. (see Appendix E.1).

As part of the approval of this maintenance plan, Reg. 1 will be updated to include 30-day rolling average limitations for PSCO-Arapahoe Station and PSCO-Cherokee Station. A NO_x limit effective January 1, 2005 is placed on PSCo-Cherokee Station Unit 1. Upon maintenance plan approval, SO_2 limits that will only apply from November 1 through March 1 are placed on PSCo-Cherokee Station Units 1 and 4 and PSCo-Arapahoe Station Unit 4.

Federal Regulation 40CFR Part 60 provides New Source Performance Standards (NSPS). Trigen-Colorado Energy Boilers 4 and 5 are subject to NSPS Subpart D. NSPS Subpart D contains NO_x limits based on a 3-hr rolling average (see Appendix E.5).

The attainment SIP contains annual reductions of NO_x and SO_2 for Trigen-Colorado Energy Units 4 and 5 combined.

Table 3.5-16. NO_x and SO_2 Emission Limitations

		Limitation (lb/mmBtu)						Limitation (tpy)	
		Reg. 1					40 CFR		
		SectionVI	Section VII		New[2]		Part 60	Attainment SIP	
Source	**Unit**	**SO_2[1]**	**NO_x[2]**	**SO_2[1]**	**NO_x[4]**	**SO_2[5]**	**NO_x[1]**	**NO_x**	**SO_2**
PSCo-Arapahoe Station	1			1.1					
	2			1.1					
	3			1.1					
	4		0.6	1.1		0.88			
				20% annual tonnage reduction					
PSCo-Cherokee Station	1			1.1	0.6	0.88			
	2			1.1					
	3		0.6	1.1					
	4		0.45	1.1		0.88			
	1, 4			20% annual tonnage reduction[3]					
Trigen-Colorado Energy Corporation	3	1.8							
	4	1.2					0.7		
	5	1.2					0.7		
	4, 5							225	125
PSCo-Valmont Station	5		0.45	1.1					

[1]3-hr rolling average unless otherwise noted.
[2]30-day rolling average.
[3]Average of both units.
[4]Based on approval of maintenance plan 30 day rolling average, effective January 1, 2005.
[5]Upon approval of maintenance plan 30 day rolling average, applicable November 1 through March 1.

3.5.2.2 Potential to Emit

AP-42 emission factors were used to determine maximum daily emissions for the following point sources (see Appendix E.3):

Table 3.5-17. PTE determined with AP-42 Emission Factors

Facility	Point	Pollutants
PSCo- Arapahoe Station	*Units 1, 2, 3*	NO_x
PSCo-Cherokee Station	*Units 1 (< 2005) and 2*	NO_x
PSCo-Valmont Station	*Unit 6 (gas)*	NO_x
Trigen-Colorado Energy Corporation	*Boilers 1 and 2 (gas)*	NO_x, SO_2
	Boiler 3	NO_x

Maximum daily NO_x and SO_2 emission rates for the turbines at Arapahoe and Valmont Stations are the maximum short-term emission rates reported in their construction permit application (see Appendix E.4, PSCo - Arapahoe).

Maximum daily emissions calculated for Furnaces 1, 2, and 3 at Rocky Mountain Bottle Company are based on stack testing data collected at maximum capacity. The daily maximum emissions from the IS Bottle Making Machines are based on mass balance and design capacity (see Appendix E.4, Rocky Mountain Bottle).

PTE estimations are summarized in Section 3.5.2.3 and attached in Appendix E.4.

3.5.2.3 Secondary PM_{10} Emission Inventory

Emission rates (ER) based on limits or AP-42 emissions factor (EF) are calculated in the following manner:

$$\text{ER}\left(\text{tpd NO}_x\right) = \text{Design Rate}\left(\frac{\text{mmBtu}}{\text{hr}}\right) \times \text{Limit or EF}\left(\frac{\text{lb NO}_x}{\text{mmBtu}}\right) \times \text{Operation}\left(\frac{24\text{ hr}}{\text{day}}\right) \times \frac{0.0005\text{ ton}}{\text{lb}}$$

$$\text{ER}\left(\text{tpd SO}_2\right) = \text{Design Rate}\left(\frac{\text{mmBtu}}{\text{hr}}\right) \times \text{Limit or EF}\left(\frac{\text{lb SO}_2}{\text{mmBtu}}\right) \times \left(1 - \frac{\eta}{100}\right) \times \text{Operation}\left(\frac{24\text{ hr}}{\text{day}}\right) \times \frac{0.0005\text{ ton}}{\text{lb}}$$

where: η = control efficiency (%), applicable for select point sources

$$\text{ER}\left(\text{tpd NO}_x\right) = \text{EF}\left(\frac{\text{lb NO}_x}{\text{ton coal}}\right) \times \text{Coal Rate}\left(\frac{\text{ton}}{\text{hr}}\right) \times \text{Operation}\left(\frac{24\text{ hr}}{\text{day}}\right) \times \frac{0.0005\text{ ton}}{\text{lb}}$$

$$\text{ER}\left(\text{tpd NO}_x\right) = \text{EF}\left(\frac{\text{lb NO}_x}{\text{ton coal}}\right) \times \frac{\text{ton coal}}{22.8\text{ mmBtu}} \times \text{Design Rate}\left(\frac{\text{mmBtu}}{\text{hr}}\right) \times \text{Operation}\left(\frac{24\text{ hr}}{\text{day}}\right) \times \frac{0.0005\text{ ton}}{\text{lb}}$$

$$\text{ER}\left(\text{tpd NO}_x\right) = \text{EF}\left(\frac{\text{lb NO}_x}{\text{mmscf}}\right) \times \text{Heating Value}\left(\frac{\text{mmscf}}{\text{mmBtu}}\right) \times \text{Design Rate}\left(\frac{\text{mmBtu}}{\text{hr}}\right) \times \text{Operation}\left(\frac{24\text{ hr}}{\text{day}}\right) \times \frac{0.0005\text{ ton}}{\text{lb}}$$

Table 3.5-18 through Table 3.5-22 summarizes the emission inventory calculations for the secondary PM_{10} stationary sources modeled at maximum allowable emissions.

Table 3.5-18. PSCo-Arapahoe Station NO_x and SO_2 Point Source Emissions

PSCo-Arapahoe Station								
Point	Design Rate (mmBtu/hr)	NO_x Limit (lb/mmBtu)	SO_2 Limit (lb/mmBtu)	SO_2 η (%)	Operation hr/day	ton/lb	NO_x ER (tpd)	SO_2 ER (tpd)
Unit 1 (2002 only)	754.8	0.977[1]	1.1	0	24	0.0005	8.9	10.0
Unit 2 (2002 only)	754.8	0.977[1]	1.1	0	24	0.0005	8.9	10.0
Unit 3	754.8	0.977[1]	1.1	0	24	0.0005	8.9	10.0
Unit 4	1709	0.6	1.1	20	24	0.0005	12.3	18.0[3]
Unit 5[2]							0.37	
Unit 6[2]							0.37	
2002 Total							39.7	48.0
2003+ Total							21.9	28.0

[1]Not a limit, PTE based on AP-42, Table 1.1-3 (10/96) 21.7 lb NO_x/ton coal and coal usage of 34 ton/hr.
[2]Maximum short-term emission rate noted in construction permit application.
[3]This rate is also equivalent to the 0.88 lb/mmBtu limit applicable from November 1 through March 1.

Table 3.5-19. PSCo-Cherokee Station NO_x and SO_2 Point Source Emissions

PSCo-Cherokee Station								
Point	Design Rate (mmBtu/hr)	NO_x Limit (lb/mmBtu)	SO_2 Limit (lb/mmBtu)	SO_2 η (%)	Operation hr/day	ton/lb	NO_x ER (tpd)	SO_2 ER (tpd)
Unit 1 (< 2005)	1392	0.96[1]	1.1	20	24	0.0005	16.0	14.7[2]
Unit 1 (≥ 2005)	1392	0.6	1.1	20	24	0.0005	10.0	14.7[2]
Unit 2	1392	0.96[1]	1.1	0	24	0.0005	16.0	18.4
Unit 3	1877	0.6	1.1	0	24	0.0005	13.5	24.8
Unit 4	3520	0.45	1.1	20	24	0.0005	19.0	37.2[2]
< 2005 Total							64.6	95.0
≥ 2005 Total							58.6	95.0

[1]Not a limit, PTE based on AP-42, Table 1.1-3 (10/96) 21.7 lb NO_x/ton coal and coal usage of 61.8 ton/hr.
[2]This rate is also equivalent to the 0.88 lb/mmBtu limit applicable from November 1 through March 1.

Table 3.5-20. PSCo-Valmont Station NO_x and SO_2 Point Source Emissions

PSCo-Valmont Station							
Point	Design Rate (mmBtu/hr)	NO_x Limit (lb/mmBtu)	SO_2 Limit (lb/mmBtu)	Operation hr/day	ton/lb	NO_x ER (tpd)	SO_2 ER (tpd)
Unit 5	1845	0.45	1.1	24	0.0005	10.0	24.4
Unit 6 (gas)	570	0.32*		24	0.0005	2.2	
Unit 7[2]						0.37	
Unit 8[2]						0.37	
Total						12.9	24.4

[1]Not a limitation, PTE based on AP-42, Table 3.1-1 (4/00).
[2]Maximum short-term emission rate noted in construction permit and application.

Table 3.5-21. Rocky Mountain Bottle Company NO_x and SO_2 Point Source Emissions

Rocky Mountain Bottle Company						
Point	*NO_x (lb/hr)*	*SO_2 (lb/hr)*	*Operation hr/day*	*ton/lb*	*NO_x ER (tpd)*	*SO_2 ER (tpd)*
Furnace 1, 2, 3	*96.8*	*82.65*	*24*	*0.0005*	*1.2*	*1.0*
IS Bottle Making Machine	*0.01*	*1.6*	*24*	*0.0005*	*0.0*	*0.0*
Total					*1.2*	*1.0*

Table 3.5-22. Trigen-Colorado Energy Corp. NO_x and SO_2 Point Source Emissions

Trigen-Colorado Energy Corp.							
Point	*Design Rate (mmBtu/hr)*	*NO_x Limit (lb/mmBtu)*	*SO_2 Limit (lb/mmBtu)*	*Operation hr/day*	*ton/lb*	*NO_x ER (tpd)*	*SO_2 ER (tpd)*
Boiler 1 (gas)	*288*	*0.28[1]*	*0.0006[2]*	*24*	*0.0005*	*1.0*	*0.0*
Boiler 2 (gas)	*288*	*0.28[1]*	*0.0006[2]*	*24*	*0.0005*	*1.0*	*0.0*
Boiler 3	*225*	*0.39[3]*	*1.8*	*24*	*0.0005*	*1.0*	*4.9*
Boiler 4	*360*	*0.7*	*1.2*	*24*	*0.0005*	*3.0*	*5.2*
Boiler 5	*650*	*0.7*	*1.2*	*24*	*0.0005*	*5.5*	*9.4*
SIP Reduction						*-0.6*	*-0.3*
Total							*19.1*

[1] Not a limit, PTE based on AP-42, Table 1.4-1 (7/98) 280 lb NO_x/mmscf and 1000 Btu/scf.
[2] Not a limit, PTE based on AP-42, Table 1.4-2 (7/98) 0.6 lb SO_2/mmscf and 1000 Btu/scf.
[3] Not a limit, PTE based on AP-42, Table 1.1-3 (9/98) 8.8 lbNO_x/ton coal and 11,400 Btu/lb coal.

3.6 Minor Point Sources

The same base point source inventory that was used for the attainment SIP was utilized for projection to 2002, 2003, 2005, 2010, and 2015 with the exception of major point sources. Data for the minor point sources not included in the previous section (3.5) are included in Appendix F.

3.7 Residential Wood Burning Emission Estimates

Denver metropolitan area wood burning devices and habits were surveyed in 1991 by R. Bruce Hutton, Ph.D and Steven W. Hartley, Ph.D. This survey is the basis for the residential wood burning emission inventories developed for the Denver PM_{10} attainment/maintenance demonstration as well as all other wood burning emission estimates subsequent to 1991. The following calculation of residential wood burning PM_{10}, nitrogen oxide and sulfur dioxide emissions for 2015 result directly from the Hutton survey as it was applied to the 1995 inventories developed for the Denver element of the Colorado PM_{10} State Implementation submission in 1995.

3.7.1 Household population and distribution in 2015

The total households for 2015 were derived from the DRCOG 2001-2006 TIP Conformity demographic data estimates. The households estimate for the 13 regions in the PM_{10} dispersion modeling domain are as follows:

Region	Households
	159,397.00
	179,540.30
	70,309.20
	58,251.90
	20,312.70
	21,487.00
	45,052.00
	63,046.20
	149,639.20
0	182,269.20
1	25,213.20
2	46,709.20
3	10,525.10
otal	1,031,752.20

3.7.2 2015 Woodburning Stove Device Population

variables:

CI91 = Colorado Phase I stove population in 1991
CII91 = Colorado Phase II stove population in 1991
conv15 = conventional stove population in 2015
CI15 = Colorado Phase I stove population
CII15 = Colorado Phase II stove population
CIII15 = Colorado Phase III stove population

/* calculate the conventional stove population in 2015

/*	80% of the new CIII wood burning devices replace conventional wood burning stoves
/*	CI and CII pops remain static w/no new devices sold
/*	CIII pop increases 1300/year plus the 4% of new houses (.8*.05)
/*		that add a CIII device to population

CA conv15 = conv91 - (2015 - 1991) * 1300 * stv-var * .8
CA ci15 = ci91
CA cii15 = cii91
CA ciii15 = ciii91 + (2015 - 1991) * 1300 * stv-var + (hh15 - hh92) * .8 * .05

3.7.3 Calculate the wood burning stove emission rates per household

Assumptions:

/***	STV-USE applied to conventional stoves since older stoves tend not to be use
/***	as regularly as new technology/more recently purchased stoves
/***
/***	the 'STV-WOOD' variable (.93) is the number of 'stoves' that are
/***	wood burning as opposed to gas burning... applied to ALL stoves
/***	(see 12/16/92 memo in 1989/1995 PM_{10} SIP WB inventory file
/***

3.7.4 Calculate the emission rates / household for conv15

CA CONV15-PM10 = (CONV15 * STV-USE * STV-CORDS * STV-WOOD * 1100. * 14.9) / HH15
CA CONV15-NOX = (CONV15 * STV-USE * STV-CORDS * STV-WOOD * 1100. * 1.4) / HH15
CA CONV15-SOX = (CONV15 * STV-USE * STV-CORDS * STV-WOOD * 1100. * .2) / HH15

3.7.5 Calculate the new technology emission rates / household

Assumptions:

/***	All new technology/more recently purchased stoves are assumed to
/***	be used regularly; consequently the 'STV-USE' variable is not
/***	applied to these stoves....
/***

3.7.6 Calculate the emission rates / household for CI15

CA CI15-PM10 = (CI15 * STV-CORDS * STV-WOOD * 1100. * 12.0) / HH15
CA CI15-NOX = (CI15 * STV-CORDS * STV-WOOD * 1100. * 1.2) / HH15
CA CI15-SOX = (CI15 * STV-CORDS * STV-WOOD * 1100. * .2) / HH15

3.7.7 Calculate the emission rates / household for CII15

CA CII15-PM10 = (CII15 * STV-CORDS * STV-WOOD * 1100. * 8.2) / HH15
CA CII15-NOX = (CII15 * STV-CORDS * STV-WOOD * 1100. * 1.8) / HH15
CA CII15-SOX = (CII15 * STV-CORDS * STV-WOOD * 1100. * .2) / HH15

3.7.8 Calculate the emission rates / household for CIII15

CA CIII15-PM10 = (CIII15 * STV-CORDS * STV-WOOD * 1100. * 5.7) / HH15
CA CIII15-NOX = (CIII15 * STV-CORDS * STV-WOOD * 1100. * 2.9) / HH15
CA CIII15-SOX = (CIII15 * STV-CORDS * STV-WOOD * 1100. * .2) / HH15

3.7.9 Calculate the conventional fireplace (FP15) devices

Assumptions:
Number of 2015 fireplaces is the remaining .29 of FP95 (1995 fireplaces) that is not converted to gas or Phase III devices (.29 =.94^20; where 20 = number of years between 1995 and 2015 and .94 is the factor that the population is reduced each year)

ca fp15 = fp95 * .29

3.7.10 Calculate the emission rates / household for FP15

CA FP15-PM10 = (FP15 * FP-USE * FP-CORDS * 10.8 * 1100.) / HH15
CA FP15-SOX = (FP15 * FP-USE * FP-CORDS * .2 * 1100.) / HH15
CA FP15-NOX = (FP15 * FP-USE * FP-CORDS * .9 * 1100.) / HH15

3.7.11 Devices Summary

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL DEVICES
1	13,376.45	1,360.79	329.81	659.62	6,065.12	21,791.79
2	7,279.38	716.007	341.893	683.785	4,844.33	13,865.40
3	4,252.75	469.367	151.679	303.357	2,278.90	7,456.05
4	4,620.31	243.465	0	0	1,705.31	6,569.09
5	198.003	134.014	0	0	751.117	1,083.13
6	659.838	0	53.788	107.577	244.81	1,066.01
7	1,292.16	757.403	0	0	2,668.20	4,717.76
8	2,752.41	1,416.74	281.316	562.632	4,283.92	9,297.02
9	8,148.82	2,809.21	680.86	1,361.72	9,817.38	22,817.99
10	5,945.68	1,792.29	0	0	8,526.42	16,264.39
11	1,040.14	300.675	43.557	87.113	1,343.35	2,814.83
12	3,581.95	928.775	0	0	3,346.82	7,857.55
13	412.153	256.193	21.597	43.195	866.713	1,599.85
	==========	==========	==========	==========	==========	==========
	53,560.04	11,184.93	1,904.50	3,809.00	46,742.40	117200.9

3.7.12 Emissions Estimate Summaries

PM_{10} Emissions Estimate (uncontrolled tons/household-season)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	56.148	1.886	1.116	1.525	9.746	70.421
2	52.963	7.858	5.455	7.455	36.711	110.44
3	23.337	3.105	1.078	1.473	7.69	36.682
4	21.612	1.44	0	0	3.858	26.91
5	2.09	2.333	0	0	5.002	9.424
6	2.643	0	0.858	1.173	1.855	6.529
7	5.754	1.527	0	0	5.145	12.426
8	13.91	10.765	2.57	3.512	18.586	49.343
9	34.955	38.327	10.687	14.606	73.198	171.773
10	49.003	34.104	0	0	82.754	165.861
11	7.925	2.907	0.394	0.539	5.776	17.541
12	21.75	29.853	0	0	41.152	92.755
13	3.681	3.075	0.38	0.519	7.237	14.892
	=========	=========	=========	=========	=========	=========
	295.77	137.18	22.537	30.8	298.712	784.999

