Colorado

2001 Air Quality Data Report

Colorado Department of Public Health and Environment

Air Pollution Control Division

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Cover photos (clockwise from left):

View of Steamboat Springs ski area and Mt. Werner, with $PM_{2.5}$ and PM_{10} monitors in the foreground.

View up Parachute creek from just northwest of the town of Parachute.

View of the flatirons from 28th Street in Boulder, with the carbon monoxide air inlet in the foreground.

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1.0 Purpose of the Annual Data Report

The Colorado Air Pollution Control Division (APCD) publishes the Colorado Air Quality Data Report as a companion document to the Colorado Report to the Public. The Air Quality Data Report addresses changes in ambient air quality measured by Division monitors. The Report to the Public discusses the policies and programs designed to improve and protect Colorado's air quality.

1.1 Design of the Annual Air Quality Data Report

This year we have changed the format of the Air Quality Data Report to reflect the requests that it should show pollutant levels by region rather than by pollutant. This change will also bring the Air Quality Data Report into better organizational alignment with the Air Quality Control Commission's Annual Report to the Public, although the geographical divisions used in this report were created to represent roughly similar types of monitoring requirements and needs. As a result of this redesign, other sub-sections have been moved to their own sections in the report. For example, information on summarized state trends and national trends appear in Sections 3 and 4, respectively. Detailed monitoring results by area appear in Section 5.

1.2 Description of Monitoring Areas in Colorado

The state has been divided into five areas that are generally based on topography. The areas are: the Eastern Plains; the Northern Front Range; the Southern Front Range; the Mountain Communities and the Western Communities. These divisions are a somewhat arbitrary grouping of monitoring sites into groups with similar characteristics. Other divisions can and have been made, but these five divisions seemed appropriate for this report. Figure 1 depicts these areas.

1.2.1 Eastern Plains Communities

The Eastern Plains Communities are those east of the I-25 corridor. Historically there have been a number of communities that were monitored for particulates. In the northeast along the I-76 corridor the communities of Sterling, Brush and Fort Morgan have been monitored. Along the I-70 corridor only the community of Limon has been monitored for particulates. In the southeast, the US-50/Arkansas River corridor, only Lamar is currently monitored for particulates. The communities of La Junta and Rocky Ford have been monitored in the past, but like the other communities that have been monitored on the Eastern Plains, the monitoring was discontinued when the levels were shown to be well below the standard.

1.2.2 Northern Front Range Communities

The Northern Front Range Communities are those along the I-25 corridor from the Colorado/Wyoming border to just south of the city of Castle Rock. This area has the majority of the larger cities in the state. The majority of monitors are located in the Denver-metro area and the remaining monitors are located in or near Fort Collins, Greeley, Longmont and Boulder.

1.2.3 Southern Front Range Communities

The Southern Front Range Communities are those along the I-25 corridor from south of the city of Castle Rock to the southern Colorado border. The cities with monitoring in the area are Colorado Springs, Pueblo, Cripple Creek, Cañon City and Alamosa. These last three cities are not strictly in the Front Range I-25 corridor but fit better with those cities than they do with the Mountain Communities. Colorado Springs is the only city in the area that is monitored for carbon monoxide and ozone; the other cities are only monitored for particulates. In the past the APCD has conducted particulate monitoring in both Walsenburg and Trinidad but that monitoring was discontinued in 1979 and 1985 respectively.

1.2.4 Mountain Communities

The Mountain Communities are generally the towns near the Continental Divide. They are all small towns in tight mountain valleys. In addition, their primary monitoring concern is with particulate pollution from wood burning and road sanding. These communities range from Steamboat Springs in the north to Silverthorne and Breckenridge in the I-70 corridor; Aspen, Leadville, Crested Butte, Mt. Crested Butte, Vail and Gunnison in the central mountains to Telluride in the southwest.

1.2.5 Western Communities

The Western Communities are generally smaller towns in fairly broad river valleys. Grand Junction is the only large city in the area and the only location that monitors for carbon monoxide on the western slope. The other locations monitor only for particulates. They are located in Parachute, Delta, Montrose, Durango and Pagosa Springs.

Table 1 – Statewide Continuous Monitors In Operation For 2001

X - Monitors continued in 2001 A – Monitors added in 2001

D – Monitors discontinued in 2001

County	Site Name	Location	CO	SO_2	NO_X	O_3	Met
Adams	Welby	78th Ave. & Steele St.	X	X	X	X	X
	S. Adams Pump	5580 Niagara St.		A			
Arapahoe	Highland Res.	8100 S. University Blvd.				X	X
Archuleta	Pagosa Springs	486 San Juan					D
Boulder	Boulder	2150 28th St.	X				
		1405½ S. Foothills Hwy.				X	
	Longmont	440 Main St.	X				
Denver	Denver CAMP	2105 Broadway	X	X	X		X
	Denver NJH	14th Ave. & Albion St.	X				
	Denver Carriage	23rd Ave. & Julian St.	X			X	X
	DESCI Building	1901 13th Ave. (Visibility)					
	Firehouse #6	1300 Blake St.	X				
	Auraria Lot R	Auraria Parkway					X
Douglas	Chatfield Res.	Roxborough Park Rd.				X	
El Paso	Colorado Springs	I-25 & Uintah St.	X				
		USAF Rd. 640				X	
		690 W. Hwy. 24	X				
Jefferson	Arvada	W. 57th Ave. & Garrison St.	X			X	X
	Welch	12400 W. Hwy. 285				X	X
	NREL	20th Ave. & Quaker St.				X	
	Rocky Flats	16600 W. Hwy. 128				X	X
		11501 Indiana St.					X
		9901 Indiana St.			D		X
		18000 W. Hwy. 72					X
		11190 N. Hwy. 93			D		X
Larimer	Fort Collins	708 S. Mason St.	X			X	X
		300 Remington St. (Visibility)					
Mesa	Grand Junction	12th St. & North Ave.	X				X
Powers	Lamar	104 Parmenter St.					X
Routt	Steamboat Spgs	137 10th St.					X
San Miguel	Telluride	Coonskin Parking Lot					X
Teller	Cripple Creek	Warren Ave. & 2nd St.					X
Weld	Greeley	811 15th St.	X			X	

Table 2 – Statewide Particulate Monitors In Operation For 2001

X - Monitors continued in 2001 A – Monitors added in 2001
D – Monitors discontinued in 2001 H – Hourly particulate monitor

County	Site Name	Location	TSP	Pb	Metals	Sulfate	PM_{10}	$PM_{2.5}$
Adams	Adams City	4301 E. 72nd Ave.	D	D	D	D	D	D
	Globeville	5400 Washington St.	X	X	X			
	Commerce City	7101 Birch St.	A	A	A	A	A	A
	Brighton	22 S. 4th Ave.					X	
	Welby	78th Ave. & Steele St.					X/H	
Alamosa	Alamosa	359 Poncha Ave.					X	
Arapahoe	Arapahoe Comm. College	6190 S. Santa Fe Dr.						X
Archuleta	Pagosa	486 San Juan					D	D
	Springs	309 Lewis St					A	A
Boulder	Boulder	2440 Pearl St.					X	X
	Longmont	3rd Ave. & Kimbark St.					X	X
	Hygiene	7024 Ute Hwy.					X	
Delta	Delta	560 Dodge St.					X	X
Denver	Denver CAMP	2105 Broadway	X	X		X	X/H	X/H
	Denver Gates	1050 S. Broadway	X	X			X	X
	Visitor Center	225 W. Colfax Ave.					X	
	Lowry AFB	8100 Lowry Blvd.					X	
Douglas	Castle Rock	310 3rd St.					D	
	Parker	10851 S. Crossroads						D
Eagle	Vail	846 Forest Rd.					D	
Elbert	Elbert	Wright-Ingraham Inst.						X
El Paso	Colorado	3730 Meadowlands					X	X
	Springs	101 W. Costilla St.	X	X			X	X
Fremont	Cañon City	7th Ave & Macon St.					X	
Garfield	Glenwood Spgs	806 Cooper Ave.					D	
	Parachute	100 E. 2nd St.					A	
	Rifle	200 W. 3rd St.					D	
Gunnison	Crested Butte	Colo.135 & Whiterock					X	
	Mt Crested Butte	9 Emmons Loop					X	X
	Gunnison	221 N. Wisconsin Ave.					A	
Jefferson	Rocky Flats	16600 W. Hwy. 128	D				D	
		11501 Indiana St.	D				D	
		9901 Indiana St.	D				D	
		18000 W. Hwy. 72	D				D	
		11190 N. Hwy. 93	D				D	
Lake	Leadville	510 Harrison St.	X	X				
La Plata	Durango	1060 2nd Ave.					X	
		623 E. 5th St.					X	X
		277 3rd Ave.					X	

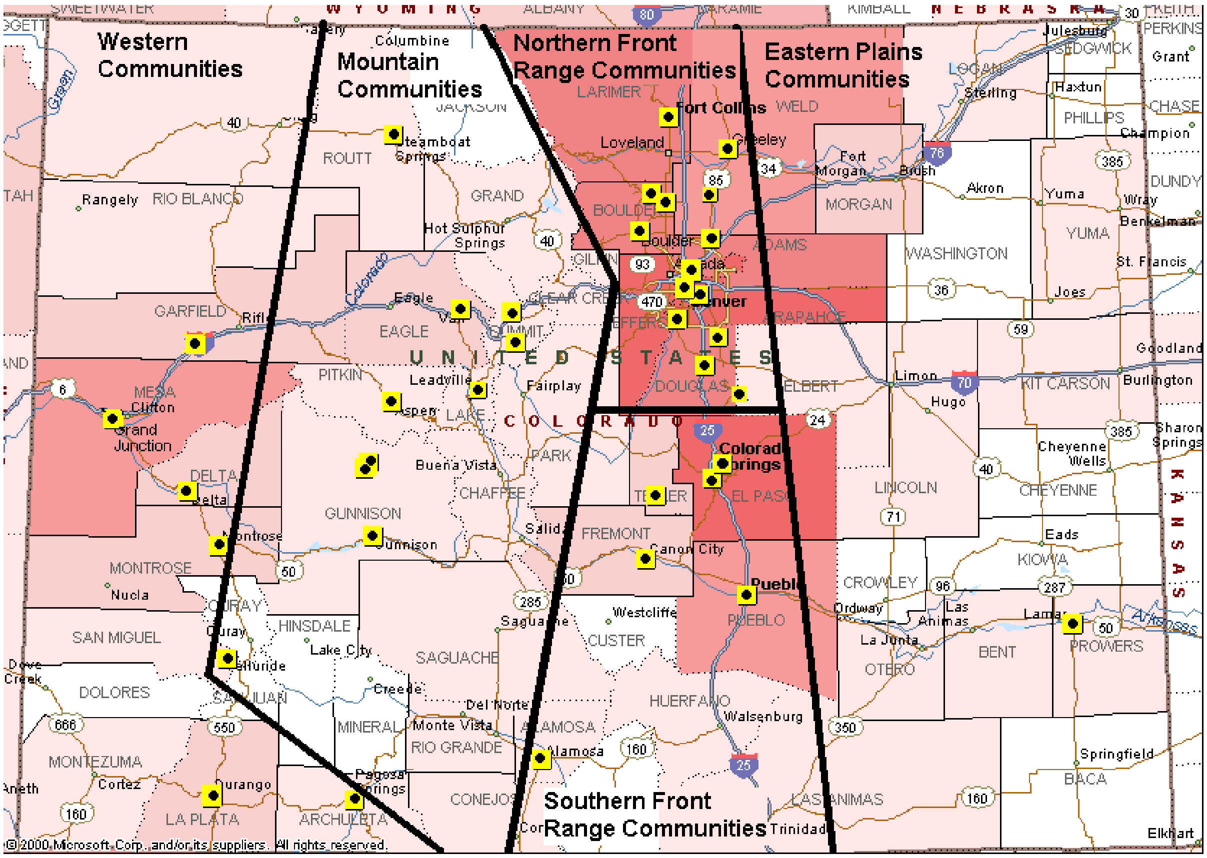
Statewide Particulate Monitors In Operation For 2001 (Continued)

X - Monitors continued in 2001 A – Monitors added in 2001

D – Monitors discontinued in 2001 H – Hourly particulate monitor

County	Site Name	Location	TSP	Pb	Metals	Sulfate	PM_{10}	$PM_{2.5}$
Larimer	Fort Collins	200 W. Oak St.					D	
		251 Edison St.					X	X
Mesa	Grand Junction	515 Patterson Rd.	A		A		X	X
		12th St. & North Ave.					X/H	
		925 4th St.	A		A			
Montrose	Montrose	125 S Townsend Ave.					X	
	Olathe	327 4th St.					D	
Pitkin	Aspen	420 Main St.					X/H	
Prowers	Lamar	100 2nd St.					X	
		104 Parmenter St.					X	
Pueblo	Pueblo	211 D St.					X	X
Routt	Steamboat Springs	136 6th St.					X	X
San Miguel	Telluride	333 W Colorado Ave.					X/H	X
Summit	Breckenridge	County Justice Center					X	
	Silverthorne	430 Rainbow Dr.					X	
Teller	Cripple Creek	209 Bennett Ave.					X	
Weld	Greeley	1516 Hospital Rd.					X	X
	Platteville	1004 Main St.						X

Figure 1
MONITORING AREAS IN COLORADO



2.0 Criteria Pollutants

The criteria pollutants are those for which the federal government has established ambient air quality standards in the Federal Clean Air Act and its amendments. There are six criteria pollutants. They are carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particulate mater. The standards for criteria pollutants are established to protect the most sensitive elements in society, usually defined as those with respiratory problems, the very young and the infirm. The levels of each standard for the criteria pollutants are discussed in each section and a summary is presented in Table 3.