NOX Emissions Estimate (uncontrolled tons/household-season)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	4.679	0.177	0.112	0.335	4.958	10.261
2	4.414	0.738	0.545	1.636	18.677	26.011
3	1.945	0.292	0.108	0.323	3.913	6.58
4	1.801	0.135	0	0	1.963	3.899
5	0.174	0.219	0	0	2.545	2.938
6	0.22	0	0.086	0.257	0.944	1.507
7	0.479	0.143	0	0	2.618	3.241
8	1.159	1.012	0.257	0.771	9.456	12.655
9	2.913	3.601	1.069	3.206	37.241	48.03
10	4.084	3.204	0	0	42.103	49.391
11	0.66	0.273	0.039	0.118	2.939	4.03
12	1.812	2.805	0	0	20.937	25.555
13	0.307	0.289	0.038	0.114	3.682	4.429
	=========	=========	=========	=========	=========	=========
	24.648	12.889	2.254	6.761	151.976	198.528

SO2 Emissions Estimate (uncontrolled tons/household-season)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	1.04	0.025	0.019	0.037	0.342	1.463
2	0.981	0.105	0.091	0.182	1.288	2.647
3	0.432	0.042	0.018	0.036	0.27	0.798
4	0.4	0.019	0	0	0.135	0.555
5	0.039	0.031	0	0	0.175	0.246
6	0.049	0	0.014	0.029	0.065	0.157
7	0.107	0.02	0	0	0.181	0.308
8	0.258	0.145	0.043	0.086	0.652	1.183
9	0.647	0.514	0.178	0.356	2.568	4.264
10	0.907	0.458	0	0	2.904	4.269
11	0.147	0.039	0.007	0.013	0.203	0.408
12	0.403	0.401	0	0	1.444	2.247
13	0.068	0.041	0.006	0.013	0.254	0.382
	==========	==========	==========	==========	==========	==========
	5.477	1.841	0.376	0.751	10.481	18.927

PM_{10} Emissions Estimate (controlled(*) tons/household-season)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	22.459	0.943	0.558	0.762	9.746	34.469
2	21.185	3.929	2.727	3.727	36.711	68.279
3	9.335	1.553	0.539	0.736	7.69	19.852
4	8.645	0.72	0	0	3.858	13.223
5	0.836	1.166	0	0	5.002	7.004
6	1.057	0	0.429	0.586	1.855	3.928
7	2.301	0.764	0	0	5.145	8.21
8	5.564	5.383	1.285	1.756	18.586	32.573
9	13.982	19.163	5.344	7.303	73.198	118.99
10	19.601	17.052	0	0	82.754	119.408
11	3.17	1.453	0.197	0.269	5.776	10.866
12	8.7	14.926	0	0	41.152	64.779
13	1.472	1.538	0.19	0.259	7.237	10.696
	==========	==========	==========	==========	==========	==========
	118.308	68.59	11.268	15.4	298.712	512.278

NOx Emissions Estimate (controlled(*) tons/household-season)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	1.872	0.089	0.056	0.167	4.958	7.142
2	1.765	0.369	0.273	0.818	18.677	21.903
3	0.778	0.146	0.054	0.162	3.913	5.052
4	0.72	0.068	0	0	1.963	2.751
5	0.07	0.11	0	0	2.545	2.724
6	0.088	0	0.043	0.129	0.944	1.204
7	0.192	0.072	0	0	2.618	2.881
8	0.464	0.506	0.128	0.385	9.456	10.939
9	1.165	1.801	0.534	1.603	37.241	42.344
10	1.633	1.602	0	0	42.103	45.339
11	0.264	0.137	0.02	0.059	2.939	3.418
12	0.725	1.402	0	0	20.937	23.065
13	0.123	0.144	0.019	0.057	3.682	4.025
	==========	==========	==========	==========	==========	==========
	9.859	6.445	1.127	3.381	151.976	172.787

SOX Emissions Estimate (controlled(*) tons/household-season)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	0.416	0.013	0.009	0.019	0.342	0.798
2	0.392	0.053	0.045	0.091	1.288	1.87
3	0.173	0.021	0.009	0.018	0.27	0.49
4	0.16	0.01	0	0	0.135	0.305
5	0.015	0.016	0	0	0.175	0.207
6	0.02	0	0.007	0.014	0.065	0.106
7	0.043	0.01	0	0	0.181	0.233
8	0.103	0.072	0.021	0.043	0.652	0.892
9	0.259	0.257	0.089	0.178	2.568	3.352
10	0.363	0.229	0	0	2.904	3.496
11	0.059	0.02	0.003	0.007	0.203	0.291
12	0.161	0.2	0	0	1.444	1.805
13	0.027	0.021	0.003	0.006	0.254	0.311
	==========	==========	==========	==========	==========	==========
	2.191	0.921	0.188	0.376	10.481	14.156

Controlled emissions assume the 60% of conventional fireplace wood burners comply with no-burn regulations. Likewise, 50% of conventional stove, phase I and II owners comply with no-burn regulations.

3.7.13 Conversion of wood burning 'season' estimates to 'seasonal' averages

The woodburning survey results in an estimate of the amount of wood burned over the period of one year. Residential wood combustion occurs primarily during the winter months of November through February. Residential wood combustion also occurs to a lesser degree in November and October as well as the spring months of March through May. It is assumed that a negligible amount occurs during June, July and August. The following methodology is used to convert the above tons per wood burning season to seasonal (i.e., winter, spring, summer and fall) inventories for utilization in the RAM dispersion modeling demonstration.

Step 1: Convert wood burning season emission inventories into an annual factor with the units in grams/second. For example:

PPM10(I,J)=VAR(1)/(24.*3600.*365.)

where: VAR(1) is the grams per wood burning season
PPM10(I,J)= gridded 'annual' rate in grams/second

Step 2: The following factors are applied to the annual rates to estimate winter, spring, summer, and fall wood burning emissions estimates.

Season	Scalar
Winter	2.16
Spring	1.21
Summer	0.00
Fall	1.57

Note that the four scalars do not add up to 4.0. This error was detected during the development of this TSD. The correct factor for the fall season is .63. Consequently the residential wood combustion emission inventory for the fall season is too high. This error does not impact dispersion modeling results since the days with the highest concentrations of modeled PM_{10} occur in the winter and spring. If the correction were made and the modeling re-run, the fall season days would fall lower in the ranking since the wood burning inventories would be reduced.

Step 3: Diurnal distribution factors are as follows:

Hour	Stoves	Fireplace	Hour	Stoves	Fireplace
0000-0100	.045	.000	1200-1300	.035	.035
0001-0200	.023	.000	1300-1400	.043	.042
0200-0300	.000	.000	1400-1500	.046	.050
0300-0400	.000	.000	1500-1600	.049	.050
0400-0500	.000	.000	1600-1700	.053	.050
0500-0600	.004	.005	1700-1800	.070	.075

Hour	Stoves	Fireplace	Hour	Stoves	Fireplace
0600-0700	.009	.010	1800-1900	.085	.098
0700-0800	.014	.015	1900-2000	.100	.120
0800-0900	.019	.020	2000-2100	.092	.144
0900-1000	.024	.020	2100-2200	.084	.109
1000-1100	.029	.020	2200-2300	.076	.072
1100-1200	.032	.030	2300-2400	.068	.036

3.7.14 Intermediate year wood burning estimates

3.7.14.1 2002 Wood burning Emission Estimates

The following calculations describe the 2002 woodburning estimates. The same methodology is used as described above for the 2015 emission estimates.

2002 Household totals:

Region	Households
1	134,694
2	133,025
3	60,732
4	47,842
5	12,933
6	18,861
7	36,188
8	61,122
9	129,508
10	133,665
11	17,410
12	40,865
13	9,318
Totals	836,161

Device and Emission Rate/household calculations:

ca fp = fp95 * .65 ; .65 = .94^7
CA FP-PM10 = (FP * FP-USE * FP-CORDS * 10.8 * 1100.) / HH02
CA FP-SOX = (FP * FP-USE * FP-CORDS * .2 * 1100.) / HH02
CA FP-NOX = (FP * FP-USE * FP-CORDS * .9 * 1100.) / HH02
CA conv = conv91 - (2002 - 1991) * 1300 * stv-var * .8
CA ci = ci91
CA cii = cii91
CA ciii = ciii91 + (2002 - 1991) * 1300 * stv-var + (hh02 - hh92) * .8 * .0
CA CONV-PM10 = (CONV * STV-USE * STV-CORDS * STV-WOOD * 1100. * 14.9) / HH02
CA CONV-NOX = (CONV * STV-USE * STV-CORDS * STV-WOOD * 1100. * 1.4) / HH02

CA CONV-SOX = (CONV * STV-USE * STV-CORDS * STV-WOOD * 1100. * .2) / HH02
CA CI-PM10 = (CI * STV-CORDS * STV-WOOD * 1100. * 12.0) / HH02
CA CI-NOX = (CI * STV-CORDS * STV-WOOD * 1100. * 1.2) / HH02
CA CI-SOX = (CI * STV-CORDS * STV-WOOD * 1100. * .2) / HH02
CA CII-PM10 = (CII * STV-CORDS * STV-WOOD * 1100. * 8.2) / HH02
CA CII-NOX = (CII * STV-CORDS * STV-WOOD * 1100. * 1.8) / HH02
CA CII-SOX = (CII * STV-CORDS * STV-WOOD * 1100. * .2) / HH02
CA CIII-PM10 = (CIII * STV-CORDS * STV-WOOD * 1100. * 5.7) / HH02
CA CIII-NOX = (CIII * STV-CORDS * STV-WOOD * 1100. * 2.9) / HH02
CA CIII-SOX = (CIII * STV-CORDS * STV-WOOD * 1100. * .2) / HH02

2002 Device Summary

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL DEVICES
1	29,982	3,006	330	660	3,021	36,998
2	16,316	1,581	342	684	1,902	20,825
3	9,532	1,037	152	303	1,187	12,210
4	10,356	538	0	0	921	11,815
5	444	296	0	0	253	993
6	1,479	0	54	108	140	1,780
7	2,896	1,673	0	0	1,169	5,738
8	6,169	3,129	281	563	2,066	12,209
9	18,265	6,205	681	1,362	4,768	31,280
10	13,327	3,959	0	0	3,874	21,159
11	2,331	664	44	87	577	3,703
12	8,029	2,051	0	0	1,710	11,790
13	924	566	22	43	431	1,986
	120,048	24,705	1,904	3,809	22,019	172,486

2002 PM_{10} (uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	125.85	4.166	1.116	1.525	4.854	137.511
2	118.71	17.356	5.455	7.455	14.413	163.387
3	52.306	6.859	1.078	1.473	4.004	65.719
4	48.441	3.18	0	0	2.084	53.705
5	4.684	5.152	0	0	1.688	11.524

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
6	5.925	0	0.858	1.173	1.059	9.015
7	12.896	3.373	0	0	2.255	18.524
8	31.177	23.778	2.57	3.512	8.965	70.002
9	78.348	84.654	10.687	14.606	35.547	223.842
10	109.834	75.327	0	0	37.601	222.763
11	17.763	6.42	0.394	0.539	2.481	27.597
12	48.749	65.938	0	0	21.023	135.709
13	8.251	6.793	0.38	0.519	3.601	19.544
	=========	=========	=========	=========	=========	=========
	662.934	302.997	22.537	30.8	139.574	1,158.84

NOX (uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	10.487	0.391	0.112	0.335	2.47	13.795
2	9.892	1.631	0.545	1.636	7.333	21.038
3	4.359	0.644	0.108	0.323	2.037	7.472
4	4.037	0.299	0	0	1.06	5.396
5	0.39	0.484	0	0	0.859	1.733
6	0.494	0	0.086	0.257	0.539	1.376
7	1.075	0.317	0	0	1.147	2.539
8	2.598	2.234	0.257	0.771	4.561	10.421
9	6.529	7.954	1.069	3.206	18.085	36.843
10	9.153	7.078	0	0	19.131	35.361
11	1.48	0.603	0.039	0.118	1.262	3.503
12	4.062	6.195	0	0	10.696	20.954
13	0.688	0.638	0.038	0.114	1.832	3.31
	=========	=========	=========	=========	=========	=========
	55.244	28.47	2.254	6.761	71.011	163.74

2002 SOX(uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	2.331	0.056	0.019	0.037	0.17	2.613
2	2.198	0.233	0.091	0.182	0.506	3.21
3	0.969	0.092	0.018	0.036	0.14	1.255
4	0.897	0.043	0	0	0.073	1.013
5	0.087	0.069	0	0	0.059	0.215
6	0.11	0	0.014	0.029	0.037	0.19
7	0.239	0.045	0	0	0.079	0.363
8	0.577	0.319	0.043	0.086	0.315	1.34
9	1.451	1.136	0.178	0.356	1.247	4.369
10	2.034	1.011	0	0	1.319	4.364
11	0.329	0.086	0.007	0.013	0.087	0.522
12	0.903	0.885	0	0	0.738	2.525
13	0.153	0.091	0.006	0.013	0.126	0.389
	=========	=========	=========	=========	=========	=========
	12.277	4.067	0.376	0.751	4.897	22.368

2002 PM_{10} (controlled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	50.34	2.083	0.558	0.762	4.854	58.598
2	47.484	8.678	2.727	3.727	14.413	77.029
3	20.923	3.429	0.539	0.736	4.004	29.631
4	19.376	1.59	0	0	2.084	23.05
5	1.874	2.576	0	0	1.688	6.138
6	2.37	0	0.429	0.586	1.059	4.445
7	5.158	1.686	0	0	2.255	9.1
8	12.471	11.889	1.285	1.756	8.965	36.366
9	31.339	42.327	5.344	7.303	35.547	121.86
10	43.934	37.664	0	0	37.601	119.199
11	7.105	3.21	0.197	0.269	2.481	13.263
12	19.5	32.969	0	0	21.023	73.491
13	3.3	3.396	0.19	0.259	3.601	10.747
	=========	=========	=========	=========	=========	=========
	265.174	151.498	11.268	15.4	139.574	582.915

2002 NOX (controlled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	4.195	0.196	0.056	0.167	2.47	7.084
2	3.957	0.815	0.273	0.818	7.333	13.196
3	1.744	0.322	0.054	0.162	2.037	4.319
4	1.615	0.149	0	0	1.06	2.824
5	0.156	0.242	0	0	0.859	1.257
6	0.197	0	0.043	0.129	0.539	0.908
7	0.43	0.158	0	0	1.147	1.735
8	1.039	1.117	0.128	0.385	4.561	7.231
9	2.612	3.977	0.534	1.603	18.085	26.811
10	3.661	3.539	0	0	19.131	26.331
11	0.592	0.302	0.02	0.059	1.262	2.235
12	1.625	3.098	0	0	10.696	15.419
13	0.275	0.319	0.019	0.057	1.832	2.502
	==========	==========	==========	==========	==========	==========
	22.098	14.235	1.127	3.381	71.011	111.851

2002 SOX (controlled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	0.932	0.028	0.009	0.019	0.17	1.158
2	0.879	0.116	0.045	0.091	0.506	1.638
3	0.387	0.046	0.009	0.018	0.14	0.601
4	0.359	0.021	0	0	0.073	0.453
5	0.035	0.035	0	0	0.059	0.128
6	0.044	0	0.007	0.014	0.037	0.103
7	0.096	0.023	0	0	0.079	0.197
8	0.231	0.16	0.021	0.043	0.315	0.769
9	0.58	0.568	0.089	0.178	1.247	2.663
10	0.814	0.506	0	0	1.319	2.638
11	0.132	0.043	0.003	0.007	0.087	0.272
12	0.361	0.443	0	0	0.738	1.541
13	0.061	0.046	0.003	0.006	0.126	0.243
	==========	==========	==========	==========	==========	==========
	4.911	2.034	0.188	0.376	4.897	12.405

3.7.14.2 2005 Wood burning Emission Inventory Calculations

The following calculations describe the 2005 woodburning estimates. The same methodology is used as described above for the 2015 emission estimates.

2005 Household totals:

Region	Households
1	141,320
2	145,004
3	64,441
4	49,947
5	14,871
6	19,372
7	38,219
8	61,551
9	135,361
10	148,297
11	19,782
12	43,174
13	9,798
Total	891,135

ca fp05 = fp95 * .54
CA FP05-PM10 = (FP05 * FP-USE * FP-CORDS * 10.8 * 1100.) / HH05
CA FP05-SOX = (FP05 * FP-USE * FP-CORDS * .2 * 1100.) / HH05
CA FP05-NOX = (FP05 * FP-USE * FP-CORDS * .9 * 1100.) / HH05
CA conv05 = conv91 - (2005 - 1991) * 1300 * stv-var * .8
CA ci05 = ci91
CA cii05 = cii91
CA ciii05 = ciii91 + (2005 - 1991) * 1300 * stv-var + (hh05 - hh92) * .8 *
CA CONV05-PM10 = (CONV05 * STV-USE * STV-CORDS * STV-WOOD * 1100. * 14.9) / H5
CA CONV05-NOX = (CONV05 * STV-USE * STV-CORDS * STV-WOOD * 1100. * 1.4) / HH05
CA CONV05-SOX = (CONV05 * STV-USE * STV-CORDS * STV-WOOD * 1100. * .2) / HH05
CA CI05-PM10 = (CI05 * STV-CORDS * STV-WOOD * 1100. * 12.0) / HH05
CA CI05-NOX = (CI05 * STV-CORDS * STV-WOOD * 1100. * 1.2) / HH05
CA CI05-SOX = (CI05 * STV-CORDS * STV-WOOD * 1100. * .2) / HH05
CA CII05-PM10 = (CII05 * STV-CORDS * STV-WOOD * 1100. * 8.2) / HH05
CA CII05-NOX = (CII05 * STV-CORDS * STV-WOOD * 1100. * 1.8) / HH05
CA CII05-SOX = (CII05 * STV-CORDS * STV-WOOD * 1100. * .2) / HH05
CA CIII05-PM10 = (CIII05 * STV-CORDS * STV-WOOD * 1100. * 5.7) / HH05

CA CIII05-NOX = (CIII05 * STV-CORDS * STV-WOOD * 1100. * 2.9) / HH05
CA CIII05-SOX = (CIII05 * STV-CORDS * STV-WOOD * 1100. * .2) / HH05

2005 Devices Summary

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL DEVICES
1	24,908	2,626	330	660	3,760	32,284
2	13,555	1,382	342	684	2,631	18,593
3	7,919	906	152	303	1,499	10,778
4	8,603	470	0	0	1,090	10,163
5	369	259	0	0	378	1,005
6	1,229	0	54	108	160	1,550
7	2,406	1,462	0	0	1,515	5,382
8	5,125	2,734	281	563	2,577	11,281
9	15,174	5,421	681	1,362	5,981	28,619
10	11,071	3,459	0	0	5,084	19,614
11	1,937	580	44	87	777	3,424
12	6,670	1,792	0	0	2,126	10,588
13	767	494	22	43	540	1,867
	=========	=========	=========	=========	=========	=========
	99,732	21,585	1,904	3,809	28,118	155,149

2005 PM_{10} (uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	0	3.64	1.116	1.525	6.043	12.323
2	0	15.164	5.455	7.455	19.936	48.009
3	0	5.992	1.078	1.473	5.057	13.6
4	0	2.779	0	0	2.466	5.245
5	0	4.502	0	0	2.515	7.017
6	0	0	0.858	1.173	1.214	3.245
7	0	2.947	0	0	2.92	5.867
8	0	20.775	2.57	3.512	11.183	38.039
9	0	73.963	10.687	14.606	44.596	143.852
10	0	65.814	0	0	49.347	115.162
11	0	5.609	0.394	0.539	3.34	9.882
12	0	57.61	0	0	26.14	83.751

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
13	0	5.935	0.38	0.519	4.508	11.341
	==========	==========	==========	==========	==========	==========
	0	264.731	22.537	30.8	179.264	497.333

2005 NOX Uncontrolled

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	8.713	0.342	0.112	0.335	3.074	12.575
2	8.218	1.425	0.545	1.636	10.143	21.968
3	3.621	0.563	0.108	0.323	2.573	7.188
4	3.354	0.261	0	0	1.255	4.87
5	0.324	0.423	0	0	1.28	2.027
6	0.41	0	0.086	0.257	0.618	1.371
7	0.893	0.277	0	0	1.486	2.656
8	2.158	1.952	0.257	0.771	5.689	10.828
9	5.424	6.95	1.069	3.206	22.689	39.338
10	7.604	6.184	0	0	25.107	38.894
11	1.23	0.527	0.039	0.118	1.699	3.614
12	3.375	5.413	0	0	13.299	22.087
13	0.571	0.558	0.038	0.114	2.293	3.574
	==========	==========	==========	==========	==========	==========
	45.895	24.874	2.254	6.761	91.205	170.989

2005 SOX Uncontrolled

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	1.936	0.049	0.019	0.037	0.212	2.253
2	1.826	0.204	0.091	0.182	0.699	3.002
3	0.805	0.08	0.018	0.036	0.177	1.116
4	0.745	0.037	0	0	0.087	0.869
5	0.072	0.06	0	0	0.088	0.221
6	0.091	0	0.014	0.029	0.043	0.177
7	0.198	0.04	0	0	0.102	0.34
8	0.48	0.279	0.043	0.086	0.392	1.279
9	1.205	0.993	0.178	0.356	1.565	4.297
10	1.69	0.883	0	0	1.731	4.305
11	0.273	0.075	0.007	0.013	0.117	0.485

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
12	0.75	0.773	0	0	0.917	2.44
13	0.127	0.08	0.006	0.013	0.158	0.384
	==========	==========	==========	==========	==========	==========
	10.199	3.553	0.376	0.751	6.29	21.169

2005 PM_{10} Controlled

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	41.821	1.82	0.558	0.762	6.043	51.004
2	39.448	7.582	2.727	3.727	19.936	73.42
3	17.382	2.996	0.539	0.736	5.057	26.71
4	16.097	1.389	0	0	2.466	19.953
5	1.557	2.251	0	0	2.515	6.322
6	1.969	0	0.429	0.586	1.214	4.198
7	4.285	1.474	0	0	2.92	8.679
8	10.36	10.388	1.285	1.756	11.183	34.971
9	26.036	36.982	5.344	7.303	44.596	120.26
10	36.499	32.907	0	0	49.347	118.753
11	5.903	2.805	0.197	0.269	3.34	12.514
12	16.2	28.805	0	0	26.14	71.145
13	2.742	2.967	0.19	0.259	4.508	10.666
	==========	==========	==========	==========	==========	==========
	220.298	132.366	11.268	15.4	179.264	558.597

2005 NOX Controlled

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	3.485	0.171	0.056	0.167	3.074	6.954
2	3.287	0.712	0.273	0.818	10.143	15.233
3	1.448	0.282	0.054	0.162	2.573	4.518
4	1.341	0.131	0	0	1.255	2.727
5	0.13	0.211	0	0	1.28	1.621
6	0.164	0	0.043	0.129	0.618	0.953
7	0.357	0.138	0	0	1.486	1.981
8	0.863	0.976	0.128	0.385	5.689	8.043
9	2.17	3.475	0.534	1.603	22.689	30.471
10	3.042	3.092	0	0	25.107	31.24

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
11	0.492	0.264	0.02	0.059	1.699	2.533
12	1.35	2.707	0	0	13.299	17.356
13	0.228	0.279	0.019	0.057	2.293	2.877
	==========	==========	==========	==========	==========	==========
	18.358	12.437	1.127	3.381	91.205	126.507

2005 SOX Controlled

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	0.774	0.024	0.009	0.019	0.212	1.039
2	0.731	0.102	0.045	0.091	0.699	1.668
3	0.322	0.04	0.009	0.018	0.177	0.566
4	0.298	0.019	0	0	0.087	0.403
5	0.029	0.03	0	0	0.088	0.147
6	0.036	0	0.007	0.014	0.043	0.101
7	0.079	0.02	0	0	0.102	0.202
8	0.192	0.139	0.021	0.043	0.392	0.788
9	0.482	0.496	0.089	0.178	1.565	2.81
10	0.676	0.442	0	0	1.731	2.849
11	0.109	0.038	0.003	0.007	0.117	0.274
12	0.3	0.387	0	0	0.917	1.604
13	0.051	0.04	0.003	0.006	0.158	0.258
Totals	4.08	1.777	0.188	0.376	6.29	12.71

3.7.14.3 2010 Wood burning Emission Inventory

The following calculations describe the 2010 woodburning estimates. The same methodology is used as described above for the 2010 emission estimates.

2010 Household totals:

Region	Households
1	149,820
2	160,393
3	69,208
4	52,653
5	17,361
6	20,028
7	40,829
8	62,102

Region	Households
9	142,885
10	167,105
11	22,831
12	46,141
13	10,416
Total:	961,771

ca fp = fp95 * .40 (.40 = .94^15, i.e., 15 years since 1995)
CA FP-PM10 = (FP * FP-USE * FP-CORDS * 10.8 * 1100.) / HH10
CA FP-SOX = (FP * FP-USE * FP-CORDS * .2 * 1100.) / HH10
CA FP-NOX = (FP * FP-USE * FP-CORDS * .9 * 1100.) / HH10
CA conv = conv91 - (2010 - 1991) * 1300 * stv-var * .8
CA ci = ci91
CA cii = cii91
CA ciii = ciii91 + (2010 - 1991) * 1300 * stv-var + (hh10 - hh92) * .8 * .0
CA CONV-PM10 = (CONV * STV-USE * STV-CORDS * STV-WOOD * 1100. * 14.9) / HH10
CA CONV-NOX = (CONV * STV-USE * STV-CORDS * STV-WOOD * 1100. * 1.4) / HH10
CA CONV-SOX = (CONV * STV-USE * STV-CORDS * STV-WOOD * 1100. * .2) / HH10
CA CI-PM10 = (CI * STV-CORDS * STV-WOOD * 1100. * 12.0) / HH10
CA CI-NOX = (CI * STV-CORDS * STV-WOOD * 1100. * 1.2) / HH10
CA CI-SOX = (CI * STV-CORDS * STV-WOOD * 1100. * .2) / HH10
CA CII-PM10 = (CII * STV-CORDS * STV-WOOD * 1100. * 8.2) / HH10
CA CII-NOX = (CII * STV-CORDS * STV-WOOD * 1100. * 1.8) / HH10
CA CII-SOX = (CII * STV-CORDS * STV-WOOD * 1100. * .2) / HH10
CA CIII-PM10 = (CIII * STV-CORDS * STV-WOOD * 1100. * 5.7) / HH10
CA CIII-NOX = (CIII * STV-CORDS * STV-WOOD * 1100. * 2.9) / HH10
CA CIII-SOX = (CIII * STV-CORDS * STV-WOOD * 1100. * .2) / HH10

2010 Device Summary

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL DEVICES
1	18,450	1,993	330	660	4,891	26,324
2	10,041	1,049	342	684	3,662	15,777
3	5,866	688	152	303	1,962	8,971
4	6,373	357	0	0	1,340	8,069
5	273	196	0	0	555	1,025
6	910	0	54	108	186	1,258
7	1,782	1,110	0	0	2,059	4,951
8	3,796	2,075	281	563	3,423	10,139
9	11,240	4,115	681	1,362	7,915	25,312
10	8,201	2,626	0	0	6,878	17,705
11	1,435	440	44	87	1,073	3,079

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL DEVICES
12	4,941	1,361	0	0	2,784	9,086
13	568	375	22	43	713	1,722
	==========	==========	==========	==========	==========	==========
	73,876	16,385	1,904	3,809	37,443	133,417

2010 PM_{10} (uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	77.446	2.763	1.116	1.525	7.86	90.709
2	73.052	11.511	5.455	7.455	27.753	125.225
3	32.189	4.549	1.078	1.473	6.621	45.909
4	29.81	2.109	0	0	3.032	34.951
5	2.883	3.417	0	0	3.697	9.997
6	3.646	0	0.858	1.173	1.413	7.09
7	7.936	2.237	0	0	3.971	14.144
8	19.186	15.77	2.57	3.512	14.85	55.888
9	48.214	56.145	10.687	14.606	59.012	188.664
10	67.59	49.959	0	0	66.758	184.307
11	10.931	4.258	0.394	0.539	4.615	20.738
12	29.999	43.732	0	0	34.236	107.967
13	5.078	4.505	0.38	0.519	5.957	16.438
	==========	==========	==========	==========	==========	==========
	407.959	200.955	22.537	30.8	239.775	902.027

2010 NOX (uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	6.454	0.26	0.112	0.335	3.999	11.159
2	6.088	1.082	0.545	1.636	14.12	23.471
3	2.682	0.427	0.108	0.323	3.369	6.909
4	2.484	0.198	0	0	1.542	4.225
5	0.24	0.321	0	0	1.881	2.442
6	0.304	0	0.086	0.257	0.719	1.366
7	0.661	0.21	0	0	2.02	2.892
8	1.599	1.482	0.257	0.771	7.555	11.664
9	4.018	5.275	1.069	3.206	30.024	43.592
10	5.633	4.694	0	0	33.965	44.291
11	0.911	0.4	0.039	0.118	2.348	3.817
12	2.5	4.109	0	0	17.418	24.027
13	0.423	0.423	0.038	0.114	3.031	4.029
	=========	=========	=========	=========	=========	=========
	33.997	18.882	2.254	6.761	121.991	183.884

2010 SOX (uncontrolled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	1.434	0.037	0.019	0.037	0.276	1.803
2	1.353	0.155	0.091	0.182	0.974	2.754
3	0.596	0.061	0.018	0.036	0.232	0.943
4	0.552	0.028	0	0	0.106	0.687
5	0.053	0.046	0	0	0.13	0.229
6	0.068	0	0.014	0.029	0.05	0.16
7	0.147	0.03	0	0	0.139	0.316
8	0.355	0.212	0.043	0.086	0.521	1.217
9	0.893	0.754	0.178	0.356	2.071	4.251
10	1.252	0.671	0	0	2.342	4.265
11	0.202	0.057	0.007	0.013	0.162	0.441
12	0.556	0.587	0	0	1.201	2.344
13	0.094	0.06	0.006	0.013	0.209	0.383
	=========	=========	=========	=========	=========	=========

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
	7.555	2.697	0.376	0.751	8.413	19.792

2010 PM_{10} (controlled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL PM10
1	30.978	1.382	0.558	0.762	7.86	41.54
2	29.221	5.755	2.727	3.727	27.753	69.184
3	12.875	2.274	0.539	0.736	6.621	23.046
4	11.924	1.055	0	0	3.032	16.01
5	1.153	1.709	0	0	3.697	6.559
6	1.458	0	0.429	0.586	1.413	3.887
7	3.174	1.119	0	0	3.971	8.264
8	7.674	7.885	1.285	1.756	14.85	33.45
9	19.286	28.072	5.344	7.303	59.012	119.016
10	27.036	24.98	0	0	66.758	118.774
11	4.372	2.129	0.197	0.269	4.615	11.583
12	12	21.866	0	0	34.236	68.102
13	2.031	2.253	0.19	0.259	5.957	10.69
	==========	==========	==========	==========	==========	==========
	163.184	100.478	11.268	15.4	239.775	530.105

2010 NOX (controlled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
1	2.582	0.13	0.056	0.167	3.999	6.933
2	2.435	0.541	0.273	0.818	14.12	18.187
3	1.073	0.214	0.054	0.162	3.369	4.871
4	0.994	0.099	0	0	1.542	2.635
5	0.096	0.161	0	0	1.881	2.138
6	0.122	0	0.043	0.129	0.719	1.012
7	0.265	0.105	0	0	2.02	2.39
8	0.64	0.741	0.128	0.385	7.555	9.45
9	1.607	2.638	0.534	1.603	30.024	36.406
10	2.253	2.347	0	0	33.965	38.565
11	0.364	0.2	0.02	0.059	2.348	2.991
12	1	2.055	0	0	17.418	20.473

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL NOX
13	0.169	0.212	0.019	0.057	3.031	3.488
	==========	==========	==========	==========	==========	==========
	13.599	9.441	1.127	3.381	121.991	149.538

2010 SOX (controlled)

REGION	FIRE PLACES	CONV STOVE	CI STOVE	CII STOVE	CIII STOVE	TOTAL SOX
1	0.574	0.019	0.009	0.019	0.276	0.896
2	0.541	0.077	0.045	0.091	0.974	1.729
3	0.238	0.031	0.009	0.018	0.232	0.528
4	0.221	0.014	0	0	0.106	0.341
5	0.021	0.023	0	0	0.13	0.174
6	0.027	0	0.007	0.014	0.05	0.098
7	0.059	0.015	0	0	0.139	0.213
8	0.142	0.106	0.021	0.043	0.521	0.833
9	0.357	0.377	0.089	0.178	2.071	3.072
10	0.501	0.335	0	0	2.342	3.178
11	0.081	0.029	0.003	0.007	0.162	0.281
12	0.222	0.294	0	0	1.201	1.717
13	0.038	0.03	0.003	0.006	0.209	0.286
	==========	==========	==========	==========	==========	==========
	3.022	1.349	0.188	0.376	8.413	13.347

3.8 Airports

Emissions from aircraft were projected to the maintenance years using population growth as the surrogate and 1995 attainment year estimates. DIA has provided estimates from their airport operations, which are provided in the next section.

3.8.1 Revised Emissions Estimates for Denver International Airport

Denver International Airport provided primary PM_{10}, NOx and SO_2 emission estimates in their report entitled, “Summary of 2001 Construction Emissions and Emission Forecasts at Denver International Airport” on November 27, 2001. This document is presented in Appendix M.

A summary of all DIA PM_{10}, NOx and SO_2 emissions are presented in Table 3.8-1. DIA Primary PM_{10} Emission InventoryTable 5. These emissions include aircraft emissions, ground support equipment (GSE), and general construction. The emissions calculated in this maintenance SIP and analysis exceed what DIA has projected, therefore, the emissions from DIA have been conservatively accounted for in the technical analysis and modeling.

Table 3.8-1. DIA Primary PM_{10} Emission Inventory

Inventory Sub-Category	*2002 PM10 (tpy)*	*2005 PM10 (tpy)*	*2010 PM10 (tpy)*	*2015 PM10 (tpy)*	*2002 PM10 (tpd)*	*2005 PM10 (tpd)*	*2010 PM10 (tpd)*	*2015 PM10 (tpd)*
Aircraft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard GSE	20.17	23.69	26.33	28.96	0.06	0.06	0.07	0.08
United Expansion GSE	0.28	1.12	1.40	1.40	0.00	0.00	0.00	0.00
Rental Car Shuttles	2.13	2.45	2.95	3.45	0.01	0.01	0.01	0.01
Employee/Public Shuttles	3.22	3.70	4.47	5.23	0.01	0.01	0.01	0.01
City Fleet and Plows	3.20	3.59	4.12	4.60	0.01	0.01	0.01	0.01
Central Plant Engines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Plant Boilers	1.71	1.71	1.71	1.71	0.00	0.00	0.00	0.00
Misc. Denver Source	0.82	0.82	0.82	0.82	0.00	0.00	0.00	0.00
Misc Nat. Gas Sources	4.80	5.51	6.66	7.78	0.01	0.02	0.02	0.02
Diesel-fueled sources	0.87	0.99	1.20	1.40	0.00	0.00	0.00	0.00
Rental Car Refueling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. (Paint booths, fuel tank farm)	2.12	2.38	2.73	3.05	0.01	0.01	0.01	0.01
Fire Fighter Training	5.70	5.70	5.70	5.70	0.02	0.02	0.02	0.02
Worldport	0.14	0.14	0.14	0.14	0.00	0.00	0.00	0.00
On-Airport Hotel	0.07	0.07	0.07	0.07	0.00	0.00	0.00	0.00
Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil and Gas Well Construction	0.90	0.90	0.90	0.90	0.00	0.00	0.00	0.00
Agricultural Activities	47.51	47.51	47.51	47.51	0.13	0.13	0.13	0.13
Construction Activities.	271.98	271.98	271.98	271.98	0.75	0.75	0.75	0.75
Totals	365.62	372.26	378.69	384.70	1.00	1.02	1.04	1.05

Table 3.8-2. DIA NOx Emission Inventory

Inventory Sub-Category	2002 NOx	2005 NOx	2010 NOx	2015 NOx	2002 NOx	2005 NOx	2010 NOx	2015 NOx
	(tpy)	(tpy)	(tpy)	(tpy)	(tpd)	(tpd)	(tpd)	(tpd)
Aircraft	3528.28	4155.64	5325.99	6496.33	9.67	11.39	14.59	17.80
United Expansion Aircraft	39.00	156.00	195.00	195.00	0.11	0.43	0.53	0.53
Standard GSE	530.20	629.68	709.52	789.35	1.45	1.73	1.94	2.16
United Expansion GSE	6.83	27.32	34.15	34.15	0.02	0.07	0.09	0.09
Rental Car Shuttles	90.99	104.61	126.32	147.68	0.25	0.29	0.35	0.40
Employee/Public Shuttles	65.42	75.22	90.83	106.19	0.18	0.21	0.25	0.29
City Fleet and Plows	183.54	206.24	236.57	264.08	0.50	0.57	0.65	0.72
Central Plant Engines	21.30	21.30	21.30	21.30	0.06	0.06	0.06	0.06
Central Plant Boilers	18.30	18.30	18.30	18.30	0.05	0.05	0.05	0.05
Misc. Denver Source	6.40	6.40	6.40	6.40	0.02	0.02	0.02	0.02
Misc Nat. Gas Sources	39.93	45.91	55.44	64.82	0.11	0.13	0.15	0.18
Diesel-fueled sources	27.93	32.11	38.77	45.33	0.08	0.09	0.11	0.12
Rental Car Refueling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. (Paint booths, fuel tank farm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fire Fighter Training	0.16	0.16	0.16	0.16	0.00	0.00	0.00	0.00
Worldport	4.52	4.52	4.52	4.52	0.01	0.01	0.01	0.01
On-Airport Hotel	2.26	2.26	2.26	2.26	0.01	0.01	0.01	0.01
Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil and Gas Well Construction	6.85	6.85	6.85	6.85	0.02	0.02	0.02	0.02
Agricultural Activities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction Activities.	638.08	638.08	638.08	638.08	1.75	1.75	1.75	1.75
Totals	5209.99	6130.60	7510.46	8840.80	14.27	16.80	20.58	24.22

Table 3.8-3. DIA SO_2 Emission Inventory

Inventory Sub-Category	2002 SO2	2005 SO2	2010 SO2	2015 SO2	2002 SO2	2005 SO2	2010 SO2	2015 SO2
	(tpy)	(tpy)	(tpy)	(tpy)	(tpd)	(tpd)	(tpd)	(tpd)
Aircraft	142.53	165.21	200.39	235.57	0.39	0.45	0.55	0.65
United Expansion	1.46	5.84	7.30	7.30	0.00	0.02	0.02	0.02
Standard GSE	12.68	15.00	16.96	18.92	0.03	0.04	0.05	0.05
United Expansion GSE	0.17	0.68	0.85	0.85	0.00	0.00	0.00	0.00
Rental Car Shuttles	0.23	0.26	0.32	0.37	0.00	0.00	0.00	0.00
Employee/Public Shuttles	0.46	0.53	0.63	0.74	0.00	0.00	0.00	0.00
City Fleet and Plows	2.93	3.29	3.77	4.21	0.01	0.01	0.01	0.01
Central Plant Engines	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00
Central Plant Boilers	2.69	2.69	2.69	2.69	0.01	0.01	0.01	0.01
Misc. Denver Source	0.08	0.08	0.08	0.08	0.00	0.00	0.00	0.00
Misc Nat. Gas Sources	0.24	0.28	0.33	0.39	0.00	0.00	0.00	0.00
Diesel-fueled sources	5.6	6.44	7.77	9.09	0.02	0.02	0.02	0.02
Rental Car Refueling	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. (Paint booths, fuel tank farm)	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fire Fighter Training	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worldport	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00
On-Airport Hotel	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00
Oil and Gas Production	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil and Gas Well Construction	0.58	0.58	0.58	0.58	0.00	0.00	0.00	0.00
Agricultural Activities	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction Activities.	67.46	67.46	67.46	67.46	0.18	0.18	0.18	0.18
Totals	237.19	268.42	309.21	348.33	0.65	0.74	0.85	0.95

The inventory prepared by DIA includes point source, on-road mobile, construction, and industrial equipment categories. Since the point sources are permitted by APCD, they are included in the point source totals presented in the point source emission inventories. The on-road mobile emission estimates account for vehicular travel on the airport property and is not included in the Denver Regional Council of Governments transportation modeling. Consequently, the DIA estimated on-road mobile source emission component is not included in the On-Road Mobile category. The construction and industrial equipment estimates are specific to DIA activities. However, since the construction and industrial emission categories were calculated on an area wide basis, it is assumed that the DIA estimates are a subtotal of the emissions presented in Table 3.1-1. PM_{10} estimates from construction activity are also estimated on an area wide basis for the total inventory

The RAM modeling results in this document are based on airport emissions shown in Table 3.1-1. Changes to the RAM model estimated concentrations at receptors around

DIA, and especially the sensitive receptors in the downtown area vary little with changes in primary PM_{10} emission estimates at DIA. DIA is 30 kilometers away from the downtown Denver. Consequently, a substantial increase in emissions at DIA would not threaten the PM_{10} standards in downtown Denver.