Table 3 - National Ambient Air Quality Standards[1]

Pollutant	Averaging Time	Concentration
Carbon Monoxide		
Primary	1-hour*	35 ppm
Primary	8-hour*	9 ppm
Ozone**		
Primary	1-hour*	0.12 ppm
Secondary	Same as primary	
Nitrogen Dioxide		
Primary	Annual arithmetic mean	0.053 ppm
Secondary	Same as primary	
Sulfur Dioxide		
Primary	Annual arithmetic mean	0.03 ppm
Primary	24-hour*	0.14 ppm
Secondary	3-hour*	0.5 ppm
Particulate (PM_{10})**		
Primary	Annual arithmetic mean	50 $\mu g/m^3$
Primary	24-hour	150 $\mu g/m^3$
Particulate ($PM_{2.5}$)**		
Primary	Annual arithmetic mean	15 $\mu g/m^3$
Primary	24-hour	65 $\mu g/m^3$
Lead		
Primary	Calendar quarter	1.5 $\mu g/m^3$

* This concentration is not to be exceeded more than once per year.

** The 1997 8-hour ozone and $PM_{2.5}$ standards and the modifications to the PM_{10} standard were withdrawn due to legal challenges. The ozone and PM_{10} standards shown here are those that were in effect prior to the court challenges. The $PM_{2.5}$ standard is the proposed standard.

2.0.1.1 Carbon monoxide – Standards

The U.S. Environmental Protection Agency (EPA) has developed two national standards for carbon monoxide. They are 35 ppm averaged over a 1-hour period and 9 ppm averaged over an 8-hour period. These values are not to be exceeded more than once in a given year at any given location. A location will violate the standard with a second exceedance of either standard in a calendar year. The EPA directive requires that comparison with the carbon monoxide standards will be made in integers. Fractions of 0.5 or greater are rounded up, thus, actual concentrations of 9.5 ppm and 35.5 ppm or greater are necessary to exceed the 8-hour and 1-hour standards, respectively.[2]

2.0.1.2 Carbon monoxide – Health Effects

Carbon monoxide affects the central nervous system by depriving the body of oxygen. It enters the body through the lungs, where it combines with hemoglobin in the red blood cells. Normally, hemoglobin carries oxygen from the lungs to the cells. The oxygen attached to the hemoglobin is exchanged for the carbon dioxide generated by the cell's metabolism. The carbon dioxide is then carried back to the lungs where it is exhaled it from the body. Hemoglobin binds approximately 240 times more readily with carbon monoxide than with oxygen. In the presence of carbon monoxide the distribution of oxygen is reduced throughout the body. Blood laden with carbon monoxide can weaken heart contractions with the result of lowering the volume of blood distributed to the body. It can significantly reduce a healthy person's ability to do manual tasks, such as working, jogging and walking. A life-threatening situation can exist for patients with heart disease when these people are unable to compensate for the oxygen loss by increasing the heart rate.[3]

The EPA has concluded that the following groups may be particularly sensitive to carbon monoxide exposures: angina patients, individuals with other types of cardiovascular disease, persons with chronic obstructive pulmonary disease, anemic individuals, fetuses and pregnant women. Concern also exists for healthy children because of increased oxygen requirements that result from their higher metabolic rate.[3]

Carbon monoxide is exhausted from the body at varying rates, depending on physiological and external factors. The general guideline is that 20 to 40 percent is lost from the system after 2 to 3 hours following exposure.[3] The severity of health effects depends on both the concentration and the length of exposure because it takes time to remove it from the blood stream.

2.0.1.3 Carbon monoxide – Sources and Characteristics

Carbon monoxide is a colorless, odorless and tasteless gas. It is the largest single fraction of pollutants found in urban atmospheres. It is produced primarily during the incomplete combustion of organic fuels used for transportation and heating. Carbon monoxide is also created during refuse and agricultural burning and as a by-product from some industrial processes.[3]

In Denver, the Division estimates that 86 percent of the carbon monoxide emissions are from automotive sources. An estimated three percent of Denver's carbon monoxide emissions are from woodburning stoves and fireplaces. The remainder originates from aircraft, locomotives, construction equipment, power plants and space heating.[4] These numbers are similar to the nationwide emissions shown in Figure 2.[5]

In Denver, the daily concentration peaks are generally just after morning and evening rush hours. The worst problems occur where slow-moving cars congregate, such as in large parking lots or traffic jams. Carbon monoxide can temporarily accumulate to harmful levels in calm weather during autumn and winter. The problem is more severe in winter because cold weather makes motor vehicles run less efficiently and woodburning emissions from space heating are increased. In addition, on winter nights, a strong temperature inversion may develop near the ground, trapping pollutants.[4]

Figure 2

National Emissions by Source Category

Carbon Monoxide

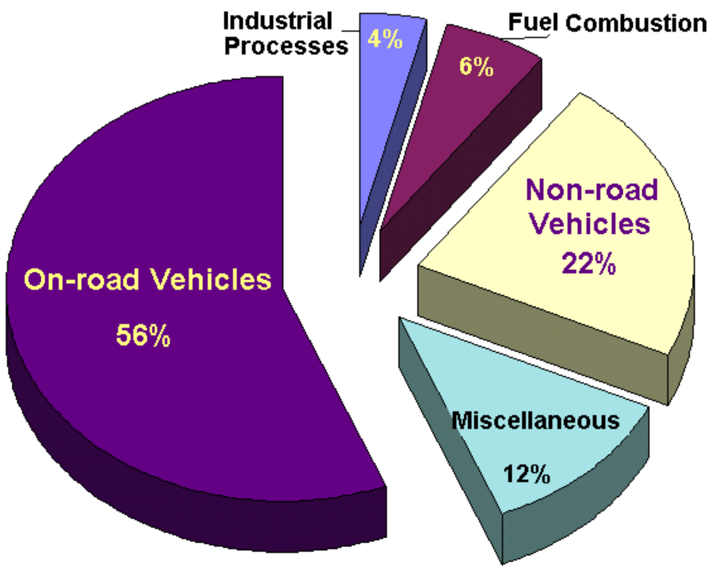


Figure 2 shows the nationwide carbon monoxide emissions for 2000. On-road vehicle sources are the exhaust from cars; trucks and buses while non-road vehicles are trains, planes, boats and construction equipment. Miscellaneous sources are forest fires and other natural sources of carbon monoxide. Fuel combustion sources are woodstoves, gas stoves and space heaters.[5]

2.0.2.1 Ozone – Standards

The 1-hour ozone standard is 0.12 ppm for a 1-hour average. On July 18, 1997, the EPA issued the final rule on a "new" ozone standard:

> *"The 1-hour primary standard of 0.12 ppm was replaced by an 8-hour standard at a level of 0.08 ppm with a form based on the 3-year average of the annual 4th-highest daily maximum 8-hour average ozone concentration measured at each monitor within an area."*[6]

The 8-hour averaging time is more directly associated with health effects of concern at lower ozone concentrations than is the 1-hour averaging time. Therefore, the 8-hour standard was felt to be more appropriate for a human health-based standard than the 1-hour standard.[6] At this time, the "new" 8-hour standard has been challenged in court and the EPA has reverted to the 1-hour standard pending a court decision.

In July 1997, the U.S. Environmental Protection Agency established a new ozone standard. The reasons for these changes were:

> *". . . to provide protections for children and other at-risk populations against a wide range of ozone induced health effects, including decreased lung function (primarily in children active outdoors), increased respiratory symptoms (particularly in highly sensitive individuals), hospital admissions and emergency room visits for respiratory causes (among children and adults with pre-existing respiratory disease such as asthma), inflammation of the lung and possible long-term damage to the lungs."*[6]

There were three changes to the standard:

1. The averaging period was changed from 1-hour periods to 8-hour periods.
2. The level of the standard was lowered from 0.12 to 0.08 ppm as the result of the increased averaging time.
3. An area will attain the standard when the 4th highest daily maximum 8-hour concentration, averaged over 3 years, is below 0.08 ppm.

How will this standard affect Colorado?

Under the past standard, all of Denver and Jefferson counties and large portions of Adams, Arapahoe, Boulder and Douglas counties are classified as nonattainment. Under the new standard, no Colorado county would be out of attainment. There are several reasons for this change in attainment, the most important of which is that ozone concentrations have been declining throughout the monitoring area. In addition, daily peak concentrations in Colorado and most other Western states tend to be short-term spikes of one to three hours, while the majority of the time the levels are quite low. In coastal California and the Eastern United States, the ozone concentrations tend to buildup all day long or even across multi-day periods.

At this time, the 8-hour standard has been challenged in federal court. Until the court makes a decision the 8-hour standard has been nullified and the 1-hour standard has been put back in effect.

2.0.2.2 Ozone – Health Effects

Short-term exposures (1 to 3 hours) to ambient ozone concentrations have been linked to increased hospital admissions and emergency room visits for respiratory-related problems. Repeated exposures to ozone can make people more susceptible to respiratory infection and lung inflammation and can aggravate preexisting respiratory diseases such as asthma. Other health effects attributed to short-term exposures to ozone, generally while individuals are engaged in moderate or heavy exertion, include significant decrease in lung function and increased respiratory symptoms such as chest pain and coughing. Children that are active outdoors during the summer when ozone levels are highest are most at risk of experiencing such effects. Other at-risk groups include outdoor workers, individuals with preexisting respiratory disease such as asthma and chronic obstructive lung disease and individuals who are unusually responsive to ozone. Recent studies have attributed these same health effects to prolonged exposures (6 to 8 hours) at relatively low ozone levels during periods of moderate exertion. In addition, long-term exposure to ozone presents the possibility of irreversible changes in the lungs that could lead to premature aging of the lungs and/or chronic respiratory illnesses.[8]

The recently completed review of the ozone standard (by the EPA and others) also highlighted concerns with ozone effects on vegetation for which the 1-hour ozone standard did not provide adequate protection. These effects can include reduction in agricultural and commercial forest yields, reduced growth and decreased survivability of tree seedlings, increased tree and plant susceptibility to disease, pests and other environmental stresses and potential long-term effects on forests and ecosystems.[8]

2.0.2.3 Ozone – Sources and Characteristics

Ozone is a highly reactive form of oxygen. At very high concentrations it is a blue, unstable gas with a characteristic pungent odor often associated with arcing electric motors, lightning storms or other electrical discharges.[7] However, at ambient concentrations, ozone is colorless and odorless. Ozone concentrations at remote locations, such as the Western National Air Pollution Background Network, range from 0.02 to 0.04 ppm year-round.[8]

At ground level, ozone is a pollutant. Although chemically identical, ground level ozone should not be confused with the stratospheric ozone layer. The stratospheric ozone layer is found between 12 and 30 miles above the earth's surface and shields the earth from intense, cancer-causing ultraviolet radiation. Concentrations of ozone in this layer are approximately 10 to 12 ppm or more than 100 times the National Ambient Air Quality Standard for ozone. Occasionally, meteorological conditions result in stratospheric ozone being brought to ground level and this can increase concentrations by 0.05 to 0.10 ppm. This stratospheric intrusion has caused concentrations higher than the 0.12 ppm standard.[8]

Ozone is not emitted directly from a source, as are other pollutants, but forms as a secondary pollutant. Its precursors are certain reactive hydrocarbons and nitrogen oxides, which react chemically in sunlight to form ozone. The sources for these reactive hydrocarbons are automobile exhaust, gasoline, oil storage and transfer facilities, industrial paint solvents, degreasing agents, cleaning fluids and ink solvents. High temperature combustion combines nitrogen and oxygen in the air to form oxides of nitrogen. Vegetation can also emit reactive hydrocarbons such as terpenes from pine trees, for example.[8]

Ozone production is a year-round phenomenon. However, the highest ozone levels generally occur during the summer season when the sunlight is more intense and the meteorological conditions are more stagnant. This combination can cause reactive pollutants to remain together in an area for several days. Ozone produced under these summer stagnant conditions remains as a coherent air mass and can be transported many miles from its point of origin.