Based on the preceding analysis, the Division has specifically identified and accounted for DIA emissions in the maintenance plan. Therefore, for the purposes of a general conformity demonstration DIA should use the emissions inventory from Table 3.8-1, Table 3.8-2, and Table 3.8-3 for PM_{10}, NOx, and SO_2, respectively.

3.9 Non-Road Mobile Sources

Attainment year (1995) construction equipment, industrial equipment, and locomotive emission inventories for Denver were developed using methods described in the document, **Procedures for Emission Inventory Preparation** [(1)]. These same methodologies served as the basis for the maintenance year emission inventories. This "procedures" document did not contain methodologies for calculating other non-road equipment categories such as airport ground support equipment, commercial equipment, lawn and garden equipment, logging equipment, boats and recreational equipment that can be found in more current emission inventories. The detailed methodology for estimating construction equipment and industrial equipment emissions for the attainment year can be found in Volume II of the attainment SIP.

The nationwide National Engine and Vehicle Emissions Study (NEVES) emission inventory were principally developed for carbon monoxide and ozone nonattainment areas. Emissions from nonroad equipment in the NEVES inventory included emissions for summer-time NOx, summer-time-VOC and winter CO but did not directly include primary PM_{10}, SO_2 or wintertime NOx. Therefore, the NEVES inventory could not serve as the basis for the construction and industrial equipment inventories in this maintenance SIP. In addition, the use of the EPA NONROAD model (Draft updated to 6/8/00) is not recommended for use at this time for primary non-road emissions in SIPs.

However, for the interim year and maintenance year emission inventories, the EPA non-road model was used in this analysis to estimate the change in emissions for various industrial and construction equipment types. These changes were then applied to project the attainment year 1995 gridded industrial equipment non-road emissions to 2002, 2005, 2010, and 2015. The model was run for the attainment year, 1995, and the four maintenance years for the counties included in the inventory. A projection factor was calculated for construction equipment, industrial equipment, and locomotives by dividing the county level emissions in the future year by the emissions in the year 1995. The factor was the same for each county within each source category. The non-road projection factor for each source category was then used to multiply the emissions in each grid cell in the year 1995 inventory to obtain the future year emissions by grid cell. Table 3.9-1 presents those scalars that were used to project 1995 emissions. Table 3.9-2 the construction and industrial equipment emission inventory that are used in the attainment and maintenance plans.

The EPA Non-Road Model indicates that in 1995, industrial equipment and construction equipment emissions account for 78%, 83%, and 83% of the PM_{10}, NOx and SO_2 emissions from non-road equipment, respectively. In addition, primary PM_{10} emissions from construction equipment is double counted in the attainment SIP because the exhaust component was not subtracted out from the construction activity emissions. Given the relatively small contribution that non-road equipment have on the overall emissions inventory and lack of EPA procedure for estimating PM_{10} and winter NOx and SO_2 emissions from non-road equipment, it is felt that non-road emissions have been adequately accounted for. In addition, some of the non-road source categories such as recreational equipment, boats, lawn and garden equipment, and logging equipment are generally not found in the downtown Denver area where the maximum PM_{10} is modeled and monitored, therefore, their emissions will have little or no impact on the maximum concentrations.

Table 3.9-1. PM10 SIP Categories as Calculated from the EPA Non-Road Model

PM10 (tpwd)	1995	2002	2003	2005	2010	2015		Ratio 2002 / 1995	Ratio 2003/ 1995	Ratio 2005/ 1995	Ratio 2010/ 1995	Ratio 2015/ 1995
Construction Equipment	2.96	2.40	2.33	2.19	2.10	2.22		0.81	0.79	0.74	0.71	0.75
Industrial Equipment	0.68	0.73	0.74	0.75	0.79	0.85		1.07	1.09	1.10	1.16	1.25
Railroad Equipment	0.02	0.01	0.01	0.01	0.01	0.01		0.50	0.50	0.50	0.50	0.50
Totals	*3.66*	*3.14*	*3.08*	*2.95*	*2.90*	*3.08*						
NOx (tpwd)												
Construction Equipment	24.94	23.81	23.24	22.28	18.31	16.43		0.95	0.93	0.89	0.73	0.66
Industrial Equipment	8.41	9.05	9.06	9.06	8.83	9.04		1.08	1.08	1.08	1.05	1.07
Railroad Equipment	0.11	0.12	0.12	0.12	0.10	0.09		1.09	1.09	1.09	0.91	0.82
Totals	*33.46*	*32.98*	*32.42*	*31.46*	*27.24*	*25.56*						
SO2 (tpwd)												
Construction Equipment	5.53	6.85	7.04	7.43	8.40	9.37		1.24	1.27	1.34	1.52	1.69
Industrial Equipment	1.63	2.16	2.24	2.40	2.78	3.12		1.33	1.37	1.47	1.71	1.91
Railroad Equipment	0.03	0.04	0.05	0.05	0.06	0.07		1.33	1.67	1.67	2.00	2.33
Totals	*7.19*	*9.05*	*9.33*	*9.88*	*11.24*	*12.56*						

Table 3.9-2. Emissions Projected from 1995 SIP Levels to Future Years Based on Non-road Model

Non-Road Source Category	1995 SIP	2002 est.	2003 est.	2005 est	2010 est	2015 est
PM10 (tpwd)						
Construction Equipment	0.40	0.32	0.31	0.30	0.28	0.30
Industrial Equipment	0.10	0.11	0.11	0.11	0.12	0.13
Railroad Equipment	0.10	0.05	0.05	0.05	0.05	0.05
Totals	*0.60*	*0.48*	*0.47*	*0.46*	*0.45*	*0.48*
NOx (tpwd)						
Construction Equipment	4.60	4.39	4.29	4.11	3.38	3.03
Industrial Equipment	4.10	4.41	4.42	4.42	4.30	4.41
Railroad Equipment	2.20	2.40	2.40	2.40	2.00	1.80
Totals	*10.90*	*11.20*	*11.10*	*10.93*	*9.68*	*9.24*
SO2 (tpwd)						
Construction Equipment	0.50	0.62	0.64	0.67	0.76	0.85
Industrial Equipment	0.10	0.13	0.14	0.15	0.17	0.19
Railroad Equipment	0.30	0.40	0.50	0.50	0.60	0.70
Totals	*0.90*	*1.15*	*1.27*	*1.32*	*1.53*	*1.74*

3.10 Natural Gas

The same methodology and emission factors that were used for the attainment SIP are used for the maintenance demonstration. A more detailed explanation of the methodology and emission factors used for the attainment and maintenance SIPs can be found in Volume II of the 1995 attainment demonstration and Volume XIV. For the maintenance SIP years 2002, 2005, 2010, and 2015, the 1995 natural gas emissions were proportioned forward using DRCOG's household and employment projections. A summary of the 1995, 2002, 2005, 2010, and 2015 winter emissions for natural gas can be found in Table 3.1-1 and Table 3.1-2.

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

Natural gas use rates per household or per business are published as a statewide average, annually, by the Department of Energy. These use rates were confirmed from data received by the Public Service Company of Colorado for the Denver metro area. A use rate of 97,000 cubic feet per household per year and 630,000 cubic feet per business per year is used for household and commercial use rates, respectively.

DRCOG demographic data is used to determine the number of households over the modeling domain and within each gridded area. The DRCOG data also presents the number of employees over the domain. The number of businesses over the domain is determined by multiplying the number of employees by a ratio of employees per business. The number of employees per business was derived from Bureau of Census data. For 1986, the number of employees for Colorado is 1,201,195 and the number of establishments is 95,145. Dividing the number of employees per business, results in the ratio of 12.6 employees/business. The ratio of employees per business is not expected to change greatly from year to year.

Natural gas emission factors are from AP-42 (1985). Emission factors for natural gas fired residential and commercial boilers are used to characterize emissions from households and commercial businesses. Table 3.10-1 presents the natural gas emission factors used in estimating the emission rates for the modeling domain.

Table 3.10-1. Natural Gas Emission Factors (lbs/MCF)

Boiler Type	*PM_{10}*	*NO_X*	*SO_2*
Residential	*0.3*	*100*	*0.6*
Commercial	*0.3*	*100*	*0.6*

Gas usage varies greatly due to heating requirements in the colder months. Data used to factor seasonal values were derived from 1987 Public Service Data. Seasonal scalars are summarized in Table 3.10-2.

Diurnally, gas usage is fairly uniform during the day. A decrease of gas usage in the afternoon is realized due to warmer ambient afternoon temperatures. Table 3.10-3 presents diurnal distribution factors for natural gas.

Table 3.10-2. Seasonal Natural Gas Scaling Factors

Winter	***Spring***	***Summer***	***Autumn***
1.70	***1.14***	***0.49***	***0.66***

Table 3.10-3. Diurnal Distribution Factors for Natural Gas

HOUR	***1***	***2***	***3***	***4***	***5***	***6***
FACTOR	***1.008***	***1.008***	***1.008***	***1.032***	***1.032***	***1.080***
HOUR	***7***	***8***	***9***	***10***	***11***	***12***
FACTOR	***1.152***	***1.200***	***1.520***	***1.080***	***1.008***	***0.936***
HOUR	***13***	***14***	***15***	***16***	***17***	***18***
FACTOR	***0.864***	***0.864***	***0.840***	***0.864***	***0.936***	***0.984***
HOUR	***19***	***20***	***21***	***22***	***23***	***24***
FACTOR	***0.984***	***1.008***	***1.008***	***1.008***	***0.984***	***0.960***

Emission rates for the maintenance year inventory are computed exactly the same way the attainment year emissions were estimated. A sample calculation for a chosen grid space in presented in Volume XIV of the SIP. The difference between the attainment year emission inventories and the attainment year natural gas emission estimates are due to the changes in the number of households and employees between the two years. The attainment year estimate of households and employees are from DRCOG data. Gas usage data, emission factors, and temporal factors are assumed to remain the same between the base year and attainment year. Table 3.10-4 presents total PM_{10}, NO_x, and SO_2 emission rates from natural gas combustion for the attainment year.

Table 3.10-4. Natural Gas PM10, NOx, SO2 Emissions (tpd)

SEASON	1995 PM10	1995 NOX	1995 SO2
Winter	1.0	32.7	0.2
Spring	0.6	19.9	0.1
Summer	0.3	8.4	0.1
Autumn	0.3	10.6	0.1
Annual	0.6	17.9	0.1
	2002 PM10	2002 NOX	2002 SO2
Winter	1.2	38.9	0.2
Spring	0.7	23.7	0.1
Summer	0.3	10.0	0.1
Autumn	0.4	12.6	0.1
Annual	0.6	21.3	0.1
	2005 PM10	2005 NOX	2005 SO2
Winter	1.3	41.9	0.3
Spring	0.8	25.5	0.2
Summer	0.3	10.8	0.1
Autumn	0.4	13.6	0.1
Annual	0.7	22.9	0.1
	2010 PM10	2010 NOX	2010 SO2
Winter	1.4	45.8	0.3
Spring	0.8	27.9	0.2
Summer	0.4	11.8	0.1
Autumn	0.5	14.8	0.1
Annual	0.8	25.0	0.2
	2015 PM10	2015 NOX	2015SO2
Winter	1.5	48.8	0.3
Spring	0.9	29.7	0.2
Summer	0.4	12.5	0.1
Autumn	0.5	15.8	0.1
Annual	0.8	26.7	0.2

3.11 Wind Erosion and Tilling

Emissions from wind erosion and tilling were held constant from the attainment SIP. The methodology for estimating wind erosion and tilling emissions can be found in the attainment SIP documentation in Volume II. A summary of wind erosion and tilling emission used for the maintenance SIP can be found in Table 3.1-1 of this document. For winter, emissions from wind erosion and tilling were zero assuming the ground was either snow covered or frozen. This same assumption was made for the attainment demonstration.

3.12 Unpaved Roads

When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Vehicle traffic over unpaved road surfaces generates fugitive dust. In some areas, fugitive emissions from unpaved road surfaces may be substantial. As described in the following sections, factors that effect emissions from unpaved roads are, vehicle characteristics such as speeds, and road surface characteristics.

The method of determining unpaved road miles for the maintenance SIP has been changed to better determine the spatial variability in unpaved roads. In the attainment SIP, miles of unpaved roads were distributed using estimated densities for urban and non-urban areas.

For this maintenance SIP the miles of unpaved roads were determine from a DRCOG GIS coverage of unpaved roads. These unpaved road links were then apportioned to grid spaces based on their location. Figure 3 presents the spatial distribution of unpaved roads.

Although small in miles, a grid space by grid space inventory of alleys in Denver County was conducted as part of the attainment SIP. Location and miles of alleys were not changed from the attainment SIP.

Since 1989, the City and County of Denver has been improving dirt alleys that have been deeded to the city by homeowners. Recycled asphalt is placed on the dirt alleys to act as a sealant and prevent the alleys from becoming rutted in the Winter. During the Summer, high temperatures and light traffic can provide the same effect as paved roads There were 66.6 miles of unpaved alleys in the 1989 inventory, 9.9 miles of which were private alleys. It is assumed that the private alleys remained unpaved for the maintenance years and most of the public alleys have been either paved or improved with the application of recycled asphalt.

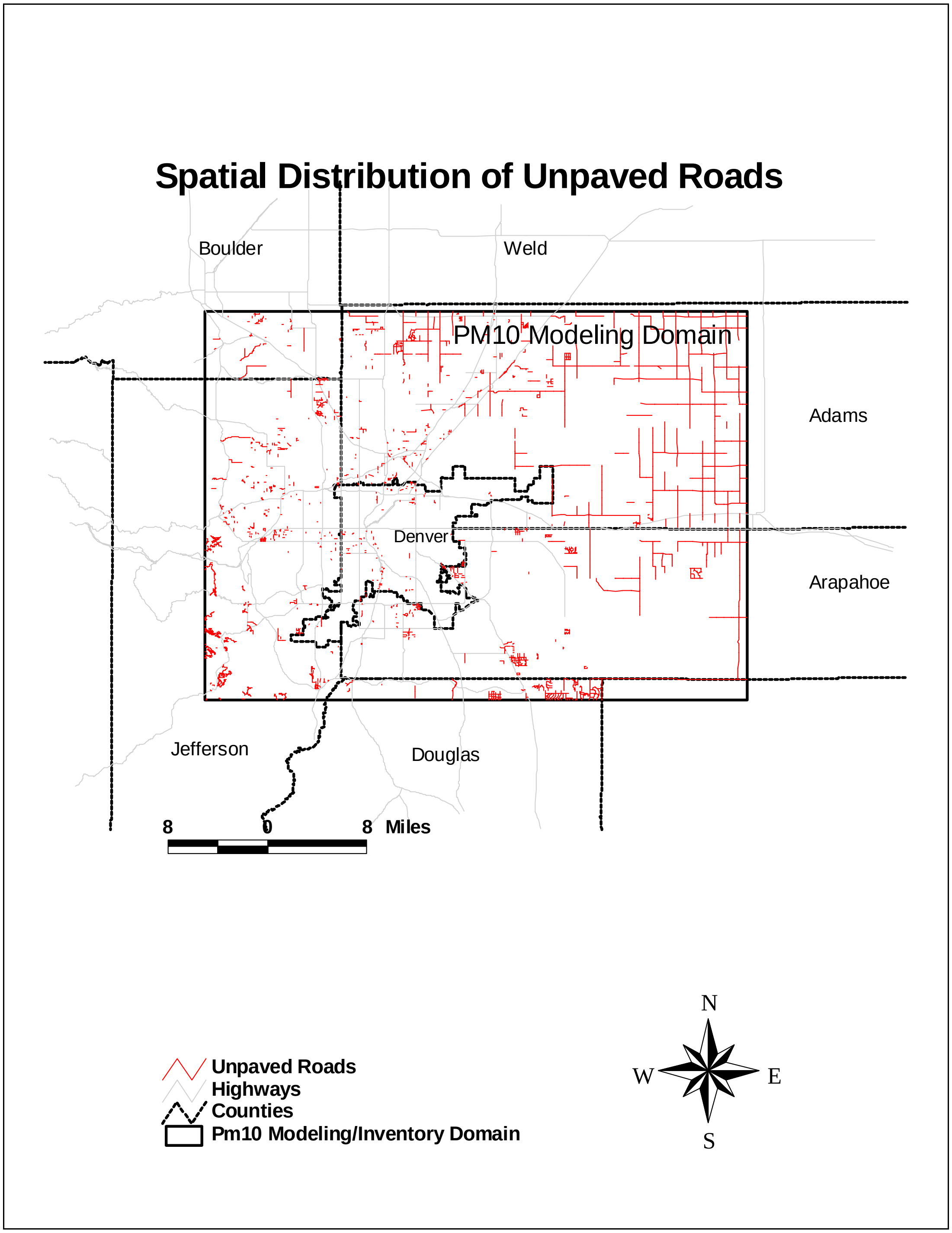

Figure 3: Spatial Distribution of Unpaved Roads in the Emission Inventory Domain

PM_{10} emission factors were derived for both unpaved roads and alleys. The equation to estimate dust emissions from unpaved roads was taken from Compilation of Air Pollutant Emission Factors, Section 11.2.1 (EPA, 1991). Equation 3.12-1 presents the equation used to estimate emissions form unpaved roads.

$$E = K(5.9)(s/12)(S/30)(W/4)^{0.7}(w/4)^{0.5}(365-p)/365 \quad \text{(Equation 3.12-1)}$$

where:
E = emission factor (pounds/vehicle-mile traveled [VMT])
K = aerodynamic particle size multiplier (K = 0.36 for PM_{10})
s = silt content (%)
S = mean vehicle speed (miles per hour [mph])
W = mean vehicle weight (tons)
w = mean number of wheels
p = number of days with >0.01 inch precipitation

Table 3.12-1 presents the values substituted into equation to estimate the emission factor for unpaved roads and alleys. These are the same values for the variables in the equation that were used for the attainment SIP except for, 'p', the number of days with > 0.01 inches of precipitation. A value for ‘p’ of 88.3 days was used for the attainment SIP, domain wide.

Table 3.12-1. Variables Used to Estimate Emissions from Unpaved Roads and Alleys

Variable	*k*	*s*	*S*	*w*	*W*	*p*	*ADT*
Roads	*0.36*	*5*	*25*	*4*	*1.5*	*variable*	*62*
Alleys	*0.36*	*5*	*10*	*4*	*1.5*	*variable*	*50*

Given the topography of the Denver area, precipitation varies greatly over the inventory domain. Precipitation is more abundant on the western and southern portions of the inventory domain due to orthographic lift. Precipitation is less in the northeastern portion of the grid on an annual basis.

As part of the analysis for the number of days with greater than 0.01 inches of precipitation, data from several rainfall reporting stations in and near the domain were used to create precipitation gradients. These gradients were created using seasonal amount from the monthly totals.

Figure 4 presents the location of the precipitation monitors around the inventory domain that were used as part of the analysis for determining the variable 'p'. The criteria for selecting the locations include; 1) must have at least a five year history of data collection, and, 2) must collect both snowfall and rainfall data. To derive the number of days with precipitation, both rainfall data > 0.01" and snow cover data >1" were used. A test was then performed to see if the number of days with snow cover was greater than the number of days with precipitation. If the numbers of days with snow cover >1" was more than the number of days with precipitation, then the number of days with snow cover was used for 'p'. Otherwise the number of days with >0.01" of precipitation was used. This test was performed on monthly basis for each reporting station. The monthly data was then combined into seasonal totals and then applied to each of the 1km grid spaces in the inventory domain.

The emission factor for unpaved or dirt alleys remain at 0.14 pound/adt, and the emission factor for improved alleys was 0.028. An 80 percent control efficiency was applied to the improved alleys emission factor[(1)]. These are the same emission factors and control efficiency assumption used in the attainment SIP for alleys.

In the attainment SIP, the ADT for dirt roads were arbitrarily selected to be around 75 vehicles per days based on state regulation. State Regulation 1.0, Section 2.a, states that roads with vehicle counts greater than 150 vehicles per day, averaged over three days, must be paved[(3)]. Assuming that an unpaved road may have between zero and 150 vehicles per day, this averages to be 75 vehicles per day. For alleys, a conservative estimate of 50 vehicles per day is used.

Since then U.S. Department of Transportation Data contained in the document, "Highway Statistics" for Colorado indicates that the statewide ADT for dirt roads are around 62 vehicles per day. Sixty-two vehicles per day for dirt roads were used for the maintenance SIP emission estimate. For alleys, the original estimate of 50 vehicles per day is still being used.

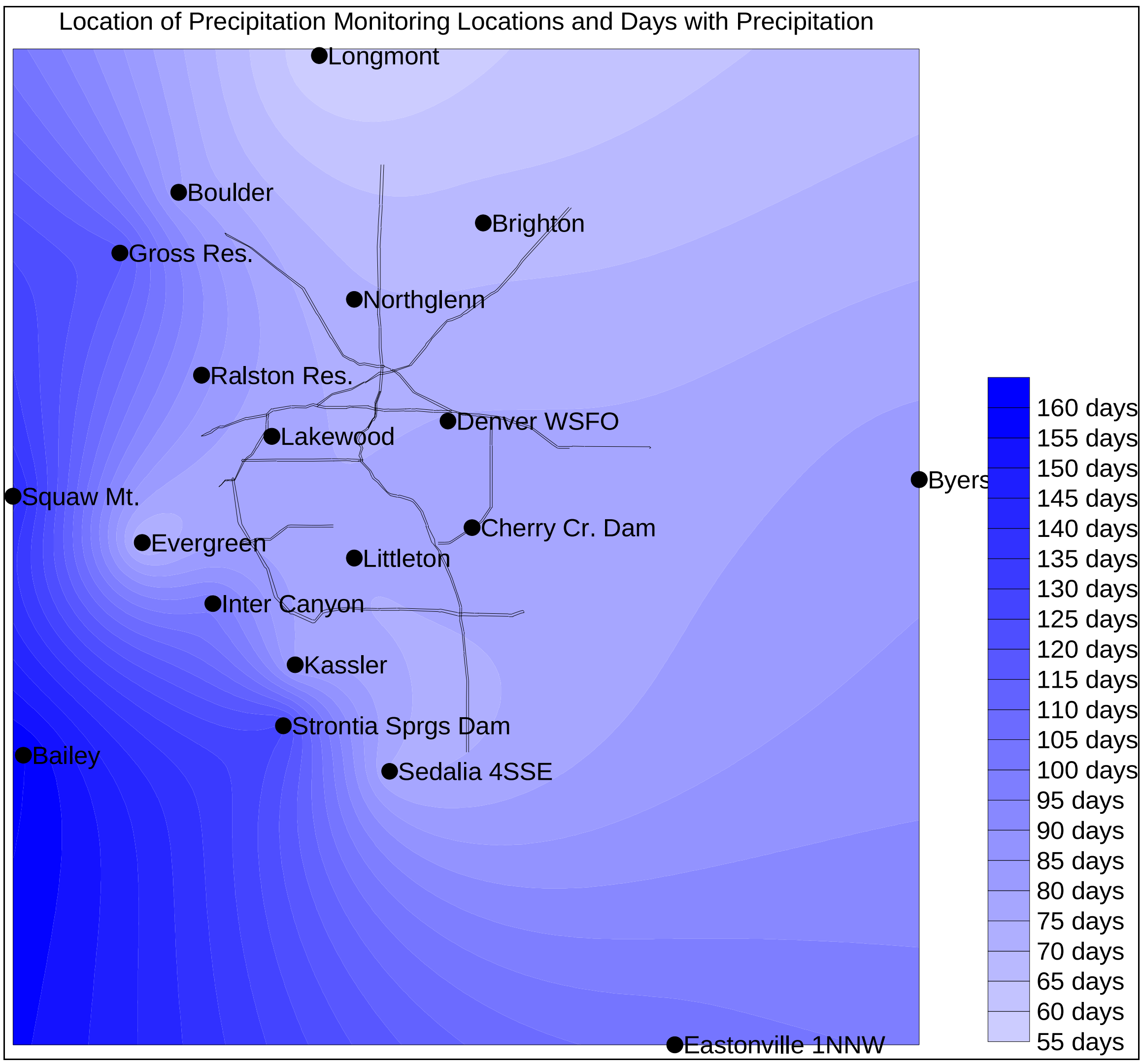

Figure 4. Location of Precipitation Monitoring Locations and Number of Days with Precipitation

Table 3.1-1 presents a summary of total emissions from unpaved roads and alleys used for all maintenance years in the SIP. These emission estimates are kept constant for all maintenance years. As seen in this table, there are no direct NO_x or SO_2 emissions estimated.

Table 3.12-2. Summary of Emissions from Unpaved Roads and Alleys (tpd)

Season	PM_{10}	NO_x	SO_2
Winter	***6.9***	***0.0***	***0.0***
Spring	***5.7***	***0.0***	***0.0***
Summer	***7.5***	***0.0***	***0.0***
Autumn	***7.9***	***0.0***	***0.0***

3.13 Charbroilers

The methodology and emission factors used to estimate emissions from charbroilers are the same as those used in the attainment SIP. Charbroiler emissions were projected to 2005, 2010, and 2020 using population growth as a surrogate. Documentation on how charbroiler emissions were calculated in the attainment SIP can be found in Volume II of the SIP. A summary of charbroiler emission for the maintenance SIP can be found in Table 3.1-1 and Table 3.1-2 of this document.

Emissions from restaurant grills include carbon dioxide, water vapor, organic vapors and particulate matter. The particulate matter consists mainly of grease, fats, and carbon. A distinction is made between restaurant grills which cover all types of restaurant grills and charbroilers. A charbroiler is a grill which grease is allowed to hit an open flame.

The number of grills are assumed to be the same as the number of eating places. The number of eating places correspond to the Standard Industrialized Code (SIC) 5812. Drinking places, SIC 5813, were not included in the inventory. The number of establishments on a county-wide basis by SIC is available in the Bureau of Census document, County Business Patterns. Population estimates by county for 1989 were obtained from the Colorado Division of Local Governments[(2)]. By dividing the county population by the number of eating places, the number of restaurant grills can be estimated on a per capita basis. Estimating the number of people per eating place provides a means to distribute the emissions, spatially. Population, the number of establishments by SIC 5812, and the ratio of population to eating establishments are presented in Table 3.13-1.

Table 3.13-1. *Whole County Estimates of Population and Eating Place (1989)*

County	*Population*	*Eating Places (SIC 5812)*	*People per Eating Place*
Adams	*270,282*	*325*	*831.6*
Arapahoe	*387,040*	*495*	*781.9*
Boulder	*216,597*	*359*	*603.3*
Denver	*511,848*	*850*	*602.2*
Douglas	*43,604*	*31*	*1,406.6*
Jefferson	*422,286*	*505*	*836.4*
totals	*1,851,757*	*2,565*	*721.9*

Because all eating establishments do not have charbroilers, an estimate of the percentage of charbroilers to the total number of eating establishment is made. Approximately 10-15% of the restaurants have charbroilers. For the purposes of inventory development, 10% is used.

The Denver PM_{10} study area has approximately 1,597,667 people. Using means for the Denver Six County area, the Denver PM_{10} study area would have an estimated number of 2,213 eating establishments. Assuming that 10% of the eating establishments have charbroilers, there are 221 charbroilers in the Six County area or 8,380 people per charbroiler.

An emission factor of 0.73 lbs particulate/hour was used for charbroilers. Charbroiler emissions are spatially distributed using gridded population estimates as a surrogate.

Not enough data could be collected to distribute grill emissions on a seasonal basis, although it is believed that there is a seasonal variation due to tourism and a diverse life-style. Diurnally, the assumption is made that the 0.73 lb/hr emission rate occurs at an equivalent rate for 12 hours/day or 8.76 lbs/day. Table 3.13-2TABLE 3.11-2 presents the diurnal scalars used for restaurant charbroilers.

Table 3.13-2. Diurnal Scalars for Charbroilers

Hour	***01***	***02***	***03***	***04***	***05***	***06***
Factor	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***
Hour	***07***	***08***	***09***	***10***	***11***	***12***
Factor	***0.000***	***0.000***	***0.000***	***0.000***	***1.000***	***1.000***
Hour	***13***	***14***	***15***	***16***	***17***	***18***
Factor	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***
Hour	***19***	***20***	***21***	***22***	***23***	***24***
Factor	***1.000***	***1.000***	***1.000***	***1.000***	***0.000***	***0.000***

The method for estimating the attainment year and maintenance year emissions are the same as the base year. The only exception is that population estimates for the maintenance years are used on a gridded basis. The emission factor, number of charbroiler per capita, and the temporal factors remained the same for the all of the inventory years. Table 3.13-3 presents the total PM_{10} emissions for the modeling domain from charbroilers.

Table 3.13-3. Summary of Charbroiler Emission Inventory (tons/day) for the Attainment Year

Season	1995 PM_{10}	2002 PM_{10}	2005 PM_{10}	2010 PM_{10}	2015 PM_{10}
Winter	1.0	1.2	1.3	1.4	1.5
Spring	1.0	1.2	1.3	1.4	1.5
Summer	1.0	1.2	1.3	1.4	1.5
Autumn	1.0	1.2	1.3	1.4	1.5
Annual	1.0	1.2	1.3	1.4	1.5

3.14 Construction

The methodology and emission factors used to estimate emissions from construction activity is the same as those used in the attainment SIP. Construction activity emissions were projected to 2002, 2005, 2010, and 2020 using population and employment on a per annual basis as a surrogate. Further documentation on how construction activity emissions were calculated in the attainment SIP can be found in Volume II of the SIP. A summary of winter emission for the maintenance SIP can be found in Table 3.1-1 and Table 3.1-2 of this document.

Construction emissions are based on the annual average growth rates in households and employment as projected by DRCOG, and on the existing level of development in each zone. A density factor describing the number of households/acre and employees/acre are derived from land use data. This density factor along with the projected growth in each grid space is used to calculate the total number of acres that will be used for the construction of new businesses and houses. For each acre that is used for construction, and estimated amount of PM_{10} emission are calculated for each grid space.

The number of acres required for new construction is based on the existing density of employees and households in each gridspace. In order to assure that not too much land is being allocated for construction, upper limits are placed on the amount of land that might be used for any one household or employee workspace.

Approximately 80% of the total land area is available for development in the Denver area. The other 20% of the land in fully developed areas becomes parks, public lands, roadways, is vacant or is unsuitable for construction. In addition, it is assumed that in developed areas, roughly 50% of the land is used for housing and 30% is used for commercial and industrial purposes.

To get a first cut at the household density, the number of households per grid space was divided by 50% of the land area to get the number of household per acre for a given area. Similarly, the number of employees per acre were calculated by taking the number of employees per gridspace and dividing by 20% of the land area.

However, in the less dense rural areas, the method for calculating household and employee density results in the number of households or employees per acre to be a very small density. This small density is not valid to estimate the acreage disturbed by construction of a house or business. Therefore, an "upper limit" is placed on the amount of land area disturbed by construction of households or businesses.

To calculate an upper limit, the 1989 demographic data set was used along with the area of each zone. For each zone, the number of households divided by 50% of the land area and the number of employees divided by 20% of the land area was once again computed. Then, each of the household/acre ratio and employee/acre ratios were added together for all demographic zones. The mean value of the households/acre and employees/acre was then computed resulting in 5.28 households/acre and 27 employees/acre. These ratios were then used as an "upper limit" of the number of acres used per employee or per household. Then, for each gridspace, the actual value of household/acre was compared against the "upper limit" value. If the actual density was greater than the "upper limit" value, then the actual density was used. Similarly, the employee density was also computed.

For the maintenance years 2002, 2005, 2010, and 2015, the increase/year in households and employees was determined by taking the difference between the 1989 and projected year DRCOG demographic data and dividing by the number of years between 1989 and the maintenance year.

Finally, the growth in households and employees per year was multiplied by the inverse of the household and employee density for each gridspace to get the number of acres disturbed by new construction.

From AP-42, an emission factor from construction activity is 1.2 tons TSP/Acre/Month[(4)]. The document, <u>GAP Filling PM_{10} Emission Factors for Selected Open Area Dust Sources</u>, presents PM_{10}/TSP ratios for topsoil removal, earthmoving and hauling[(5)]. If the PM_{10}/TSP ratios for these activities are averaged, then the PM_{10}/TSP ratio for construction activity becomes 0.24. Applying this ratio to 1.2 tons TSP/acre/month results in a PM_{10} emission factor of 0.288 tons/acre/month. This factor converts to the metric units of 0.0995 grams/acre/second.

Under Colorado Reg. 1, Section III.D.2.b - "Construction Activities", all sites larger than one acre should be controlled in a non-attainment area[(6)]. AP-42 gives a general dust control efficiency of up to 50% for watering[(4)]. For the purposes of inventory development, a control efficiency of 25% is used since not all construction areas are watered on a regularly schedule basis to receive 50% credit and some areas are smaller than one acre. Applying 25% credit for watering results in an emission factor of 0.0746 grams/acre/second.

Construction activity is expected to vary seasonally and diurnally. The largest amount of construction is expected to occur in the summer and fall, and most that activity is expected to occur during the day.

Seasonal factors are defined as the ratio of seasonal emission rates to the annual average. Table 3.14-1 presents an estimate of the seasonal distribution factors. The operating Engineers International Union indicates that the majority of shift occurs during the summer and fall with the largest amount of construction occurring during the fall.

Table 3.14-1. Construction Activity Seasonal Scalars

Winter	*Spring*	*Summer*	*Autumn*
0.40	*0.80*	*1.20*	*1.60*

Hourly diurnal distribution factors are evenly distributed throughout the daytime hours. If 100% of the construction is done between 0700 and 1700, then 10% of the construction is done per hour during the daytime. Table 3.14-2 gives the hourly diurnal distribution for construction.

Table 3.14-2. Diurnal Scalars for Construction Activity

HOUR	*01*	*02*	*03*	*04*	*05*	*06*
FACTOR	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
HOUR	*07*	*08*	*09*	*10*	*11*	*12*
FACTOR	*0.000*	*2.400*	*2.400*	*2.400*	*2.400*	*2.400*
HOUR	*13*	*14*	*15*	*16*	*17*	*18*
FACTOR	*2.400*	*2.400*	*2.400*	*2.400*	*2.400*	*0.000*
HOUR	*19*	*20*	*21*	*22*	*23*	*24*
FACTOR	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

Table 3.14-3 presents a summary of emissions from construction activity for the attainment year. The maintenance year emissions were estimated using the same methodology as the 1989 base year and 1995 in the attainment SIP, however, employment and household estimates for maintenance years were used. A sample calculation for a selected gridspace is presented in Volume XIV of the attainment SIP.

Table 3.14-3. Summary of Emissions from Construction Activity (tons/day) for the Attainment Year

Season	*1995 PM_{10}*	*2002 PM10*	*2005 PM10*	*2010 PM10*	*2015PM*

Season	*1995 PM_{10}*	*2002 PM10*	*2005 PM10*	*2010 PM10*	*2015PM*
Winter	*2.9*	*3.95*	*4.09*	*3.91*	*3.7*
Spring	*5.7*	*7.90*	*8.18*	*7.81*	*7.4*
Summer	*8.6*	*11.85*	*12.26*	*11.72*	*11.1*
Autumn	*11.5*	*15.8*	*16.35*	*15.62*	*14.8*
Annual	*7.2*	*9.88*	*10.22*	*9.76*	*9.25*

EPA's transportation conformity regulation 40 CFR 93.122(d) requires all PM_{10} nonattainment and maintenance areas to include highway and transit construction-related PM_{10} emissions in their regional conformity analysis if their PM_{10} SIP identifies construction as a contributor to the PM_{10} problem. The regulation does not require areas to specifically identify highway and transit project construction as a source of PM_{10} in the SIP.