2.0.3.1 Sulfur dioxide – Standards

There are two primary standards for sulfur dioxide. The first is a long-term, one-year arithmetic average not to exceed 0.03 ppm. The second is a short-term, 24-hour average where concentrations are not to exceed 0.14 ppm more than once per year. The secondary standard is a 3-hour average not to exceed 0.5 ppm more than once per year.[9]

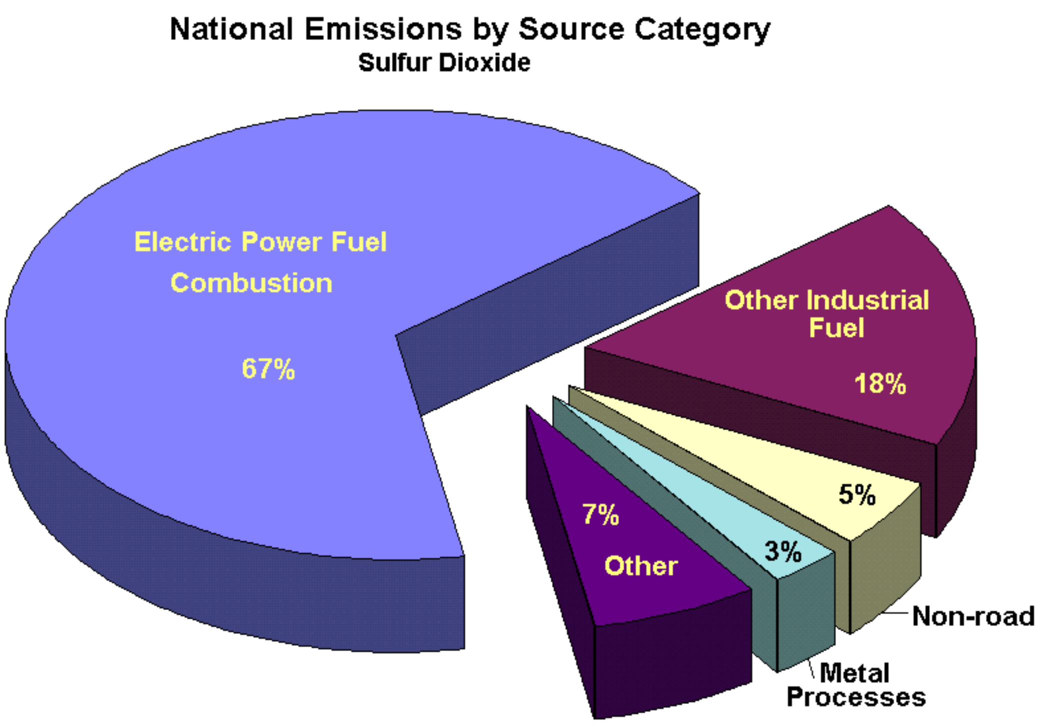
2.0.3.2 Sulfur dioxide – Health Effects

Sulfur dioxide can be converted in the atmosphere to sulfuric acid aerosols and particulate sulfate compounds, which are corrosive and potentially carcinogenic (cancer-causing). Worldwide elevated sulfur dioxide and particulates have been associated with many air pollution disasters. Deaths in these disasters were due to respiratory failure and occurred predominantly, but not exclusively, in the elderly and infirm. Sulfur dioxide may also play an important role in the aggravation of chronic illnesses such as asthma. The incidence and intensity of asthma attacks increase when people with asthma are exposed to higher levels of sulfates.

2.0.3.3 Sulfur dioxide – Sources and Characteristics

Sulfur dioxide is a colorless gas with a pungent odor. It is detectable by smell at concentrations of about 0.5 to 0.8 ppm.[10] It is highly soluble in water. In the atmosphere, sulfur oxides and nitric oxides are converted to "acid rain". On a worldwide basis, sulfur dioxide is considered a major pollution problem. In the United States, sulfur dioxide is emitted mainly from stationary sources that burn coal and oil. Other sources include refineries and smelters. Significant amounts of sulfur dioxide are also emitted from natural sources such as volcanoes, which rarely contribute to the urban sulfur dioxide problem.[10] Figure 3 shows the distribution of sulfur dioxide emissions nationwide in 2000.

Figure 3



2.0.4.1 Nitrogen dioxide – Standards

The annual standard for nitrogen dioxide is 0.053 ppm expressed as an annual arithmetic mean (average).[11] Los Angeles is the only U.S. city that has recorded exceedances of the nitrogen dioxide annual standard in the past ten years. The last time Los Angeles exceeded the standard was 1992.[12]

2.0.4.2 Nitrogen dioxide – Health Effects

Elevated levels of nitrogen dioxide cause respiratory distress, degradation of vegetation, clothing and visibility, and increased acid deposition. Nitrate aerosols, which result from nitric oxide and nitrogen dioxide combining with water vapor in the air, have been consistently linked to Denver's visibility problems.

2.0.4.3 Nitrogen dioxide – Sources and Characteristics

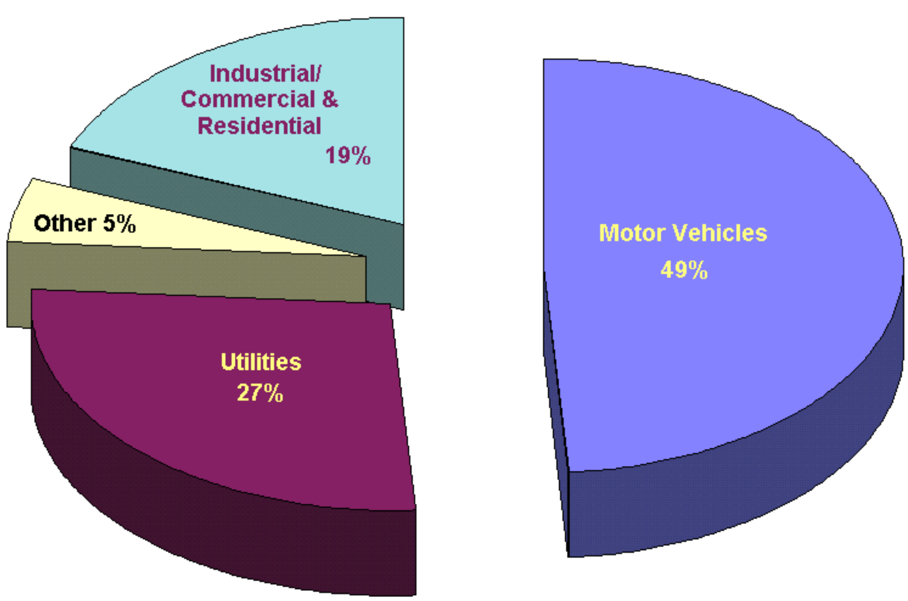
In its pure state, nitrogen dioxide is a reddish-brown gas with a characteristic pungent odor. It is corrosive and a strong oxidizing agent. As a pollutant in ambient air, however, it is virtually colorless and odorless and can be an irritant to the eyes and throat. Oxides of nitrogen (nitric oxide and nitrogen dioxide) are formed when the nitrogen and oxygen in the air are combined in high temperature combustion.

About 44 percent of the emissions of nitrogen dioxide in the Denver area come from large combustion sources such as power plants. Almost 33 percent comes from motor vehicles, 15 percent from space heating, 3 percent from aircraft and 5 percent from miscellaneous off-road vehicles. Minor sources include fireplaces and woodstoves and high temperature combustion processes used in industrial work.[13] National nitrogen dioxide emissions can be seen in Figure 4.[14]

Figure 4

National Emissions by Source Category

Nitrogen Dioxide



2.0.5.1 Particulate Matter – PM_{10} – Standards

In July 1987, EPA promulgated National Ambient Air Quality Standards for particulates with an aerodynamic diameter of 10 microns or less (PM_{10}). This is a size that can be inhaled into the bronchial and alveolar regions of the lungs. The standard has two forms, a 24-hour standard of 150 $\mu g/m^3$ and an annual arithmetic mean standard of 50 $\mu g/m^3$.[15]

1. The 24-hour standard is attained when the expected number of exceedances for each calendar year, averaged over three years, is less than or equal to one. The estimated number of exceedances is computed quarterly using available data and adjusting for missing sample days.
2. The annual arithmetic mean standard is attained when the annual mean, averaged over three years is less than or equal to the level of the standard. Each annual mean is computed from the average of each quarter in the year, with adjustments made for missing sample days.
3. In both cases, a data recovery of 75 percent is needed for each calendar quarter to be considered a valid quarter of data.

The 24-hour standard was modified in by EPA in July 1997, but was subsequently nullified back to this form in May 1999 due to a challenge in the courts.

2.0.5.2 Particulate Matter – PM_{10} – Health Effects

According to American Lung Association's paper <u>The Perils of Particulates</u>:

"The health risk from an inhaled dose of particulate matter depends on the size and concentration of the particulate. Size determines how deeply the inhaled particulate will penetrate into the respiratory tract where they can persist and cause respiratory damage. Particles less than 10 microns in diameter are easily inhaled deep into the lungs. In this range, larger particles tend to deposit in the tracheobronchial region and smaller ones in the alveolar region. Particulates deposited in the alveolar region can remain in the lungs for long periods because the alveoli have a slow mucociliary clearance system."[16]

"Fine particulate pollution does not affect the health of exposed persons with equal severity. Certain subgroups of people potentially exposed to air pollutants can be identified as potentially 'at risk' from adverse health effects of air borne pollutants. There is very strong evidence that asthmatics are much more sensitive (i.e., respond with symptoms at relatively low concentrations) to the effects of particulates than the general healthy population. Conversely, little scientific evidence exists that show elderly persons (greater than 65 years old) are particularly sensitive to the effects of particulate matter air pollution"[16]

The welfare effects of particulate exposure may be the most widespread of all the pollutants. Because of the potential for extremely long-range transport of fine particles and chemical reactions that occur, no place on earth has been spared from the particulate pollution generated by urban and rural sources. The effects of particulates range from visibility degradation to climate changes and vegetation damage. General soiling, commonly thought to be just a nuisance, can have long-term adverse effects on building paints and other materials. Acid deposition as particulates can be detected in the most remote areas of the world.

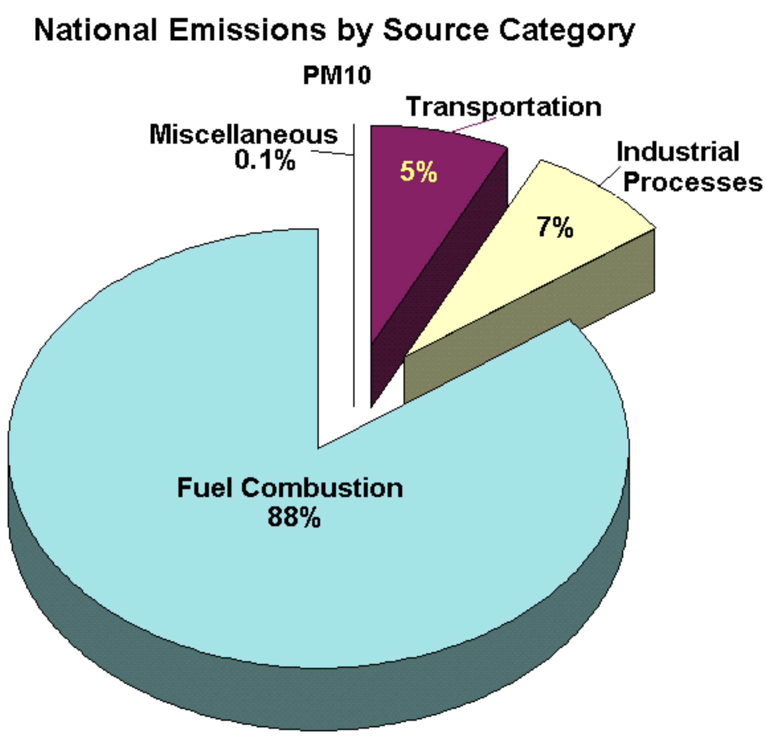
2.0.5.3 Particulate Matter – PM_{10} – Source and Characteristics

Particulate matter is the term given to the tiny particles of solid or semi-solid material suspended in the atmosphere. Particulates can range in size from less than 0.1 microns to 50 microns. Particles larger than 50 microns tend to settle out of the air quickly and are not considered to have a health effect. Particulate matter 10 microns in diameter and smaller is considered inhalable and has the greatest health impact.[17]

Most anthropogenic (manmade) particulates are in the 0.1 to 10 micron diameter range. Particles larger than 10 microns are usually due to "fugitive dust". Fugitive dust is wind-blown sand and dirt from roadways, fields and construction sites that contain large amounts of silica (sand-like) materials. Anthropogenic particulates are created during the burning of fuels associated with industrial processes or heating. These particulates include fly ash (from power plants), carbon black (from automobiles and diesel engines) and soot (from fireplaces and woodstoves). The PM_{10} particulates from these sources contain a large percentage of elemental and organic carbon. These types of particles play a role in both visual haze and health issues.[17]

Figure 5 shows the distribution of particulate emissions nationwide by source category.[17]

Figure 5



2.0.6.1 Particulate Matter – $PM_{2.5}$ – Standards

In 1997, the EPA added new fine particle standards, $PM_{2.5}$, to the existing PM_{10} standards. The numbers, 2.5 and 10 refer to the particle size measured in microns. EPA added an annual $PM_{2.5}$ standard set at a concentration of 15 micrograms per cubic meter ($\mu g/m^3$) and a 24-hour $PM_{2.5}$ standard set at 65 $\mu g/m^3$. However, a lawsuit by the American Trucking Association questioned the EPA's authority to create the new standard. A US

District court ruling blocked implementation of the $PM_{2.5}$ standard, but the US Supreme court reversed the lower court and unanimously upheld the legality of the EPA and its creation of the $PM_{2.5}$ standard. The Supreme Court decision was issued on February 27, 2001. The annual component of the standard was set to provide protection against typical day-to-day exposures as well as longer-term exposures, while the daily component protects against more extreme short-term events. The EPA retained the current annual PM_{10} standard of 50 $\mu g/m^3$ and the PM_{10} 24-hour standard of 150 $\mu g/m^3$.

Areas will be considered in compliance with the annual $PM_{2.5}$ standard when the 3-year average of the annual arithmetic mean $PM_{2.5}$ concentrations, from single or multiple community-oriented monitors, is less than or equal to 15 $\mu g/m^3$. The 24-hour $PM_{2.5}$ standard is based on the 98th percentile of 24-hour $PM_{2.5}$ concentrations in a year (averaged over 3 years).

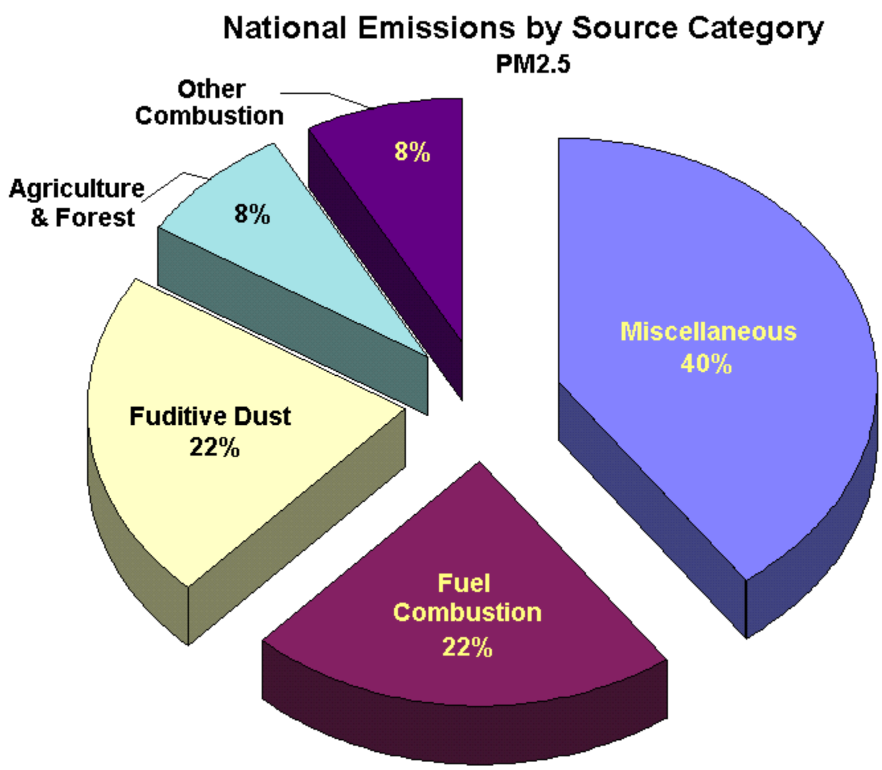
2.0.6.2 Particulate Matter – $PM_{2.5}$ – Health Effects

The health effects of $PM_{2.5}$ are not just a function of their size, 1/20th the size of a human hair, which allows them to be breathed deeply into the alveoli the lungs, but of their composition. These particles can remain in the lungs for a long time and cause a great deal of damage to the lung tissue. They can reduce lung function as well as cause or aggravate respiratory problems. They can increase the long-term risk of lung cancer or lung diseases such as emphysema or pulmonary fibrosis.[18]

2.0.6.3 Particulate Matter – $PM_{2.5}$ – Source and Characteristics

According to the Environmental Protection Agency's Latest Findings on National Air Quality: 2000 Status and Trends, Particulate Matter. "$PM_{2.5}$ is composed of a mixture of

Figure 6



particles directly emitted into the air and particles formed in the air by the chemical transformation of gaseous pollutants. The principle types of secondary pollutants are ammonium sulfate and ammonium nitrate formed in the air from gaseous emissions of SO_2 and NO_X, reacting with ammonia. The main source of SO_2 is combustion of fossil fuels in boilers and the main source of NO_X are the combustion of fossil fuels in boilers and mobile sources. Some secondary particles are also formed from semi-volatile organic compounds which are emitted from a wide range of combustion sources."

Figure 6 shows the distribution of $PM_{2.5}$ particulates nationwide emissions by source category in 2000.[19]

The principle types of directly emitted particles are crustal materials and carbonaceous material resulting from the incomplete combustion of fossil fuels and other organics compounds.[19] Particles less than 2.5 microns in diameter, or $PM_{2.5}$, are the major contributors to visibility problems because of their ability to scatter light. In Denver, the effects of this particulate pollution can be seen as the "Brown Cloud" or more appropriately, the "Denver Haze" because it is frequently neither brown nor an actual cloud.

2.0.7.1 Lead – Standards

The current federal standard for lead is a calendar quarter (3-month) average concentration not to exceed 1.5 micrograms of lead per cubic meter of air ($\mu g/m^3$). This standard was established to maintain blood lead levels below 30 µg/dL due to exposure to atmospheric lead concentrations.[20] In the future, the focus on lead monitoring will shift to ensure that stationary sources do not create violations of the standard in localized areas. Colorado has at least one such source in the Denver area that is the subject of monitoring. The Historical Lead Comparison graphs show data back to 1990. The levels recorded at most of the monitoring sites are approaching the limits of detection for ambient lead. The last violation of the lead standard was the first quarter of 1980.

2.0.7.2 Lead – Health Effects

Exposure to lead can occur through several pathways, including inhalation of contaminated air and ingestion of lead in food, water, soil or dust. Excessive lead exposure can cause seizures, mental retardation and/or behavioral disorders. Low doses of lead can lead to central nervous system damage. Recent studies have also shown that lead may be a factor in high blood pressure and in subsequent heart disease in middle-aged white males.[27]

The nervous system is most sensitive to the effects of lead. Neurological deficits have been found in children with lead levels previously thought to cause no harmful outcomes. These effects include low IQ scores and deficits in speech, language processing and attention, and classroom performance. Learning and behavioral abnormalities have been associated with lead levels of less than 25 micrograms per deciliter of blood (µg/dL).[21]

2.0.7.3 Lead – Sources and Characteristics

Lead gasoline additives, nonferrous smelters and battery plants are the most significant contributors to atmospheric lead emissions. In 1997, transportation sources contributed 13 percent of the annual emissions; this was down significantly from 1970 when transportation accounted for approximately 78 percent of the total lead emissions. In 1999, transportation accounted for only 12.8 percent of the total lead emissions.[22] The initial strategy for controlling lead in the environment was to decrease the lead content in gasoline. Refining companies have reduced the lead content of their products from as high as six

Figure 7

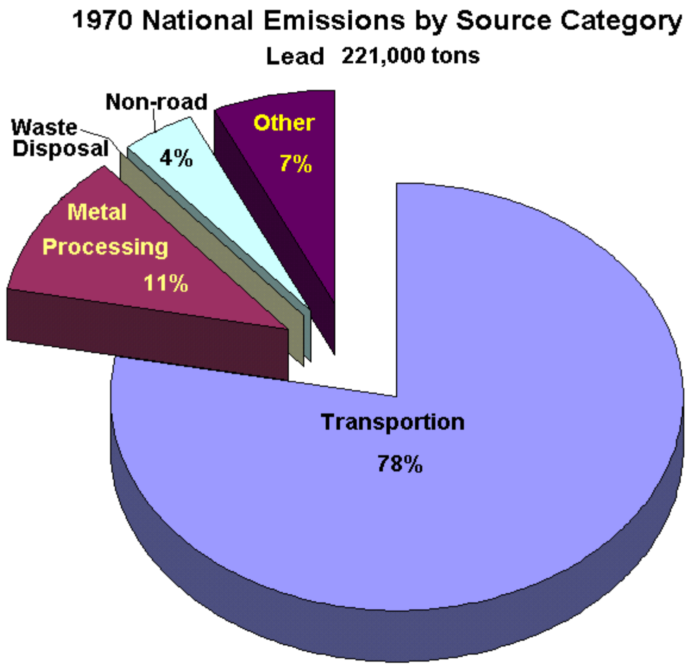
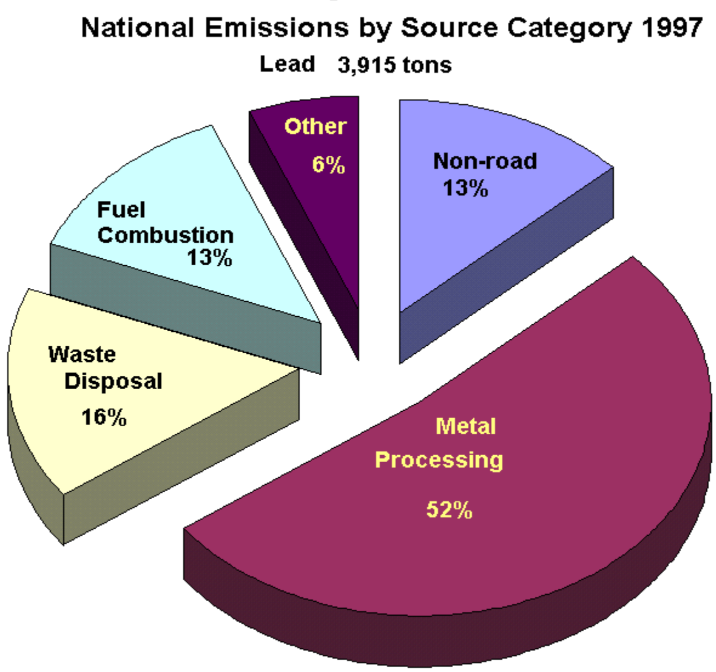


Figure 8



grams per gallon in the early 1970s to 0.5 grams per gallon or less by July 1, 1985, and to 0.1 gram per gallon by January 1, 1986. Some manufacturers have eliminated lead entirely and others have introduced lead substitutes to prevent excess wear on valve stems and valve seats in older cars. Leaded gasoline sales have declined since the introduction of unleaded gas in 1975. The national average is less than 1 percent of gasoline sales.[27]

Figures 7 and 8 show the changes in nationwide lead emissions. There was nearly a 98 percent reduction in total lead emissions between 1970 and 1997. Almost 170, 000 tons of lead emissions, or about 75 percent of the reduction, came from the reduction of lead in gasoline, while metal processing has increased from 11 percent of total lead emissions in 1970 to 53 percent in 1997. The actual amount of lead emissions were reduced from 24,000 tons in 1970 to about 2,000 tons in 1997.[27]

2.1 Non-Criteria Pollutants

2.1.1 Visibility

2.1.1.1 Visibility – Standards

The Colorado Air Quality Control Commission established a visibility standard in 1990 for the Front Range cities from Fort Collins to Colorado Springs. The standard, an atmospheric extinction of 0.076 per kilometer, was based on the public's definition of unacceptable amounts of haze as judged from slides of different haze levels taken in the Denver area. At the standard, 7.6 percent of the light in a kilometer of air is blocked. The standard applies from 8 a.m. to 4 p.m. each day, during those hours when the relative humidity is less than 70 percent. Visibility, along with meteorology and levels of other pollutants for which National Ambient Air Quality Standards exist, is used to determine the need for mandatory woodburning and voluntary driving restrictions.

There is no quantitative visibility standard for Colorado's pristine and scenic rural areas. However, in the 1977 amendments to the Federal Clean Air Act, Congress added Section 169a[23] and established a national visibility goal that created a qualitative standard of "the prevention of any future and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution". The implementation of Section 169a has led to federal requirements to protect visual air quality in large national parks and wilderness areas.[24] Colorado has 12 of these Class I areas. Federal and state law prohibits visibility impairment in national parks and wildernesses due to large stationary sources of air pollution.

2.1.1.2 Visibility – Health Effects

Visual air quality is an element of public welfare. Specifically, it is an important aesthetic, natural and economic resource of the state of Colorado. The worth of visibility is difficult to measure; yet good visibility is something that people undeniably value. Impaired visibility can affect the enjoyment of a recreational visit to a scenic mountain area. Similarly, people prefer to have clear views from their homes and offices. These concerns are often reflected in residential property values and office rents. Any loss in visual air quality may contribute to corresponding losses in tourism and usually make an area less attractive to residents, potential newcomers and industry.

There is increasing information that shows a correlation between ambient concentrations of particulate matter and respiratory illnesses. Some researchers believe this link may be strongest with levels of fine particles, which also contribute to visibility impairment. In July 1997, the EPA developed a National Ambient Air Quality Standard for particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). See the section 2.0.6.1for more information on $PM_{2.5}$ and the status of the standard. Any control strategies to lower ambient concentrations of fine particulate matter for health reasons will also improve visibility.

2.1.1.3 Visibility – Sources and Characteristics

Visibility is unique among air pollution effects in that it involves human perception and judgment. It has been described as the maximum distance that an object can be perceived against the background sky. Visibility also refers to the clarity with which the form and texture of distant middle and near details can be seen as well as the sense of the trueness of their apparent coloration. As a result, measures of visibility serve as surrogates of human perception. There are several ways to measure visibility but none of them tell the whole story or completely measure visibility as human beings experience it.

The cause of visibility impairment in Colorado is most often fine particles in the 0.1 to 2.5 micrometer size range (one micrometer is a millionth of a meter). Light passing from a vista to an observer is either scattered away from the sight path or absorbed by the atmospheric fine particulate. Sunlight entering the pollution cloud may be scattered into the sight path adding brightness to the view and making it difficult to see elements of the vista. Sulfate, nitrate, elemental carbon and organic carbon are the types of particulate matter most effective at scattering and/or absorbing light. The man-made sources of these particulates include woodburning, electric power generation, industrial combustion of coal or oil, and emissions from cars, trucks and buses.

Visibility conditions vary considerably across the state. Usually, visibility in Colorado is among the best in the country. Our prized western vistas exist due to unique combinations of topography and scenic features and because air in much of the west contains low humidity and minimal levels of visibility-degrading pollution. Nevertheless, visibility problems occur periodically throughout the state.

Woodburning haze is a concern in several mountain communities each winter. Denver's “Brown Cloud” persists and other major population centers in Colorado are concerned about the potential for worsening visibility. Monitoring performed in and near national parks, monuments, and wilderness areas shows pollution-related visibility impairment occurring in these areas in Colorado. The type of impairment most often impacting Colorado's important scenic mountain views is known as regional haze. It is characterized by having many sources and interstate or even regional-scale transport between source areas and areas of impact.

The visibility problems across the state have raised public concern and spurred research. The goal of Colorado's visibility program is to protect visual air quality where it is presently good and improve visibility where it is degraded.

2.1.1.4 Visibility – Monitoring

There are several ways to measure visibility. Currently, the Division uses camera systems to provide qualitative visual documentation of a view. Transmissometers and nephelometers are used to measure the atmosphere’s ability to attenuate light quantitatively.