This maintenance plan includes PM_{10} emission estimates for construction activities in general. All types of construction, including highway and transit construction, are assumed to be included in this analysis.

The construction emissions inventory in this maintenance plan was developed using the same economic activity factors that DRCOG used to develop its most recent 2020 Transportation Plan and 2001-2006 TIP, upon which this maintenance plan is also based. Therefore, the 2020 Transportation Plan and the current and subsequent TIPs are presumed to be consistent with this maintenance plan for purposes of considering PM_{10} construction-related emissions in future conformity determinations. Thus, the construction-related emissions from the 2020 Transportation Plan and current and subsequent TIPs are accounted for in the maintenance demonstration, as are any new or revised transportation plans or improvement programs with construction-related emissions equal to, or less than, the construction-related emissions from the 2020 Transportation Plan and 2001-2006 TIP.

DRCOG may presume that any future plan or program, or amendment to a plan or program, will have construction-related emissions less than, or equal to, the 2020 Transportation Plan and 2001-2006 TIP if the number of lane miles to be constructed, on an annualized basis, in such new or amended plan or program are less than or equal to the maximum number of lane-miles to be constructed, on an annualized basis, pursuant to the 2020 Transportation Plan and 2001-2006 TIP. For purposes of making this determination, the term "lane-miles" shall mean one mile of a transit line or one mile of a lane on a roadway on the regional plan. If the number of lane miles to be constructed in a new or amended plan or program exceed the number of lane miles to be constructed pursuant to the 2020 Transportation Plan and 2001-2006 TIP, the existing interagency consultation process will be used to determine how the additional construction-related emissions, if any, will be analyzed or mitigated for purposes of the regional emissions analysis.

3.15 Budget Related Emission Inventories for 2005, 2010, and 2013

As shown in Section 5.2 of this document the 2002, 2005, 2010 and 2015 regional emissions inventories for primary PM_{10} and PM_{10} precursors are below the level necessary to demonstrate continued maintenance of the PM_{10} standard (150 ug/m^3). As a result, EPA's conformity regulation (40 CFR 93.124) allows the implementation plan to quantify explicitly the amount by which motor vehicle emissions could be higher while still demonstrating compliance with the maintenance requirement. The implementation plan can then allocate some or all of this additional "safety margin" to the emissions budget(s) for conformity purposes. This maintenance plan allocates the available "safety margin" and establishes emission budgets in the maintenance year presented in Table 3.15-1. Table 3.15-2Table 4.5 below illustrates the allocation of the "safety margin" demonstrates continued maintenance of the standard.

Table 3.15-1. Motor Vehicle Emissions Budgets for PM_{10} and NOX

	PM_{10} (tpd)	*NO_X (tpd)*
2015 and beyond	*51*	*101*

Table 3.15-2. Demonstration of Maintenance with Motor Vehicle Emissions Budgets in 2015

Maximum Allowable Concentration	149.9 ug/m^3
Maintenance demonstration (Table 5.2-1)	148.8 ug/m^3
Available "safety margin" below standard	1.1 ug/m^3
Allowable secondary concentration	47.2 ug/m^3
Allowable NOx+SO2 Emissions**	505 tpd
2015 Allowable NOx+SO2 Emissions (Table 4.3-2)	492 tpd
Available "safety margin" for NO_X emissions	13 tpd
Motor vehicle NO_X emissions in 2015 (Table 4.3-2)	88 tpd
NO_X emissions budget	101 tpd

PM10 24-hour Standard = 150 ug/m^3

PM_{10} emissions kept constant. 10.7 tpd of NO_X equals 1 ug/m^3

4 Air Quality Modeling Methodology

Model application is consistent with Appendix W of 40 CFR Part 51 - Guideline on Air Quality Models (*EPA Guideline*) and with EPA Region 8 methods approved in the attainment SIP. As required by CAA Section 175(a), each request for redesignation shall be accompanied by a SIP revision which provides for maintenance for the NAAQS for at least 10 years after redesignation. EPA guidance and policy requires the same level of modeling for maintenance plans as that which was performed for the attainment demonstration (EPA, 1992). Maintenance of the standard is demonstrated through the use of dispersion models for primary PM_{10} and proportional modeling for secondary particulate concentrations. The maintenance demonstration are projected for years 2002, 2003, 2005, 2010, and 2015.

4.1 Overview of Modeling Process

The 1990 federal Clean Air Act Amendments (CAAA) requires a state implementation plan to demonstrate attainment of the PM_{10} National Ambient Air Quality Standards (NAAQS) using U. S. EPA approved air quality models. The modeling analysis includes both area-wide analysis and hot spot analyses. An area wide analysis is performed to determine regional PM_{10} concentrations. The EPA RAM model was used to estimate area wide concentrations. The Industrial Source Complex Model (ISC3) was used to estimate concentrations and hot spots from major point sources.

Secondary particulate concentrations are based on Chemical Mass Balance model results. These monitored secondary concentrations are then proportioned to future years by a total combined NOx and SO_2 emission inventory. These projected concentrations are then added onto the area wide (RAM model) and hot spot (ISC3) model results for each receptor and day of simulation.

A primary PM_{10} background concentration was also established as part of the base year for the attainment SIP. The methodology that was used to establish this background concentration is presented in Volume XIV of the attainment SIP. The total concentration at each receptor is then the sum of the area-wide analysis (RAM model), hot spot analysis (ISC3), secondary concentration, and the primary PM_{10} background concentration.

4.2 Model Selection

Volume VII and VIII of the attainment SIP contains the rationale for using the RAM and ISC models for the dispersion modeling analysis of primary PM_{10}. Since the attainment analysis for Denver, there have been some changes to both the RAM model and ISC model.

The RAM model is no longer a preferred model in Appendix W of 40 CFR Part 51 - Guideline on Air Quality Models. The State feels that RAM is still the most appropriate model to use for the maintenance analysis because of its historic use for both the attainment SIP and transportation conformity analysis. Also, EPA has not provided any other guidance or recommendation for modeling PM_{10} except in their guidance document, **PM_{10} SIP Development Guidelines** (June 1987).

For the attainment SIP hot spot analysis the ISCST model was used. Since then several changes have been made to the ISC model and the model has been completely rewritten. Some of the changes include an improved area source algorithm over that what was in ISCST, improved algorithms for buoyant sources, and, improved downwash algorithms. For the maintenance SIP major point sources have been modeled using the ISC3 model.

With the improved area source algorithm, it is possible to do an area wide analysis with ISC3 which would be comparable to using RAM. However, given the historic use of RAM for Denver a consistent model analysis between the attainment demonstration and several conformity analysis can be made. In addition, the ISC3 model may itself be replace by AERMOD as the preferred model for industrial complexes and AERMOD does not have the ability to model a large number of area sources efficiently.

4.3 Secondary Particulate Concentrations Estimates

The same secondary roll-forward methodology used for the attainment SIP was used for the maintenance SIP. Documentation of this approach is contained in the document, Calculation of Secondary PM_{10} concentration in the Denver PM_{10} SIP Attainment Demonstration, (EPA, April 1994), and, in Volume XIV, Appendix B (Revised 1994) in the attainment SIP Technical Support Document. Although there are some models like Models-3 and UAM-AERO that could be used to model primary and secondary particulate, these models are still fairly untested at the present time for Urban areas. Models-3 and UAM-AERO are also episodic models that cannot be fully run for a one or five year meteorological data sets because of computational limitations. Table 4.3-2 contains the analysis used to estimate winter-time secondary particulate concentrations for 2002, 2003, 2005, 2010, and 2015, respectively.

Table 4.3-1 presents a summary of major and minor point source emissions that were used in the secondary particulate concentrations estimates. Table 4.3-2 shows the calculations and resulting estimated secondary particulate concentration that was added onto the dispersion model estimates.

Table 4.3-1. Point Source Emissions and Contribution to Secondary Particulate Concentration

Source (tpy)	1995 NOx	1995 SO2	2002 NOx	2002 SO2	2003 NOx	2003 SO2	2005 NOx	2005 SO2	2010 NOx	2010 SO2	2015 NOx	2015 SO2
			(w/ Arap. 1 & 2)		(w/o Arap. 1 & 2)							
Cherokee (pte)	20525	30026	23577	34683	23577	34683	21382	34683	21382	34683	21382	34683
Arapahoe (pte)	10643	12912	14485	17498	8002	10226	8002	10226	8002	10226	8002	10226
Valmont (pte)	3548	8872	4705	8893	4705	8893	4705	8893	4705	8893	4705	8893
Zuni (actual*growth)	4026	4	306	0	311	0	324	0	347	0	372	0
Coors (reg, and pte)	5439	7337	3962	6959	3962	6959	3962	6959	3962	6959	3962	6959
Rocky Mt. Bottle (permitted)	609	362	424	369	424	369	424	369	424	369	424	369
Minor Point Sources (actual*growth)	6460	3906	7752	4687	7881	4765	8204	4961	8786	5312	9414	5692
Total	51250	63419	55210	73089	48862	65895	47003	66091	47607	66442	48261	66822
Source (tpd)	1995 NOx	1995 SO2	2002 NOx	2002 SO2	2003 NOx	2003 SO2	2005 NOx	2005 SO2	2010 NOx	2010 SO2	2015 NOx	2015 SO2
Cherokee (pte)	56.23	82.26	64.59	95.02	64.59	95.02	58.58	95.02	58.58	95.02	58.58	95.02
Arapahoe (pte)	29.16	35.38	39.68	47.94	21.92	28.02	21.92	28.02	21.92	28.02	21.92	28.02
Valmont (pte)	9.72	24.31	12.89	24.36	12.89	24.36	12.89	24.36	12.89	24.36	12.89	24.36
Zuni (actual*growth)	11.03	0.01	0.84	0.00	0.85	0.00	0.89	0.00	0.95	0.00	1.02	0.00
Coors (permitted)	14.90	20.10	10.85	19.07	10.85	19.07	10.85	19.07	10.85	19.07	10.85	19.07
Rocky Mt. Bottle (permitted)	1.67	0.99	1.16	1.01	1.16	1.01	1.16	1.01	1.16	1.01	1.16	1.01
Minor Point Sources (actual*growth)	17.70	10.70	21.24	12.84	21.59	13.06	22.48	13.59	24.07	14.55	25.79	15.60
Total	140.41	173.75	151.25	200.24	133.85	180.54	128.78	181.07	130.43	182.03	132.22	183.07
Total NOx+SO2	314.16		351.49		314.39		309.84		312.46		315.29	

Table 4.3-2. Secondary Particulate Concentration Worksheet

	1995	2002	2003	2005	2010	2015
NOx Emissions (tpwd)						
Point Sources	137.8	151.2	133.9	128.8	130.4	132.2
Natural Gas	32.7	38.9	39.9	41.9	45.8	48.8
Wood Burning	0.5	0.6	0.6	0.7	0.9	1.0
Airport	11.4	13.7	13.9	16.8	20.6	24.2
Other Non-Road	10.9	11.2	11.1	10.9	9.7	9.2
Mobile Exhaust	119.4	137.7	130.4	109.6	104.0	87.8
Total NOx	312.7	353.3	329.8	308.7	311.4	303.3
SO2 Emissions (tpwd)						
Point Sources	175.5	200.2	180.5	181.1	182.0	183.1
Natural Gas	0.2	0.2	0.2	0.3	0.3	0.3
Wood Burning	0.0	0.1	0.1	0.1	0.1	0.1
Airport	1.0	1.1	1.2	1.2	1.3	1.4
Other Non-Road	0.9	1.2	1.3	1.3	1.5	1.7
Mobile Exhaust	2.5	5.6	5.8	6.1	2.1	2.2
Total SO2	180.1	208.4	189.1	190.0	187.3	188.8
Secondary Particulate Concentration (ug/m3)	46.1	52.6	48.4	46.6	46.6	46.1

4.4 Primary PM_{10} Background Concentration

The modeling analysis includes a background concentration that was added onto the dispersion model and secondary particulate concentration analysis to account for the impact of emissions and concentrations not considered in the modeling analysis within the modeling domain. A full description of the methodology used to establish monthly background concentrations for the attainment, and, now the maintenance SIPs can be found in Volume XIV-Additional Modeling Information in the attainment SIP. Five years of particulate data from monitors in Estes Park and Limon and five years of meteorological data from Stapleton International Airport were used to establish background concentrations. Table 4.4-1 presents a summary of the monthly background concentrations.

Table 4.4-1. Monthly Mean PM10 Background Concentrations

MONTH	PM_{10} BACKGROUND (ug/m^3)
JANUARY	15.4
FEBRUARY	15.8

MONTH	***PM_{10} BACKGROUND (ug/m³)***
MARCH	***19.8***
APRIL	***18.7***
MAY	***19.1***
JUNE	***21.7***
JULY	***23.3***
AUGUST	***24.5***
SEPTEMBER	***21.8***
OCTOBER	***18.9***
NOVEMBER	***17.7***
DECEMBER	***14.4***
ANNUAL AVERAGE	***19.8***

4.5 Meteorological Data used in the Dispersion Modeling Analysis

The same meteorological data set that was used for the base year and attainment year analysis are used for the maintenance SIP. A full description of this data set is contained in Volume X of the attainment SIP

Raw data from upper air and surface meteorological observations were obtained from the National Climatic Data Center. Five years of Stapleton International Airport meteorological observations, from 1985 through 1989, were used for the data base. The meteorological data was prepared for RAM and ISC3 model inputs using the RAMMET Meteorological Preprocessor. The data from the RAMMET model was further refined to limit the urban mixing heights to no less than 50 meters. In comparing the five year data set, wind speed, wind direction, and temperature compared well with the long term climatic data. The 1985 through 1989 meteorological data set was used to be consistent with the base year model validation, attainment year demonstration and the conformity analysis.

4.6 Modeling Domain

Table 4.6-1 present specifications of the modeling domain within the PM_{10} nonattainment area. The same modeling domain used for the attainment demonstration is being used for the maintenance demonstration. The modeling domain is also shown graphically in Figure 5.

The area source emission inventory used for the modeling consists of 1km receptors over the central Denver area where the maximum emissions are most likely to occur as well as the highest simulated concentrations.

The receptor scheme consists of 1294 receptors. The nested grid receptor scheme consists of 1116 receptors spaced 1km apart, nested within 165 receptors placed 5km apart. The area where receptors are placed 1km apart are where maximum concentrations are expected. Whether the receptors are place 1km or 5km apart, the receptors are located at intersections of area source emissions. Figure 5 depicts the area source gridding scheme and the receptor scheme.

In addition to the gridded receptors, there are discrete receptors placed at the location of each monitoring location. These locations are the nine Denver metro PM_{10} monitoring sites which include Adam City, Arvada, Aurora, Denver 414, Camp, Gates, Englewood, Golden, and Lakewood. Two additional receptors were placed at two CMB sites, Auraria and Welby. EPA Region VIII also requested that downwash modeling be performed for Public Service Company's Cherokee plant, Conoco Refinery and Colorado Refinery(6) as part of the attainment SIP. As a result of this downwash modeling, two points of maximum concentration was identified. These two points, identified as DWP1 and DWP2, were also modeled as discrete receptors.

The **PM_{10} SIP Development Guideline**(2) does not specify any guideline for determining the modeling domain within a Non-Attainment area. In the document, **Example Modeling to Illustrate SIP Development for the New Particulate Matter NAAQS**(6) any one of three approaches are described:

a) A qualitative analysis of the area of represented by the monitoring sites, together with consideration of terrain, meteorology and sources of emissions;
b) Spatial interpolation of air monitoring data;
c) Air quality by dispersion modeling.

For the Denver PM_{10} SIP, all three approaches were followed for the 1989 base year analysis. Topography was examined for the Denver Metro area. The topographic features indicate that the meteorology from Stapleton parallel the Platte River Valley, therefore, the Stapleton meteorological data base is representative of the Denver metro area at large. However, the topographic features indicate that there is a ridge between Denver and Boulder. The topographic features would indicate that Boulder is in a different air drainage than Denver, therefore, Stapleton data would not be representative of Boulder. For the most part, Boulder is not included in the modeling domain for this reason.

The attainment year modeling protocol presented in Volume VI of the attainment SIP presented an analysis based on spatial interpolation of air monitoring data. The overall maximum PM_{10} concentration at the nine network monitor locations were used to create an isopleth plot with the location of the 150 ug/m^3 contour line. The 150 ug/m^3 isopleth for the monitored data used was well within the proposed modeling domain with ample area around the isopleth to allow for transport.

The base year, attainment year SIP, and, the transportation conformity dispersion modeling analysis over the past several years indicate that the maximum concentrations are expected to radiate out from the downtown Denver area. The modeling domain for the maintenance demonstration is adequate to demonstrate where the maximum concentrations are within the Non-attainment area including a buffer zone.

Table 4.6-1. Denver metropolitan area PM_{10} Modeling Domain.