A visibility site was installed in Denver in late 1990 using a long path transmissometer. Visibility in the downtown area is monitored using a receiver located near Cheesman Park and a transmitter located on the roof of a downtown building. This instrument directly measures light extinction, which is proportional to the ability of atmospheric particles and gases to attenuate image-forming light as it travels from an object to an observer. The visibility standard is stated in units of atmospheric extinction. Days when visibility is affected by rain, snow or high relative humidity are termed "excluded" (as shown in Figures 21 and 22) and are not counted as violations of the visibility standard. In September 1993, a transmissometer and nephelometer were purchased by the city of Fort Collins to monitor visibility.

In Colorado, several agencies of the federal government, in cooperation with regional and nationwide state air pollution organizations, also monitor visibility in a number of Class I areas, either individually or jointly through the Inter-agency Monitoring of PROtected Visual Environments (IMPROVE) monitoring program. The goals of the monitoring programs are to establish background visibility levels, identify trends of deterioration or improvement and to identify suspected sources of visibility impairment. Visibility and the atmospheric constituents that cause visibility degradation are characterized with camera systems, transmissometers and extensive fine-particle chemical composition measurements by the monitoring network. There are currently monitoring sites in Rocky Mountain National Park, Mesa Verde National Park, Weminuche Wilderness, Mount Zirkel Wilderness, Great Sand Dunes National Monument and Maroon Bells/Snowmass Wilderness. These data are not contained in this report, but will be available at this web site address: http://alta_vista.cira.colostate.edu

2.1.2 Nitric Oxide – Sources and Characteristics

Nitric oxide is the most abundant of the oxides of nitrogen emitted from combustion sources. There are no known adverse health effects at normal ambient concentrations. However, nitric oxide is the precursor, or involved in the reaction, of nitrogen dioxide, nitric acid, nitrates and ozone, all of which have demonstrated adverse health effects.[25] There are no federal or state standards for nitric oxide.

2.1.3 Total Suspended Particulates – Sources and Characteristics

Total suspended particulates were first monitored in Colorado in 1960 at 414 14th St. in Denver. This location monitored particulates until 1988. The Adams City and Gates total suspended particulate monitors began operation in 1964 and the Denver CAMP monitor at 2105 Broadway began operating in 1965. Either the Federal EPA or the City of Denver operated these monitors until the mid-1970s when daily operation was taken over by the Colorado Department of Health.

Particulate monitoring expanded to more than 70 locations around the state by the early 1980s. The primary standards for total suspended particulates were 260 $\mu g/m^3$ as a 24-hour sample and 75 $\mu g/m^3$ as an annual geometric mean. On July 1, 1987, with the promulgation of the PM_{10} standards, the old particulate standards were eliminated. The reason that TSP samplers are still in operation is to measure particulate sulfates, lead and other metals such as cadmium, arsenic and zinc found in particulates. While there are still monitors that exceed the old standards, as can be seen by comparing the current data to the historical maximums, the levels have declined dramatically.

2.1.4 Sulfates – Sources and Characteristics

Sulfates are any of the group of compounds that contain the sulfate ion. Sulfates are generally found as fine particulate matter with a diameter of 2.5 microns or less ($PM_{2.5}$).

Natural sources of sulfates include sea spray and volcanic eruptions. Sulfates can also be directly emitted from the application of fertilizers and some industrial sources. However, most sulfates are secondary particulates not directly emitted from a source but created by the oxidation of sulfur dioxide. Sulfur dioxide can be transformed into sulfate by several atmospheric chemical reactions. These various reactions involve water vapor, ozone, hydrocarbons, peroxides or free radicals. Atmospheric sulfates usually exist as sulfuric acid or ammonium sulfate.[26]

2.1.4 Sulfates – Health Effects

Health impacts are associated with acidic sulfate aerosols. In laboratory studies, short-term exposures of 100 $\mu g/m^3$ of sulfuric acid, a level at the extremely high end of the ambient concentrations, have been shown to cause respiratory impairment in some healthy adults and no effect in others. Some studies have shown decreased lung function in exercising adolescents with asthma, while other studies have shown no adverse effects on this group at 100 $\mu g/m^3$ of sulfuric acid. Increased respiratory difficulties are seen with exposures to sulfur dioxide. Further sensitivity studies are necessary to find the health impacts of sulfate.[27,28]

Fine particulate sulfate is efficient at scattering light; thus, it is a factor in visibility degradation. Even at low concentrations, below 3 $\mu g/m^3$, sulfate will affect visibility. The light-scattering potential of sulfate increases with increasing relative humidity. Seasonal changes in sulfate levels are associated with seasonal changes in visual range in the western United States.[29] Section 2.1.1.4 of this report provides further discussion concerning visibility issues in Colorado.

Sulfate compounds, as acid deposition, can adversely affect aquatic and terrestrial ecosystems. Water supplies are affected when minerals are leached from the soil by acid deposition. Drinking water containing either sulfates or leached metals can cause human health problems.

No standards have been promulgated for sulfates. Control of sulfates is achieved by federal ambient and source emissions standards for sulfur dioxide and PM_{10}.

2.1.5 Arsenic – Sources and Characteristics

The Agency for Toxic Substances and Disease Registry report on arsenic says: "EPA has set limits on the amount of arsenic that industrial sources can release to the environment and has restricted or canceled many uses of arsenic in pesticides. EPA has set a limit of 0.05 parts per million (ppm) for arsenic in drinking water. The EPA arsenic drinking water standard of 0.01 ppm (10 ppb) reported in the ATSDR February 2001 Arsenic ToxFAQs was based on the EPA final rule for arsenic in drinking water, published on January 22, 2001, in the Federal Register. However, the EPA is currently reviewing the science and cost estimate supporting this rule, and, in the interim, has reverted to the previous standard for arsenic. Thus, the current EPA arsenic drinking water standard remains at 0.05 ppm (50 ppb).

The Occupational Safety and Health Administration has set limits of 10 microgram arsenic per cubic meter of workplace air (10 $\mu g/m^3$) for 8-hour shifts and 40 hour work weeks."[30]

2.1.6 Cadmium – Sources and Characteristics

The Agency for Toxic Substances and Disease Registry report on cadmium says: "Cadmium is a natural element in the earths crust. It is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate or cadmium sulfide)." The primary sources for cadmium exposure in the environment are from pigments, batteries and metal coatings.[31]

The only federal limits established for cadmium are 5 parts per million in drinking water and 100 micrograms of cadmium per cubic meter of workplace air as fumes and 200 micrograms per cubic meter as cadmium dust.

2.1.7 Meteorology

The Air Pollution Control Division takes a limited set of meteorological measurements at nineteen locations around the state. These measurements are limited to wind speed, wind direction, temperature, standard deviation of horizontal wind direction and some monitoring of relative humidity. Relative humidity measurements are also taken in conjunction with the two visibility monitors and the $PM_{2.5}$ particulate monitors. The humidity data are not summarized in this report since they are used primarily to validate the visibility and particulate measurements taken at the specific locations. In addition the Division does not collect precipitation measurements. The wind speed, wind direction and temperature measurements are collected primarily for air quality forecasting and air quality modeling. The instruments are on ten-meter towers and the data are stored as hourly averages.

This year's report has included a graphical representation of annual wind speed and direction data known as a wind rose. These wind roses are placed on a background map that shows the approximate location of the meteorological site. The wind roses are based on the direction that the wind is blowing from. Another way of visualizing a wind rose is to picture yourself standing in the center of the plot and facing into the wind. The wind direction is broken down in the 16 cardinal directions (i.e. N, NNE, NE, ENE, E, ESE, SE, SSE, S, etc). The wind speed is broken down in 6 categories. The graphs in this report use 1-3 mph, 4-5 mph, 7-11 mph, 12-14 mph, 15-38 mph and greater than 38 mph. The length of each arm of the wind rose represents the percentage of time the wind was blowing from that direction at that speed. The longer the arm the greater percentage of time the wind is blowing from that direction. A review of the wind rose in Figure 14, for example, shows that in Lamar the majority of the winds come from the west and west-northwest and that these winds are generally in the 1-3 mph and 4-6 mph range.

2.1.8 Air Toxics – Sources and Characteristics

Toxic air pollutants, or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects. Air toxics may also cause adverse environmental and ecological effects. EPA is required to reduce air emissions of 188 air toxics listed in the Clean Air Act. Examples of toxic air pollutants include benzene, found in gasoline; perchloroethylene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent by a number of industries. Most air toxics originate from man-made sources, including mobile sources (e.g., cars, trucks, construction equipment) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires.[32]

People exposed to toxic air pollutants at sufficient concentrations may experience various health effects including cancer, and damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, respiratory and other health problems. In addition to exposure from breathing air toxics, risks also are associated with the deposition of toxic pollutants onto soils or surface waters, where they are taken up by plants and ingested by animals and eventually magnified up through the food chain. Like humans, animals may experience health problems due to air toxics exposure.

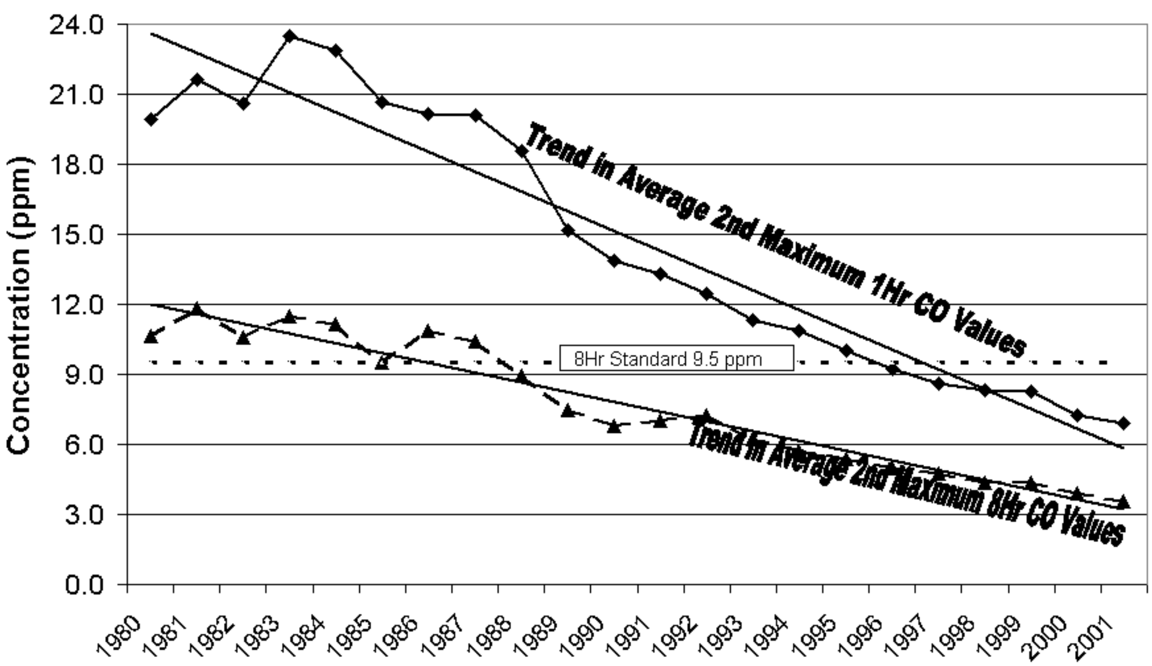
3.0 Statewide Summaries For Criteria Pollutants

3.1 Carbon monoxide

Carbon monoxide levels have dropped dramatically from the early 1970s. This change can be seen in both the concentrations measured and the number of monitors in the state that exceeded the level of the 8-hour standard of 9.5 ppm. In 1975, 9 of the 11 state-operated monitors exceeded the 8-hour standard. In 1980, 13 of the 17 state-operated monitors exceeded the 8-hour standard. Since 1995 the Colorado has recorded only one exceedance of the 8-hour standard at any of the 13 monitors.

Figure 9

Statewide Ambient Trends - CO



As shown in the Figure 9, through out the 1980s the average 2nd maximum 8-hour concentration for all state-operated carbon monoxide monitors was greater than the 8-hour standard of 9.5 ppm. In 2001 the statewide average was 3.5 ppm. This is about a 65 percent drop in 20 years of monitoring.

The trend in the 1-hour average carbon monoxide concentrations statewide has fallen even more drastically than the 8-hour concentrations. The maximum concentration ever recorded at any of the state-operated monitors was a 79.0 ppm recorded at the Denver CAMP monitor in 1968. As shown in Table 6, exceedances of both the 1-hour and 8-hour standard were common in the late 1960s and early 1970s. In 2001, the maximum 1-hour concentration was again recorded at the Denver CAMP monitor, but it was 14.4 ppm. In comparison, in 1966, there were 367 exceedance periods of the 8-hour standard compared to none in 1996, 1997, 1998, 2000 and 2001. The 1-hour annual maximum levels have declined from more than twice the standard in the late 1960s to less than one half of the standard in 2001.

Table 4 - Historical Maximum 1-Hr and 8-Hr Carbon Monoxide Concentrations[33]

1-Hour ppm	Location	Date	Number of Annual Exceedances Periods	8-Hour ppm	Location	Date	Number of Annual Exceedances Periods
79.0	CAMP	11-20-68	13	48.1	CAMP	12-21-73	133
70.0	CAMP	11-21-74	15	33.9	CAMP	12-28-65	197
67.0	CAMP	12-21-73	21	33.4	CAMP	12-04-81	42
65.0	CAMP	12-21-73	21	33.2	CAMP	12-23-71	188
64.9	NJH-W	11-16-79	15	33.1	CAMP	11-20-68	98

3.2 Ozone

Figure 12, Statewide Ambient Trends, shows that the second maximum 1-hour ozone levels have had a consistent decline since 1983. The trend is not as clear for the 8-hour average ozone levels but over the past twenty years it is slightly downward. However, in the past six years there has been no real change in levels for either the 1-hour or 8-hour averages at all. The elevated concentrations recorded in 1998 are the result of a hot dry summer.

Figure 10

Statewide Ambient Trends - Ozone

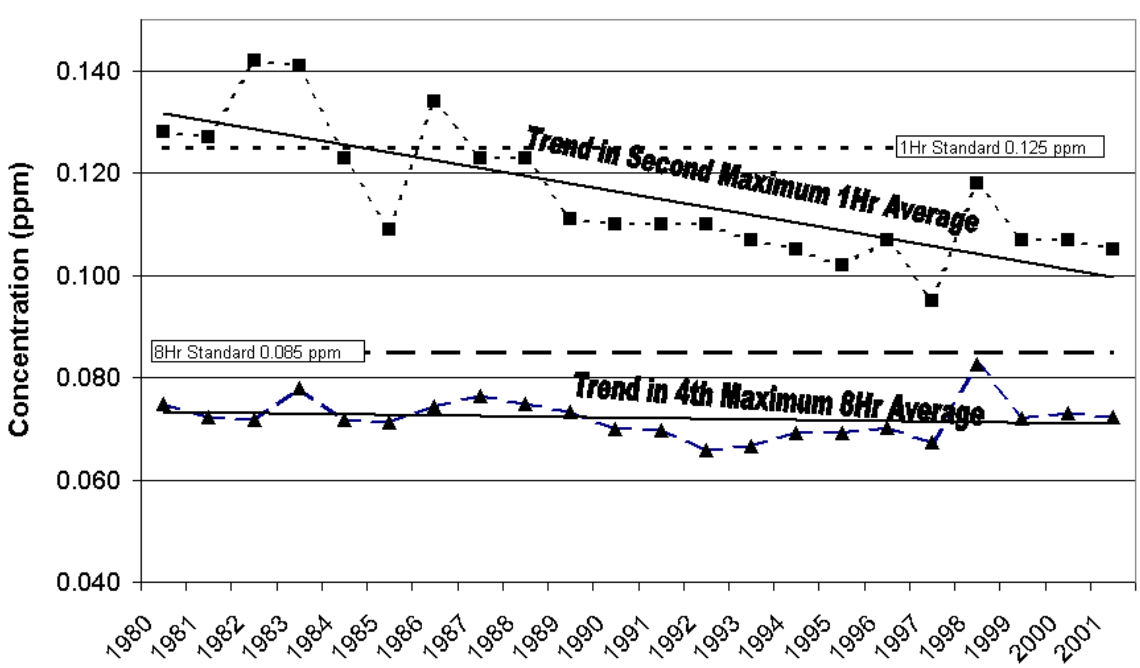


Table 5 lists the five highest 1-hour ozone concentrations recorded in Colorado. Ozone monitoring began in 1972 at the Denver CAMP station and eight exceedances of the standard were recorded that year. However, data before 1975 are not included because quality assurance and maintenance records are no longer available. In addition, a review of the ozone data before 1975 shows several values that are questionable because of time of day, time of year and inconsistencies with other monitors in the area.

Table 5 - Historical Maximum 1-Hour Ozone Concentrations[34]

1-Hour ppm	Monitor	Date
0.223	Welby	March 3, 1978
0.197	Arvada	July 28, 1975
0.186	Children's Asthmatic Research Institute and Hospital, 23rd Ave. & Julian St.	September 17, 1976
0.184	Arvada	June 30, 1976
0.182	Welby	August 5, 1975

3.3 Sulfur Dioxide

The concentrations of sulfur dioxide in Colorado have never been a major health concern since we do not have the types of industries that burn large amounts of coal. The concern in Colorado with sulfur dioxide has been associated with acid deposition and its affects on the mountain lakes and streams. Historically the maximum annual concentration recorded by Department monitors was 0.018 ppm in 1979 at the Denver CAMP monitor. The annual standard is 0.030 ppm. Since 1990 the annual average at the Denver CAMP monitor has declined from a high in 1992 of 0.010 ppm to 0.005 ppm in 2001.

Figure 19 shows both the declining trend in sulfur dioxide readings as well as the generally low levels of sulfur dioxide recorded at the Division's monitors. This same trend is evident, although not as pronounced, in the 3-hour and 24-hour averages as well.

Table 6 - Historical Maximum Annual Average Sulfur Dioxide Concentrations[35]

Annual Average ppm	Monitor	Date
0.018	Denver CAMP	1979
0.013	Denver CAMP	1980
0.013	Denver CAMP	1981
0.013	Denver CAMP	1983
0.012	Denver CAMP	1978

3.4 Nitrogen Dioxide

Colorado exceeded the nitrogen dioxide standard in 1977 at the Denver CAMP monitor. However, levels have shown a gradual but constant decline since then. The missing data between 1990 and 1992 are due to instrument problems and make the trend for Colorado less clear. However, the annual average has been nearly flat for the past seven years.

Figure 20 shows the general decline in nitrogen dioxide levels from those recorded in the mid-1970s and early 1980s. It also shows the slight increase in levels over the past nine years. The cause of this change is most likely due to an increase in the number of vehicles and increased power consumption associated with the increases in population in the Denver-metro area.

Table 7 - Historical Maximum Annual Average Nitrogen Dioxide Concentrations[36]

Annual Average ppm	Monitor	Date
0.052	Denver CAMP	1975
0.052	Denver CAMP	1976
0.052	Denver CAMP	1979
0.052	Denver CAMP	1973
0.051	Denver CAMP	1977

3.5 Particulates – PM_{10}

Particulate matter 10 microns and smaller (PM_{10}) data has been collected in Colorado since 1985. The samplers were modified in 1987 to conform to the requirements of the new standard when it was established in July of 1987. Therefore annual trends are only valid back to July 1987.

Since 1988 the state has had at least one monitor exceed the level of the 24-hour PM_{10} standard (150 $\mu g/m^3$) every year. By contrast, no monitor with at least 75 percent data recovery has exceeded the level of the annual standard (50 $\mu g/m^3$). In both cases however, the trend in the statewide concentrations has been down. As seen in the following graph the there is a great deal more variation in the 24-hour maximum values than in the annual averages but the trend in both levels is down even if the 412 $\mu g/m^3$ in 1991 is removed.

The data contained in the Statewide Trends graph, and the data in the Historical Maximum values table, do not reflect those concentrations that are the result of exceptional events. There have been several of these events documented in Colorado since 1988. In general, in order to qualify for this exclusion a value (or values) has to be associated with a regional natural phenomenon. One such event was the large wind and dust storm that occurred on March 31, 1999 when monitors from Steamboat Springs to Telluride reported high PM_{10} levels. Similar exceptional events have been documented in Lamar and Alamosa.

These events are not included, not because they are without any health risk but because they are natural and are not controllable or predictable.

Figure 11
Statewide Ambient Trends - PM10

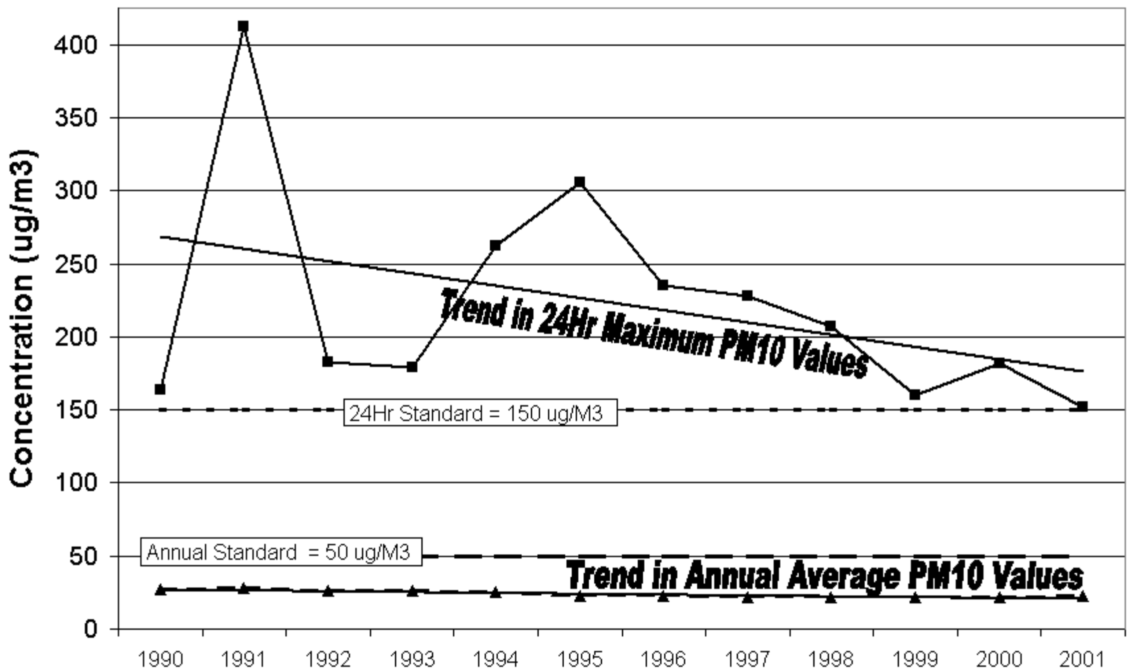


Table 8 - Historical Maximum 24-Hour PM_{10} Concentrations[37]

24-hour Maximum µg/m³	Monitor	Date
412	Alamosa	4-10-1991
306	Cripple Creek	12-27-1995
262	Pagosa Springs	12-29-1994
236	Aspen	2-22-1991
235	Cripple Creek	2-11-1997

3.6 Particulates – $PM_{2.5}$

Monitoring for $PM_{2.5}$ in Colorado began with the establishment of sites in Denver, Grand Junction, Steamboat Springs, Colorado Springs, Greeley, Fort Collins, Platteville and Elbert County in 1999. Additional sites were established nearly every month until full implementation of the base network was achieved in April of 2000. By 2001, there were twenty $PM_{2.5}$ monitoring sites in Colorado. Thirteen of the twenty sites were selected based on the population of the metropolitan statistical areas. This is a federal selection criteria that was developed to protect the public health in the highest population centers. In addition, there are seven special purpose-monitoring sites. These sites were selected due to historically elevated levels of PM_{10} or because citizens or local governments had concerns of possible high $PM_{2.5}$ concentrations in their communities.

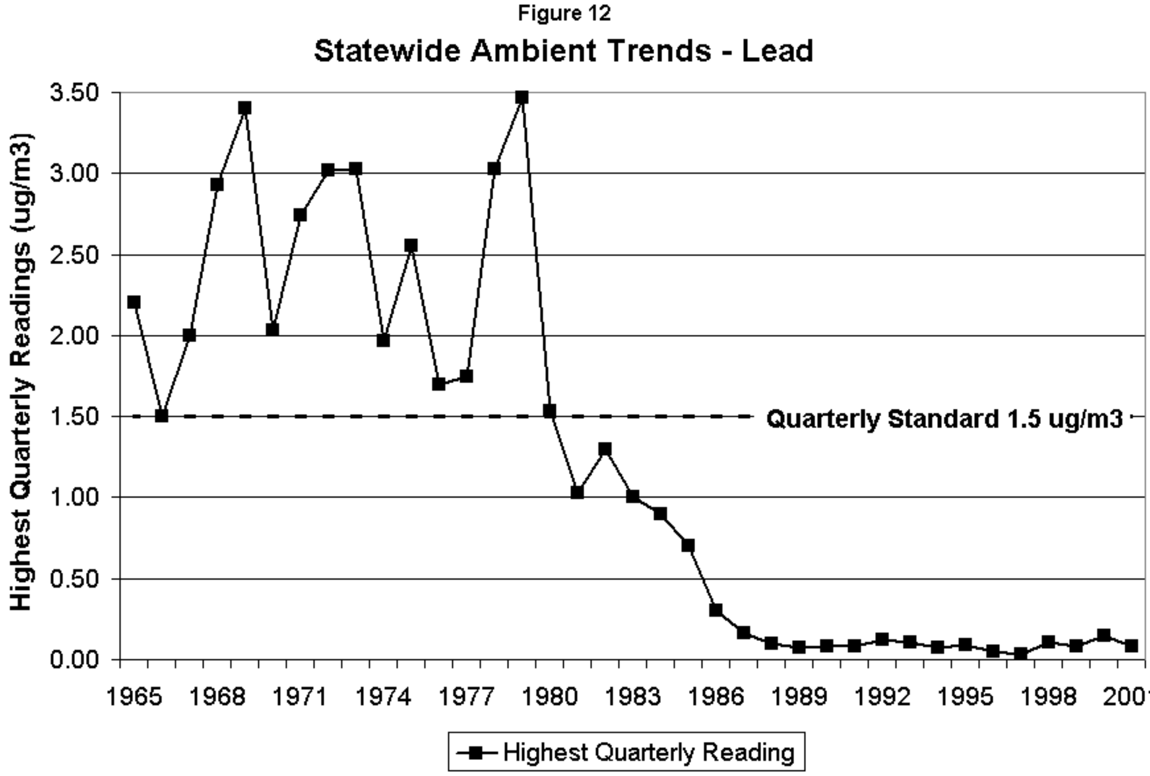
Only one site in Colorado has exceeded the level of the new 24-hour standard and no sites have exceeded the level of the new annual standard. The Denver CAMP site exceeded the 24-hour level of the standard twice in 2002. The exceedances occurred on Thursday, February 15, 2001 (68.4 $\mu g/m^3$) and Saturday, February 17, 2001 (68.0 $\mu g/m^3$). This is not a violation of the standard since this determination cannot be made until three complete years of data are collected at this location.