Coarse Grid UTM Origin (Easting)	*477,900 meters*
Coarse Grid UTM Origin (Northing)	*4,376,700 meters*
UTM Zone	*13*
Cells in X-direction	*14*
Cells in Y-direction	*10*
Cell side dimension	*5 km*
Nested Grid UTM Origin (Easting)	*782,900 meters*
Nested Grid UTM Origin (Northing)	*4,376,700 meters*
UTM Zone	*13*
Cells in X-direction	*31*
Cells in Y-direction	*36*
Cell side dimension	*1 km*

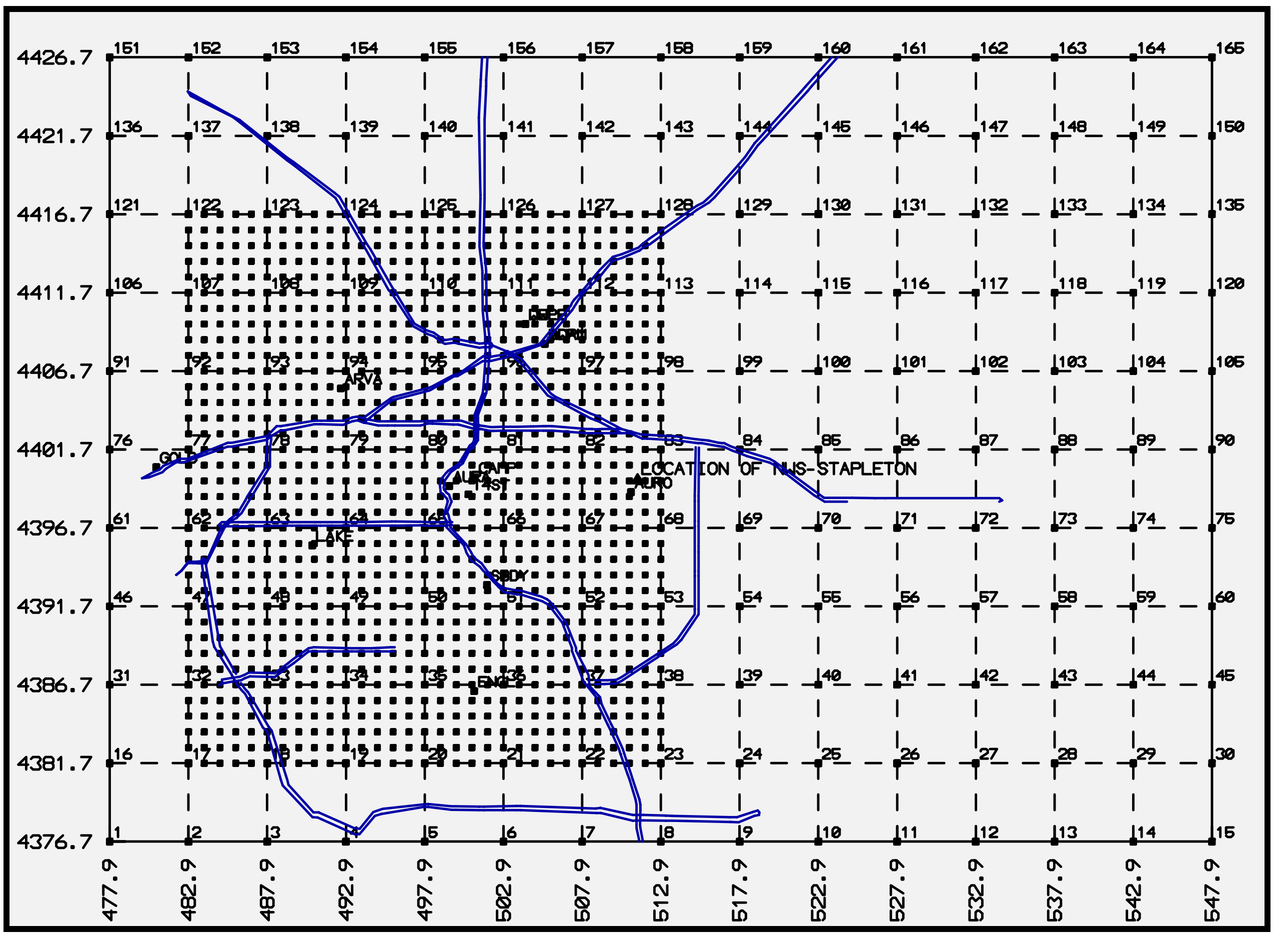

Figure 5. Area Source and Receptor Schemes

4.7 Model Performance Evaluation

Model validation and performance was performed as part of the 1989 base year in the attainment SIP. There has not been any additional model validation or performance demonstrations done since then. A complete description of the model performance and validation for the Denver area can be found in Volume XI of the attainment SIP as part of the 1989 modeling results.

Base year dispersion model runs were performed to estimate model results for 1989 and to establish model performance for the Denver PM_{10} SIP Element. Establishment of model performance is helpful in providing the degree of certainty the model will predict attainment and maintenance year concentrations. An evaluation of the overall model performance is presented in Volume XI by comparing monitored data with modeled data, and, also, Receptor Modeling results with source apportionments predicted by the dispersion models. In July of 1992, the EPA/RAQC/APCD agreed that the dispersion model generally meets modeling performance standards and is adequate for use in estimating the attainment year concentrations. It is assumed that the modeling system is also adequate for demonstrating continuing maintenance of the standard.

5 Modeling-Based Maintenance Demonstration

5.1 Control Strategies

The following sections present a brief description of the control strategies that went into the emission inventory and dispersion model analysis. Further information on control strategies used for the maintenance demonstration can be found in the AQCC/APCD/RAQC document entitled, *PM_{10} Redesignation Request and Maintenance Plan for the Denver Metropolitan Area*.

5.1.1 Federal fuels and tailpipe standards and regulations

Credits have been taken where appropriate for Federal fuels and tailpipe standards and regulations. Tailpipe nitrogen oxide emission inventory was adjusted using the methodology outlines in Mobile5 Information Sheet #8. The following table summarizes the analysis years and the emission reductions due to Federal fuels and tailpipe standards and regulations. Table 5.1-1 presents the emission reductions due to federal fuels and tailpipe regulations.

Table 5.1-1. Emission Reductions Due to Federal Fuels, tailpipe Standards, and Regulations

Year	*MOBILE5B Inventory (tons/day)*	*Tier II / Low Sulfur adjustment (tons/day)*	*Adjusted Inventory (tons/day)*
2002	*137.7*	*0.00*	*137.7*
2005	*121.8*	*-12.2*	*109.6*
2010	*131.3*	*-27.3*	*104.0*
2015	*122.4*	*-34.6*	*87.8*

The EPA mobile particulate emission factor model PART5 was utilized for the calculation of the PM_{10} and sulfur dioxide emission factors. An EPA memorandum, Development of On-Highway Inventory Adjustment Factors used in the Tier 2 Final Rule Air Quality Analysis, (John Koupal and Gary Dolce, Office of Mobile Sources, October 18, 1999) was used to adjustment emission factors resultant from PART5 to account for Tier II/ Low sulfur regulation. This memo details vehicle type specific gram per mile reductions for PM_{10} and SO_2 in the years 2007 and 2030. Values for 2015 and 2010 were interpolated from the 2007 and 2030 values. These reductions were applied to the each area type, road class and time of day by vehicle type. The composite emission factor was then re-calculated. Table 5.1-2 lists the multiplicative adjustment that were applied to each vehicle type.

Table 5.1-2. *Multiplicative Adjustments Each Vehicle Type*

Vehicle Type	*2015 PM10 Multiplicative Adjustment*	*2015 SO2 Multiplicative Adjustment*
LDGV	*.416*	*.088*
LDGT1	*.339*	*.088*
LDGT2	*.357*	*.088*
HDGV	*.767*	*.088*
LDDV	*.577*	*1.000*
LDDT	*.559*	*1.000*
All other vehicle types	*1.000*	*1.000*
Vehicle Type	*2010 PM10 Multiplicative Adjustment*	*2010 SO2 Multiplicative Adjustment*
LDGV	*.415*	*.088*
LDGT1	*.341*	*.088*
LDGT2	*.365*	*.088*
HDGV	*.767*	*.088*
LDDV	*.732*	*1.000*
LDDT	*.710*	*1.000*
All other vehicle types	*1.000*	*1.000*

No adjustments were made to the 2002 or 2005 PART5 emission factors for PM10 or sulfur dioxide.

5.1.2 Woodburning

The following assumptions were used in calculation of the woodburning emission inventories:

- Certified Stoves: exempted from compliance with no-burn days; no emissions reduction
- Non-certified stoves: 60% comply with no-burn days; emissions reduced 60%
- Fireplaces: 50% comply with no burn days; emission reduced 50%

5.1.3 Street Sanding

One of the more important PM_{10} control measures for the Denver metropolitan area is the restrictions on street sanding and required street sweeping as defined in Regulation No. 16. Street sand is required to meet stringent specifications to reduce the amount of fines and increase the durability of the sanding materials. Most metro-area governments were required to reduce the amount of street sand applied to their roadways by 20 percent from a base sanding amount;

the City of Denver was required to reduce the amount of sand applied by 30-50 percent. Additionally, mandatory street sweeping is required in the central area after each sanding event. The suite of controls applied to the 2002, 2005, 2010 and 2015 road dust and sanding emissions are presented in Table 5.1-3. Table 5.1-4 presents the uncontrolled and controlled road dust and sanding emissions by control area.

Table 5.1-3. Road Dust and Sanding Emission Reductions

Area	*Geographical description of Area*	*Road Dust and Sanding Emissions Reduction**
1	*Denver Central Business District*	*72%*
2	*I-25 between 6th Avenue and University Blvd.*	*54%*
3	*Area bounded by Louisiana Ave, Federal Blvd., 38th Avenue and Downing Ave.*	*50%*
4	*Foothills areas as defined in Regulation 16*	*20%*
5	*Metropolitan area not covered in areas above*	*30%*

**Agencies are required to meet the specified level of emission reduction by a combination of reduced sand application and sweeping.*

Table 5.1-4. The 2015 Uncontrolled and Controlled Road Dust and Sanding Emissions

Area	*Geographical description of Area*	*Uncontrolled Road Dust (tons/day)*	*Controlled Road Dust (tons/day)*	*Uncontrolled Sanding (tons/day)*	*Controlled Sanding (tons/day)*
1	*Denver Central Business District*	*.358*	*.100*	*.039*	*.011*
2	*I-25 between 6th Avenue and University Blvd.*	*.973*	*.365*	*.204*	*.094*
3	*Area bounded by Louisiana Ave, Federal Blvd., 38th Avenue and Downing Ave.*	*2.831*	*1.415*	*.465*	*.233*
4	*Foothills areas as defined in Regulation 16*	*.754*	*.604*	*.130*	*.104*
5	*Metropolitan area not covered in areas above*	*55.134*	*38.594*	*9.066*	*6.347*
	Totals	*59.871*	*41.078*	*9.905*	*6.788*

5.1.4 Automobile Inspection and Maintenance

Colorado's Automobile Inspection and Readjustment (AIR) Program is described in AQCC Regulation No. 11 and has been applicable in the Denver area since 1981. The AIR Program works to reduce NO_x pollutants from gasoline-powered motor vehicles by requiring them to meet emission standards through periodic tailpipe tests, maintenance, and specific repairs. NO_x emissions react in the atmosphere to form fine particulates. The AIR Program was updated in 1994 to meet the requirements of the Clean Air Act Amendments of 1990, and a more stringent and effective "enhanced" inspection program began in 1995. The enhanced program uses a loaded-mode dynamometer test called I/M 240 for 1982 and newer vehicles and an idle test for older vehicles and heavy trucks. Table 5.1-5 presents the I/M program assumptions for the various maintenance years.

Table 5.1-5. I/M Program Assumptions for the Various Analysis Years

Year	***I/M Program Parameters***
2002	*No nitrogen dioxide cut-point controls on I/M 240 program*
2005	*2.5 g/mi nitrogen dioxide cut-point on I/M 240 program; 60% RSD program*
2010	*1.5 g/mi nitrogen dioxide cut-point on I/M 240 program; 80% RSD program*
2015	*1.5 g/mi nitrogen dioxide cut-point on I/M 240 program; No RSD program*

5.1.5 Non-Road- Construction Equipment and Industrial Equipment

EPA's Non-Road Model was used to proportion the 1995 attainment SIP emissions (PM_{10}, NO_x, and SO_2) from construction equipment and industrial equipment to 2002, 2003, 2005, 2010, and 2015. The ratio derived from the non-road model had the effect of taking credit for Tier I and Tier II non-road engines standards and projected growth. Credit was also taken for low sulfur gasoline for 2010 and 2015. No credit was taken for low sulfur diesel regulations that may take effect at a later date. A summary of credits from using the non-road model are presented in Table 3.9-1.

5.2 Model Results

The modeling process includes dispersion modeling using five years of Denver Stapleton data from 1985-1989. Area sources, mobile, and minor point source are modeled using the RAM model. This Industrial Source Complex model (ISC3) was used to model primary PM_{10} from major stationary sources. Secondary particulate concentration estimates are based on Chemical Mass Balance model results and proportioned to estimated changes in NOx and SO_2 emissions. Primary PM_{10} background concentrations are based on historic monitoring data from Estes Park and Limon.

Table 5.2-1 presents the maximum highest sixth-high concentration model for the five maintenance years. These total concentrations include the RAM model results, ISC3 model results, secondary proportioned concentration for the maintenance years, and the background concentration. All of the maximum highest sixth-high concentrations occurred at the modeled receptor located at the CAMP monitoring location except for 2002. The highest concentration in 2002 occurred at receptor 973.

Table 5.2-1. *Summary of Maintenance Year Model Demonstration*

Maintenace Year	*Sixth-Highest Modeled Concentration (ug/m3)*
2002	*148.6*
2003	*144.9*
2005	*140.3*
2010	*145.2*
2015	*148.8*

A summary of the highest sixth-high for each maintenance year is presented in Appendices G through K. Concentrations isopleths for the maintenance years are presented in Figures for 2002, 2003, 2005, and 2010 and 2015, respectively. Based on the dispersion modeling analysis for the Denver nonattainment area, the area has attained the national standards for PM_{10}, and, through measures presented in the maintenance plan, can maintain the PM_{10} standard for at least ten years into the future.