The $PM_{2.5}$ site in Grand Junction is the only site with three complete calendar years of data to compare to the standards and it is well below both the 24-hour and the annual $PM_{2.5}$ standards.

3.7 Lead

In Colorado the last violation of the federal lead standard occurred in the first quarter of 1980 at the Denver CAMP monitor. Since then, the levels recorded at all monitors have shown a steady decline, to the point where now all monitors are regularly at or near the minimum detectable limits of analysis. This decline is the direct result of the use of unleaded

Figure 12



gasoline and replacement of older cars with newer ones that do not require leaded gasoline. The reduction in atmospheric lead shows what pollution control strategies can accomplish.

Table 9 - Historical Maximum Quarterly Lead Concentrations[38]

Quarterly Maximum $\mu g/m^3$	Monitor	Date
3.47	Denver CAMP, 2105 Broadway	1st Qtr 1979
3.40	Denver, 414 14th St.	4th Qtr 1969
3.03	Denver, 414 14th St.	1st Qtr 1973
3.03	Denver CAMP, 2105 Broadway	4th Qtr 1978
3.02	Denver, 414 14th St.	4th Qtr 1972

4.0 National Comparisons For Criteria Pollutants

4.1 Carbon monoxide

According to the Environmental Protection Agency's emissions trends report: "Nationally, the 2000 ambient average CO concentration is 61 percent lower than that for 1981 and is the lowest level recorded during the past 20 years. Carbon monoxide emissions levels decreased 18 percent over the same period. Between 1991 and 2000, ambient CO concentrations decreased 41 percent, and the estimated number of exceedances of the national standard decreased 95 percent while CO emissions fell 5 percent. This improvement occurred despite a 24 percent increase in vehicle miles traveled in the United States during this 10-year period."[39]

4.2 Ozone

In 1997, EPA revised the national ambient air quality standards for ozone by setting new 8-hour 0.08 ppm standards. Currently, EPA is tracking trends based on both the 1-hour and 8-hour data.

Over the past 20 years, national ambient ozone levels decreased 21 percent based on 1-hour data, and 10 percent based on 8-hour data. Between 1981 and 2000, emissions of volatile organic compounds (VOCs) have decreased 32 percent. During that same time period, emissions of the oxides of nitrogen (NO_X) increased 4 percent.[40]

Because sunlight and heat play a major role in ozone formation, changing weather patterns contribute to yearly differences in ozone concentrations. To better reflect the changes that emissions have on measured air quality concentrations, EPA is able to make analytical adjustments to account for this annual variability in meteorology. For 52 metropolitan areas, the adjusted trend for 1-hour ozone levels shows improvement over the 20 year period from 1981–2000. However, beginning in 1994, the rate of improvement appears to level off and the trend in the last 10 years is relatively flat.

Across the country, the highest ambient ozone concentrations are typically found at suburban sites, consistent with the downwind transport of emissions from urban centers. During the past 20 years, ozone concentrations decreased more than 24 percent at urban sites and declined by 21 percent at suburban sites. For the more recent 10-year period, urban sites show decreases of approximately 12 percent and suburban sites show 11 percent decreases. However, at rural monitoring locations national improvements have been slower. One-hour ozone levels for 2000 are 15 percent lower than those in 1981 but only 6 percent below 1991 levels. In 2000, for the third consecutive year, rural 1-hour ozone levels are greater than the levels observed for the urban sites, but they are still lower than levels observed at suburban sites.

4.3 Sulfur Dioxide

Nationally, average sulfur dioxide (SO_2) ambient concentrations have decreased 50 percent from 1981to 2000 and 37 percent over the more recent 10-year period 1991–2000. Sulfur dioxide emissions decreased 31 percent from 1981 to 2000 and 24 percent from 1991–

2000. Reductions in SO_2 concentrations and emissions since 1994 are due, in large part, to controls implemented under EPA's Acid Rain Program beginning in 1995.[41]

4.4 Nitrogen Dioxide

Over the past 20 years, monitored levels of NO_2 have decreased 14 percent. All areas of the country that once violated the national air quality standard for NO_2 now meet that standard. While levels around urban monitors have fallen, national emissions of nitrogen oxides have actually increased over the past 20 years by 4 percent. This increase is the result of a number of factors, the largest being an increase in nitrogen oxides emissions from diesel vehicles. This increase is of concern because NO_X emissions contribute to the formation of ground-level ozone (smog), but also to other environmental problems, such as acid rain and nitrogen loadings to water bodies.[42]

4.5 Particulates – PM_{10}

Between 1991 and 2000, average PM_{10} concentrations decreased 19 percent, while direct PM_{10} emissions decreased 6 percent.[43]

4.6 Particulates – $PM_{2.5}$

As the national monitoring network started in 1999, there are not enough data to show a national long-term trend in urban $PM_{2.5}$ air quality concentrations. However, 36 sites in the IMPROVE network (10 in the East, and 26 in the West) have enough data to assess trends in average rural $PM_{2.5}$ concentrations from 1992–1999. In the East, where sulfates contribute most to $PM_{2.5}$, the annual average across the 10 sites decreased 5 percent from 1992–1999. The peak in 1998 is associated with increases in sulfates and organic carbon. Average $PM_{2.5}$ concentrations across the 26 sites in the West from 1992–1999, were about one-half of the levels measured at Eastern sites.

4.7 Lead

Because of the phase-out of leaded gasoline, lead emissions and concentrations decreased sharply during the 1980s and early 1990s. The 2000 average air quality concentration for lead is 93 percent lower than in 1981. Emissions of lead decreased 94 percent over that same 20-year period. Today, the only violations of the lead national air quality standard occur near large industrial sources such as lead smelters.[44]

5.0 Monitoring Results by Area in Colorado

5.1 Eastern Plains Communities

The Eastern Plains Communities are those east of the I-25 corridor. Historically there have been a number of communities that were monitored for particulates. In the northeast along the I-76 corridor, the communities of Sterling, Brush and Fort Morgan have been monitored. Along the I-70 corridor only the community of Limon has been monitored for particulates. In the southeast, the US-50/Arkansas River corridor, only Lamar is currently monitored for particulates. The communities of La Junta and Rocky Ford have been monitored in the past, but like the other communities that have been monitored on the Eastern Plains, the monitoring was discontinued when the levels were shown to be below the standard.

Table 10 – Eastern Plains Monitors In Operation For 2001

X - Monitors continued in 2001 A – Monitors added in 2001

D – Monitors discontinued in 2001 H – Hourly particulate monitor

County	Site Name	Location	PM_{10}	Met
Prowers	Lamar	100 2nd St.	X	
		104 Parmenter St.	X	X

Table 11 – Eastern Plains Particulate Values For 2001

Site Name	Location	PM_{10} (µg/m^3)	
		Annual Average	24-hour Maximum
Lamar	100 2nd St.	31	152
	104 Parmenter St.	23	101

Figure 13 - Eastern Plains Particulate Graphs

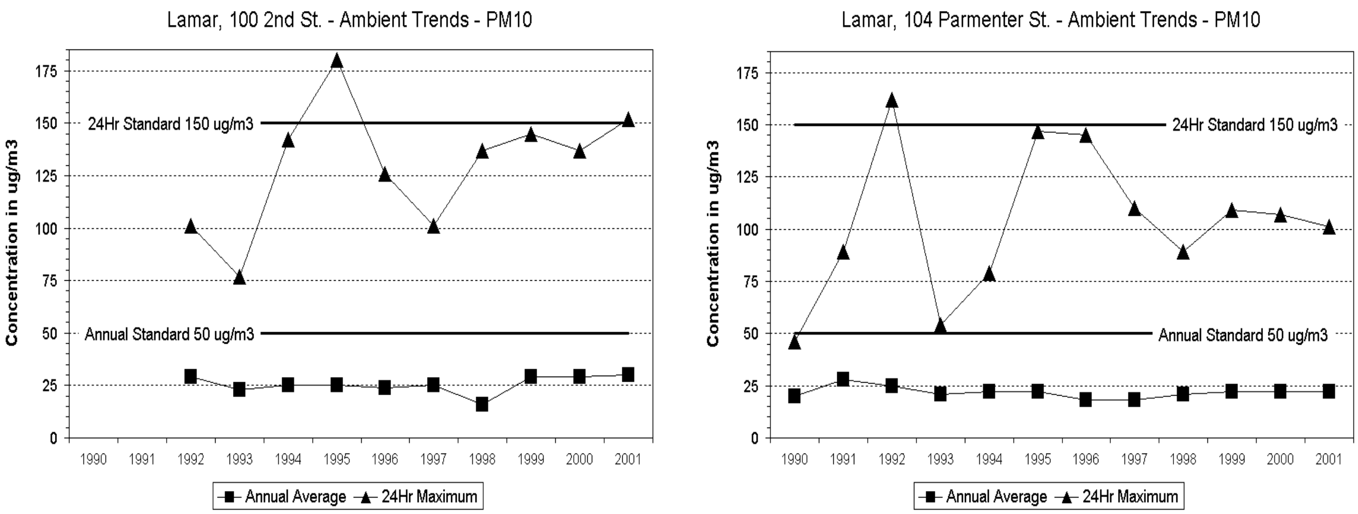
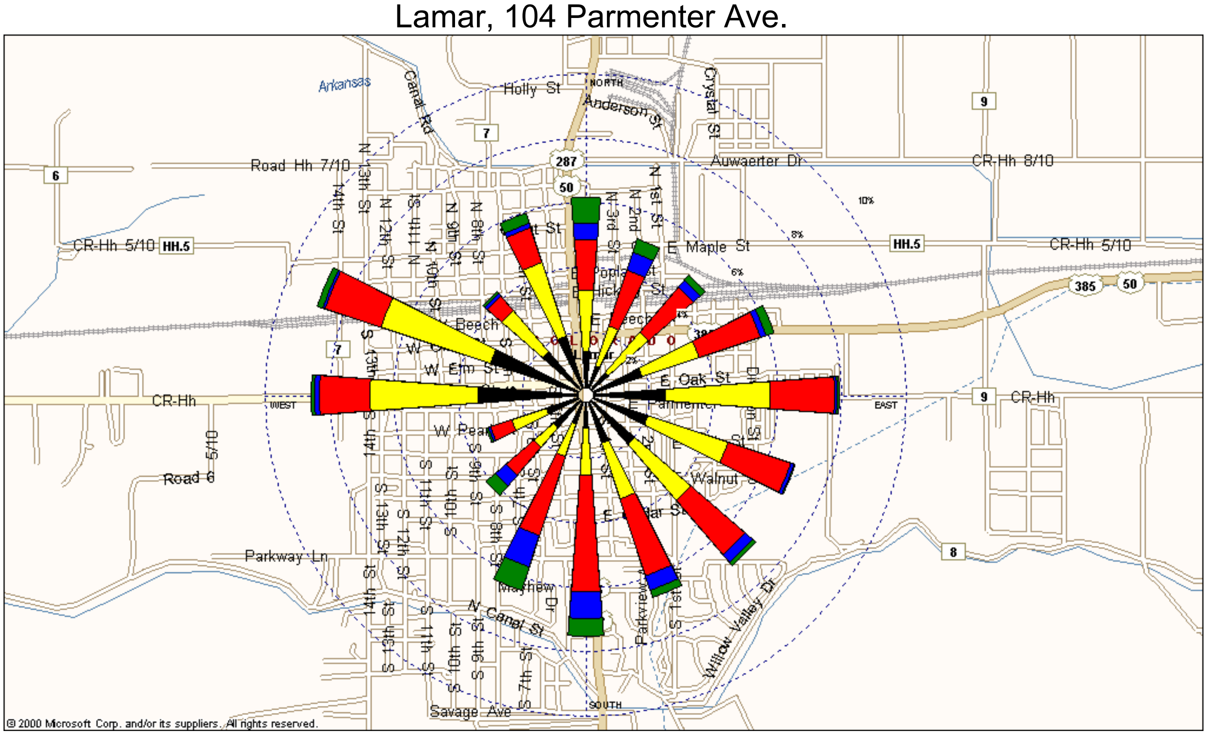


Figure 14 - Eastern Plains Wind Rose

Lamar, 104 Parmenter Ave.



5.2 Northern Front Range Communities

The Northern Front Range Communities are those along the I-25 corridor from the Colorado/Wyoming border to just south of the city of Castle Rock. This area has the majority of the larger cities in the state. The majority of monitors are located in the Denver-metro area and the rest are located in or near Fort Collins, Greeley, Longmont and Boulder.