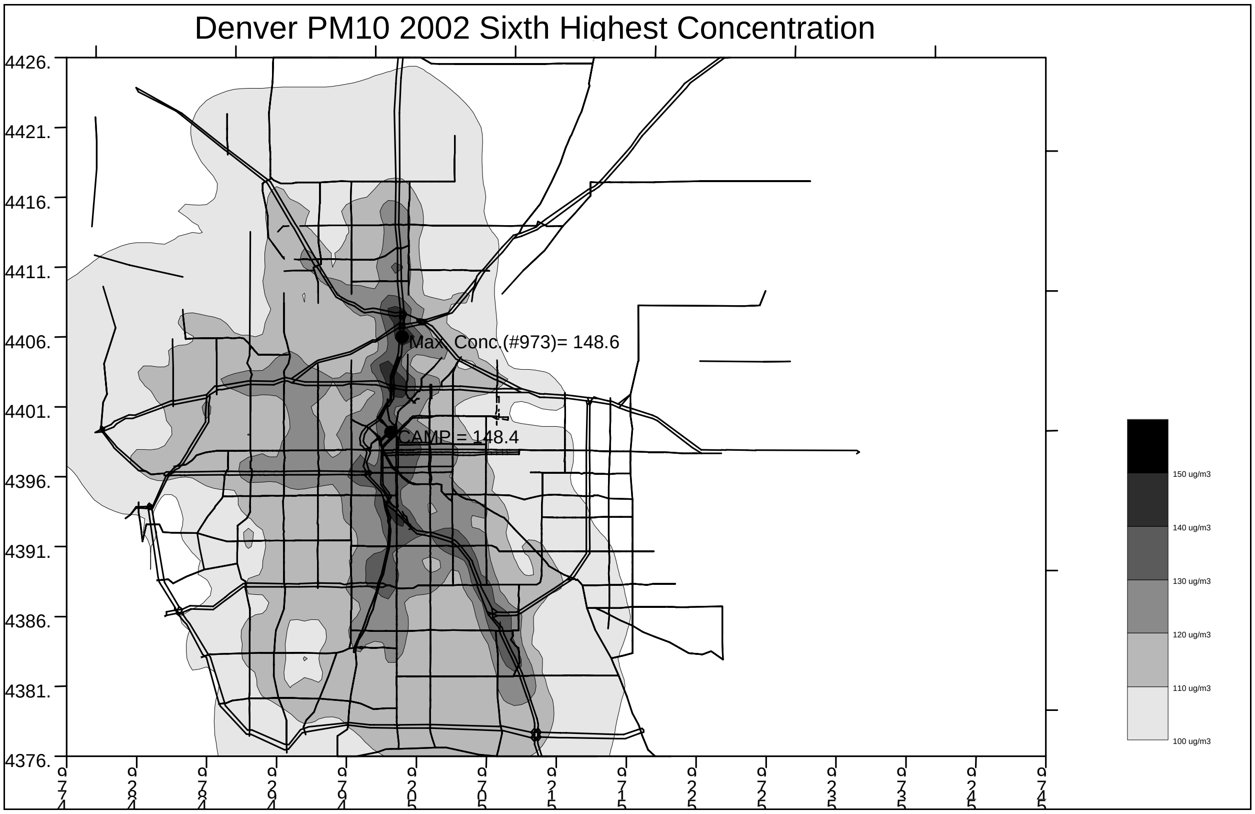

Figure 6. 2002 Maintenance Year Concentration Isopleths

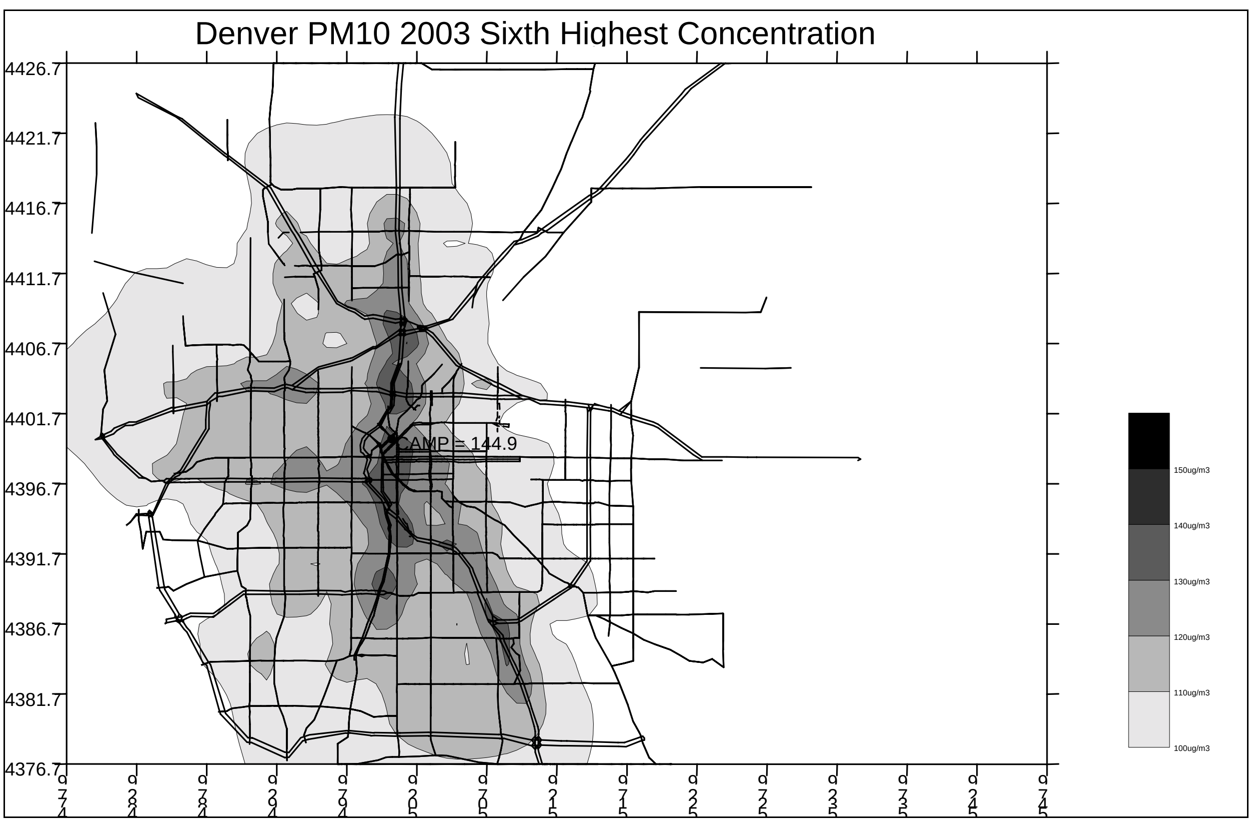

Figure 7. 2003 Maintenance Year Concentration Isopleths

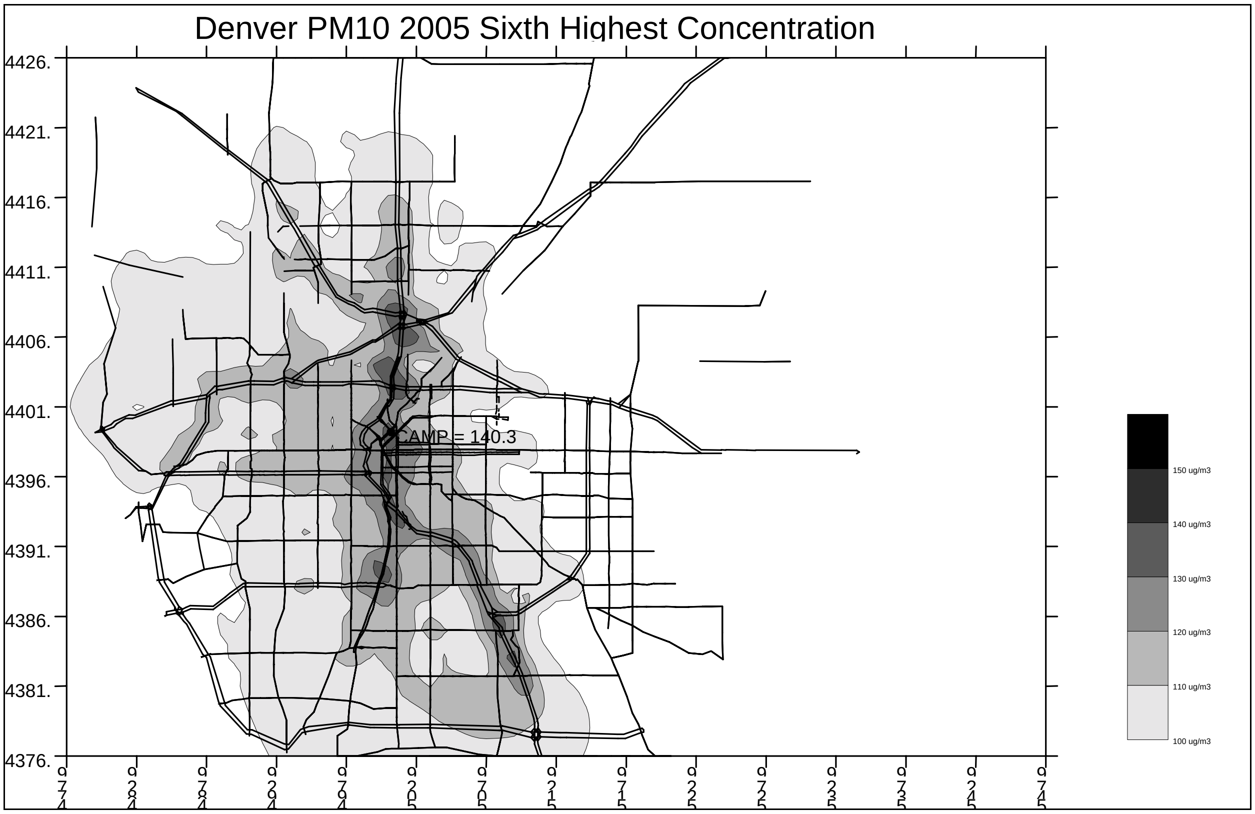

Figure 8. 2005 Maintenance Year Concentration Isopleths

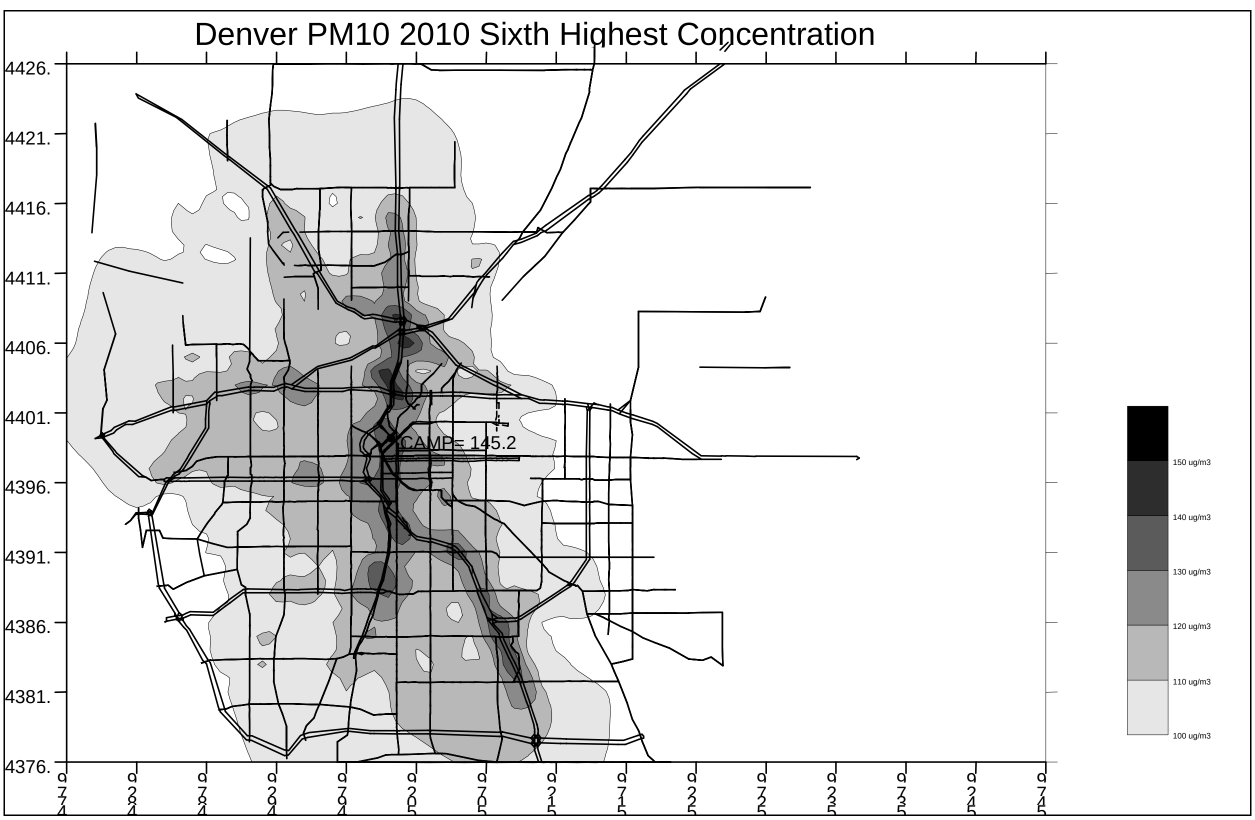

Figure 9. 2010 Maintenance Year Concentration Isopleths

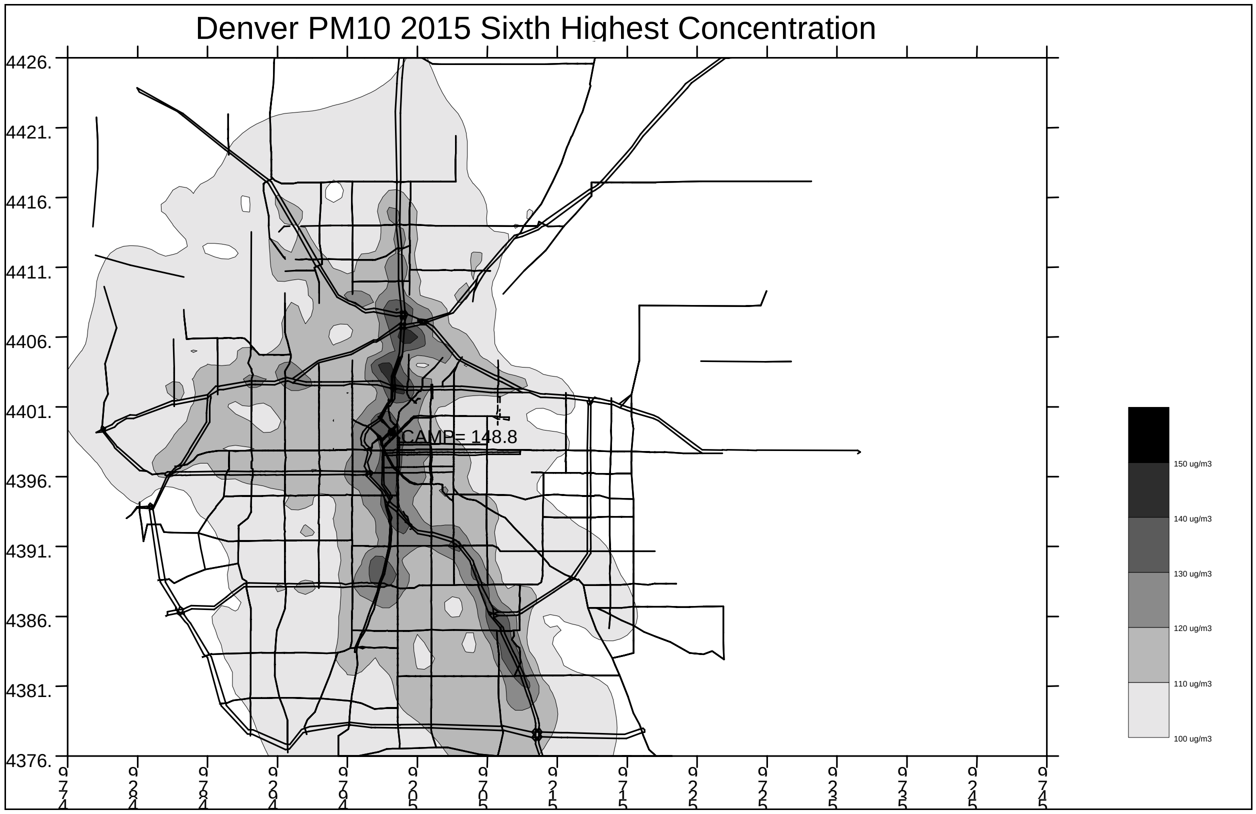

Figure 10. 2015 Maintenance Year Concentration Isopleths

6 Monitoring-Based Attainment Demonstration

6.1 Denver Area Historical Perspective

Historically, the particulate matter standard had been frequently violated in the 1970s, 1980s, and early 1990s throughout the Denver metropolitan area. In recent history, there has only been one exceedance of the 24-hour standard during the 1994 through 1999 period. With the implementation of emission control programs aimed at reducing re-entrained fugitive dust, automobile and industrial emissions, PM_{10} concentrations have stabilized at levels well below the NAAQS.

6.2 Monitoring-Based Attainment Demonstration

Attainment of the 24-hour PM_{10} NAAQS, which is 150 ug/m^3 of PM_{10} in ambient air for a 24-hour averaging time, is demonstrated when the average annual number of expected exceedances is less than or equal to one. The following monitoring information demonstrates, as required by Section 107(d)(3)(E) of the Clean Air Act, that the Denver metropolitan area has attained the NAAQS for PM_{10}. This demonstration is based on quality assured monitoring data collected in the Denver metropolitan area.

6.3 PM_{10} Monitoring Network

The current PM_{10} ambient air monitoring network in the Denver area consists of eleven stations operated by the Colorado Air Pollution Control Division. There have been other stations that have operated in the past as well as special purpose monitoring efforts that are ongoing (such as at the Rocky Flats facility

This section shall not be construed to establish a monitoring network in the federally-enforceable SIP. EPA has already approved a monitoring SIP for the State of Colorado and this description of the PM_{10} monitoring network shall not be construed to amend such a monitoring SIP.

6.4 Monitoring Results and Attainment Demonstration

The monitoring data presented in Table 6.5-1 verify that the Denver area is attaining 24-hour PM_{10} NAAQS, in accordance with the federal requirements of 40 CFR Part 58. Since 1993, the three-year average of expected values greater than 150 ug/m^3 is less than or equal to one.

6.5 Quality Assurance Program

PM_{10} monitoring data for the Denver area have been collected and quality-assured in accordance with 40 CFR, Part 58, Appendix A, EPA's "Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. 11; Ambient Air Specific Methods", the

APCD's Standard Operating Procedures Manual, and Colorado's Monitoring SIP which EPA approved in 1993. The data are recorded in EPA's Aerometric Information Retrieval System (AIRS) and are available for public review at the APCD and through EPA's AIRS database. Table 6.5-2 presents the data recovery rates for each monitoring site.

Table 6.5-1. Monitoring Data and Three-Year Average of Expected Exceedances of the PM_{10} NAAQS

Adams City--4301 E. 72nd Ave.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	99	97	0	0.34	33
1996	98	96	0	0	34
1997	98	98	0	0	35
1998	118	99	0	0	36
1999	160	141	1.16	0.39	37
2000	135	134	0	0.39	43

Brighton--22 S. 4th Ave.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	101	84	0	0	21
1996	57	54	0	0	23 *
1997	86	71	0	0	23
1998	64	55	0	0	21
1999	42	35	0	0	19
2000	69	46	0	0	20 *

Welby--78th Ave. & Steele St.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	73	46	0	0	21
1996	59	57	0	0	21 *
1997	60	46	0	0	22
1998	40	39	0	0	22
1999	44	42	0	0	22
2000	45	43	0	0	24

Welby Continuous PM10--78th Ave. & Steele St.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	55	44	0	0	17
1996	59	58	0	0	19
1997	59	53	0	0	17 *
1998	62	56	0	0	19
1999	50	49	0	0	15
2000	70	33	0	0	13 *

Boulder--14th & Spruce

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	35	29	0	0	13 *
1996	41	31	0	0	16
1997	28	27	0	0	15
1998 N / A 2000	*sampling ended 9-30-97*				

Longmont--3rd & Kimbark

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	91	61	0	0	19
1996	66	59	0	0	19
1997	44	41	0	0	18
1998	50	38	0	0	19
1999	58	56	0	0	21 *
2000	91	68	0	0	23

Boulder Chamber Bldg.--2440 Pearl St.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	51	45	0	N / A	20
1996	39	35	0	0	20 *
1997	43	42	0	0	21
1998	47	45	0	0	24
1999	46	43	0	0	23 *
2000	41	39	0	0	22 *

CAMP Primary hi-vol--2105 Broadway

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	52	50	0	0	28
1996	59	54	0	0	28
1997	67	66	0	0	26
1998	48	47	0	0	27
1999	52	49	0	0	30
2000	60	57	0	0	34 *

CAMP Continuous PM10--2105 Broadway

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	75	65	0	0	21
1996	74	67	0	0	20
1997	86	71	0	0	23 *
1998	108	81	0	0	31
1999	67	64	0	0	27 *
2000	78	59	0	0	28 *

Gates Primary hi-vol--1050 S. Broadway

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	57	45	0	0	27
1996	63	53	0	0	28
1997	94	93	0	0	29
1998	71	69	0	0	27
1999	61	47	0	0	28
2000	58	54	0	0	28

Denver Visitor's Center--225 W. Colfax

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	91	80	0	0.36	21
1996	81	70	0	0	23
1997	68	66	0	0	22
1998	77	75	0	0	30 *
1999	96	83	0	0	27
2000	74	72	0	0	29

Castle Rock--310 3rd St.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	34	32	0	0	15 *
1996	28	26	0	0	15 *
1997	54	54	0	0	21 *
1998	51	47	0	0	16 *
1999	49	24	0	0	16 *
2000	52	31	0	0	15

Arvada--8101 Ralston Road.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	41	36	0	0	18
1996	56	38	0	0	20
1997	70	70	0	0	21 *
1998	47	46	0	0	23
1999	*sampling ended 12-31-98*				
2000					

Golden--911 10th St.

Year	1st Max. (ug/m^3)	2nd Max. (ug/m^3)	Yearly Estim. Exceed.	3 yr. avg. Estim. Exceed.	Annual Avg. (ug/m^3)
1995	38	37	0	0	16
1996	43	31	0	0	16 *
1997	33	28	0	0	24 *
1998	*sampling ended 6-30-97*				
1999					
2000					

* *Annual Average was calculated with one or more quarters having less than 75% data recovery*

Table 6.5-2. PM_{10} Data Recovery Rates for Each Monitoring Site

Adams City--4301 E. 72nd Ave.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	> 100	> 100	100
1998	> 100	> 100	> 100	> 100	100
1999	> 100	> 100	> 100	> 100	100
2000	95	97	98	92	95

Brighton--22 S. 4th Ave.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	100	88	97
1998	100	90	90	94	93
1999	90	97	87	87	90
2000	97	87	*construction 9/20/00-2/22/01*		

Welby--78th Ave. & Steele St.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	> 100	> 100	100
1998	> 100	93	100	81	94
1999	100	100	100	93	98
2000	75	87	100	93	89

Welby Continuous PM10--78th Ave. & Steele St.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	> 100	> 100	100
1998	> 100	> 100	> 100	> 100	100
1999	> 100	> 100	> 100	> 100	100
2000	> 100	> 100	> 100	*sampler out 8/28/00-3/1/01*	

Boulder--14th & Spruce

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	87	100	94	73	89
1996	87	100	100	100	97
1997	100	93	93	N / A	96
1998					
1999	*sampling ended 9-30-97*				
2000					

Longmont--3rd & Kimbark

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	93	100	98
1998	67	100	94	77	85
1999	87	100	87	70	86
2000	87	97	100	80	91

Boulder Chamber Bldg.--2440 Pearl St.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	100	93	100	87	95
1996	87	73	100	87	87
1997	100	87	80	94	90
1998	70	97	94	> 100	90
1999	93	100	93	69	89
2000	94	87	93	67	85

CAMP Primary hi-vol--2105 Broadway

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	80	93	94	> 100	92
1996	100	93	94	80	92
1997	100	100	87	> 100	97
1998	87	87	93	81	87
1999	100	90	*constr. 6/99-2/00*		96
2000	60	93	100	93	96

CAMP Continuous PM10--2105 Broadway

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	> 100	> 100	100
1998	> 100	> 100	> 100	> 100	100
1999	> 100	> 100	*constr. 6/99-11/01*		100
2000	*constr. 6/99-11/01*			> 100	100

Gates Primary hi-vol--1050 S. Broadway

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	93	100	100	93	97

1996	100	100	100	100	100
1997	100	93	93	100	97
1998	100	80	93	88	90
1999	93	100	100	100	98
2000	100	100	100	93	98

Denver Visitor's Center--225 W. Colfax

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	> 100	> 100	> 100	> 100	100
1996	> 100	> 100	> 100	> 100	100
1997	> 100	> 100	> 100	> 100	100
1998	> 100	> 100	> 100	> 100	100
1999	> 100	> 100	> 100	> 100	100
2000	> 100	> 100	> 100	> 100	100

Castle Rock--310 3rd St.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	67	73	88	73	75
1996	80	60	81	93	79
1997	87	53	93	81	79
1998	7	93	100	100	75
1999	67	93	87	87	83
2000	94	100	100	93	97

Arvada--8101 Ralston Road

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	93	100	100	100	98
1996	93	100	100	100	98
1997	87	87	73	100	87
1998	100	87	100	81	92
1999 2000	*sampling ended 12-31-98*				

Golden--911 10th St.

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Overall
1995	93	93	88	93	92
1996	93	100	100	73	92
1997	33	33	N / A	N / A	33
1998 1999 2000	*sampling ended 6-30-97*				

** Overall average is calculated based on 100% as a maximum recovery*

7 Data Access

When requested, key modeling input and output files and this report will be made available on the Internet at:
http://apcd.state.co.us

Files that are prohibitively large will not be available for download. To obtain data or information not published on the Internet, contact the Division directly.

8 References

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