Table 12 - Northern Front Range Particulate Monitors In Operation For 2001

X - Monitors continued in 2001 A – Monitors added in 2001
D – Monitors discontinued in 2001 H – Hourly particulate monitor

County	Site Name	Location	TSP	Pb	Metals	PM_{10}	$PM_{2.5}$
Adams	Adams City	4301 E. 72nd Ave.	D	D	D	D	D
	Globeville	5400 Washington St.	X	X	X		
	Commerce City	7101 Birch St.	A	A	A	A	A
	Brighton	22 S. 4th Ave.				X	
	Welby	78th Ave. & Steele St.				X/H	
Arapahoe	Arapahoe Community Coll.	6190 S. Santa Fe Dr.					X
Boulder	Boulder	2440 Pearl St.				X	X
	Longmont	3rd Ave & Kimbark St.				X	X
	Hygiene	7024 Ute Hwy.				X	
Denver	Denver CAMP	2105 Broadway	X	X		X/H	X/H
	Denver Gates	1050 S. Broadway	X	X		X	X
	Visitor Center	225 W. Colfax Ave.				X	
	Lowry AFB	8100 Lowry Blvd.				X	
Douglas	Castle Rock	310 3rd St.				D	
	Parker	10851 S. Crossroads					D
Elbert	Elbert	Wright-Ingraham Inst.					X
Jefferson	Rocky Flats	16600 W. Hwy. 128	D			D	
		11501 Indiana St.	D			D	
		9901 Indiana St.	D			D	
		18000 W. Hwy. 72	D			D	
		11190 N. Hwy. 93	D			D	
Larimer	Fort Collins	200 W. Oak St.				D	D
		251 Edison St.				X	X
Weld	Greeley	1516 Hospital Rd.				X	X
	Platteville	1004 Main St.					X

Table 13 - Northern Front Range Particulate Values For 2001

Site Name	Location	PM_{10} ($\mu g/m^3$)		$PM_{2.5}$ ($\mu g/m^3$)	
		Annual Average	**24-hour Maximum**	**Annual Average**	**24-hour Maximum**
Adams City	4301 E. 72nd Ave.	(34)	134	(12.3)	57.3
Commerce City	7101 Birch St.	36	142	10.5	54.7
Brighton	22 S. 4th Ave.	20	61		
Welby	78th Ave. & Steele St.	28	81		
Arapahoe Community College	6190 S. Santa Fe Dr.			8.9	32.5
Boulder	2440 Pearl St.	24	49	8.4	33.4
Longmont	3rd Ave. & Kimbark St.	22	57	9.9	42.0
Hygiene	7024 Ute Hwy.	19	123		
Denver CAMP	2105 Broadway	39	78	11.9	68.4
Denver Gates	1050 S. Broadway	28	49		
Visitor Center	225 W. Colfax Ave.	37	119		
Lowry AFB	8100 Lowry Blvd.	22	89		
Castle Rock	310 3rd St.	(15)	26		
Parker	10851 S. Crossroads			6.4	15.3
Elbert	Wright-Ingraham Inst.			4.3	11.6
Rocky Flats	16600 W. Hwy. 128	(14)	30		
	11501 Indiana St.	(16)	33		
	9901 Indiana St.	(16)	28		
	18000 W. Hwy. 72	(15)	28		
	11190 N. Hwy. 93	(16)	33		
Fort Collins	200 W. Oak St.	(18)	30		
	251 Edison St.	20	47		
Greeley	1516 Hospital Rd.	21	55	9.6	14.2
Platteville	1004 Main St.			(9.6)	14.2

( ) indicates less than 75% data for the year.

Table 14 - Northern Front Range TSP and Lead Values For 2001

Site Name	Location	TSP ($\mu g/m^3$)		Lead ($\mu g/m^3$)	
		Annual Geometric Mean	24-hour Maximum	Maximum Quarter	24-hour Maximum
Adams City	4301 E. 72nd Ave.	(84)	168	(0.02)	0.04
Globeville	5400 Washington St.	97	230	0.10	0.41
Commerce City	7101 Birch St.	(89)	211	(0.04)	0.19
Denver CAMP	2105 Broadway	97	164	0.04	0.14
Denver Gates	1050 S. Broadway	67	141	(0.03)	0.09
Rocky Flats	16600 W. Hwy. 128	(29)	98		
	11501 Indiana St.	(37)	88		
	9901 Indiana St.	(34)	88		
	18000 W. Hwy. 72	(40)	129		
	11190 N. Hwy. 93	(58)	109		

( ) indicates less than 75% data for the year.

Table 15 - Northern Front Range Metals & Sulfate Values For 2001

Site Name	Arsenic ($\mu g/m^3$)		Cadmium ($\mu g/m^3$)		Sulfate ($\mu g/m^3$)	
	Annual Average	24-hour Maximum	Annual Average	24-hour Maximum	Annual Average	24-hour Maximum
Adams City	(0.005)	0.005	(0.0017)	0.003	(6.05)	12.3
Globeville	(0.005)	0.010	(0.0028)	0.031		
Commerce City	(0.005)	0.005	(0.0015)	0.002	(5.95)	9.1
Denver CAMP					(6.69)	17.8

( ) indicates less than 75% data for the year.

Figure 15 - Northern Front Range Particulate Graphs

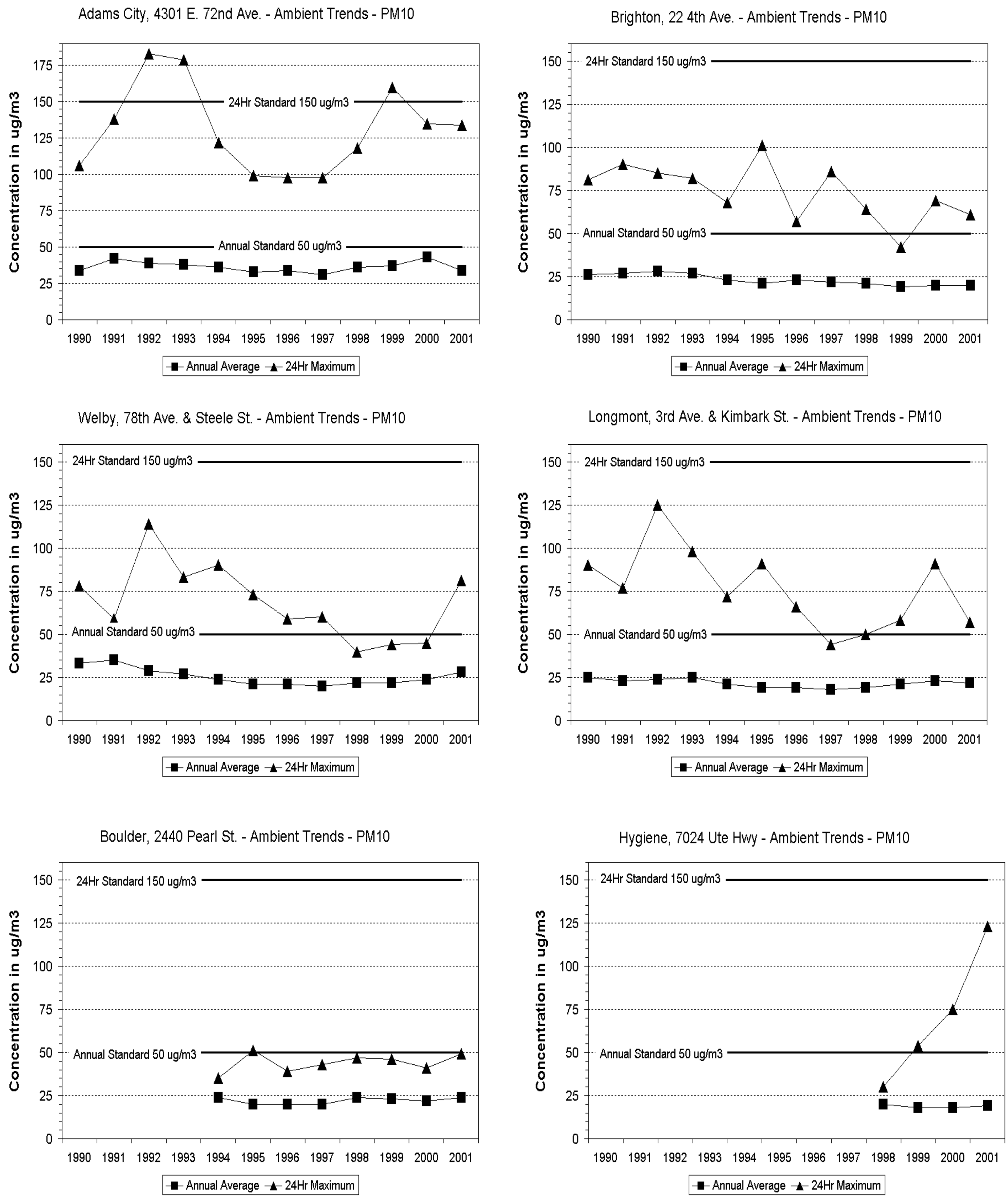
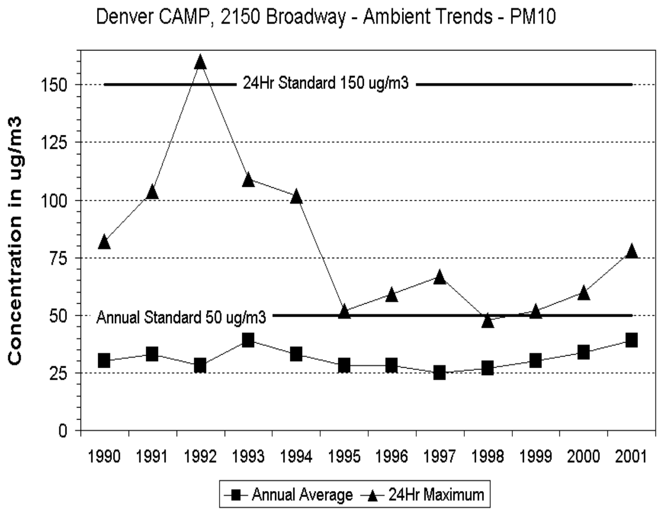
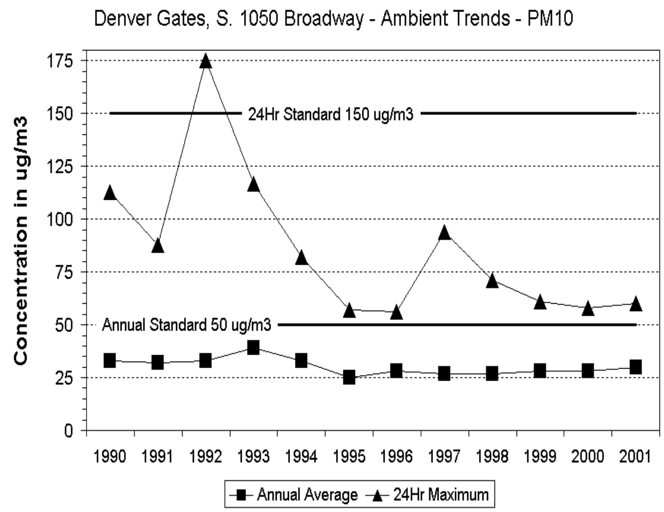
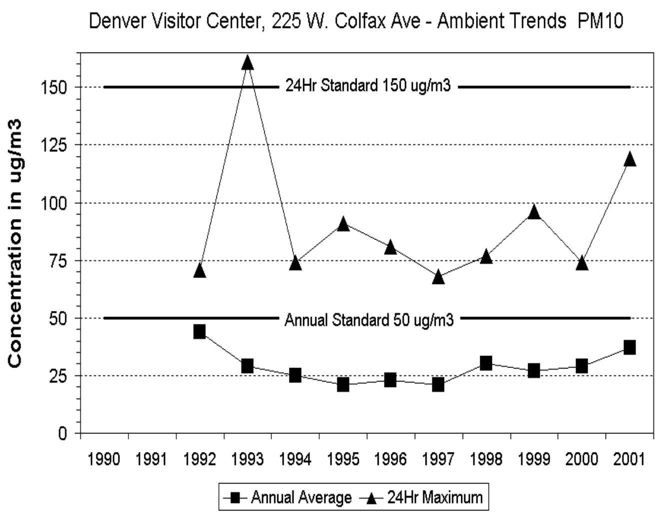
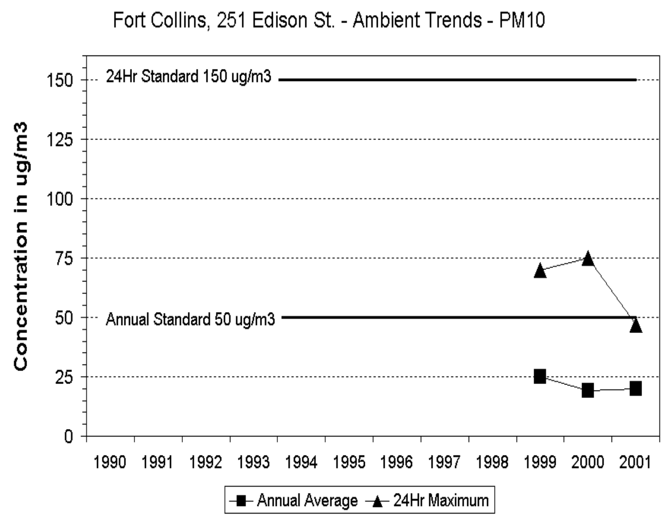


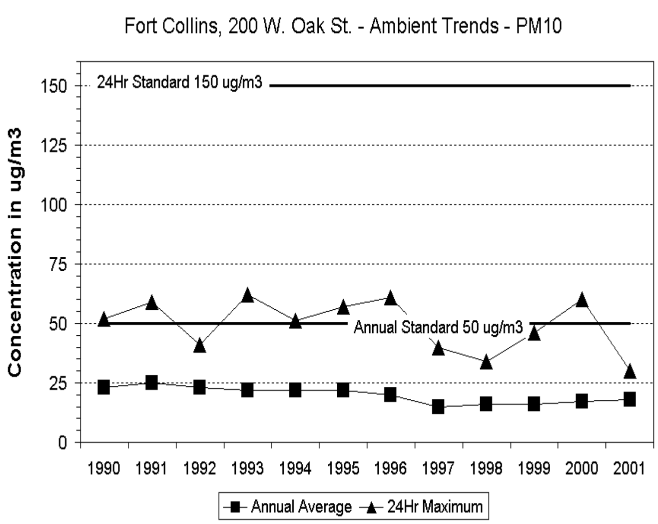
Figure 15 - Northern Front Range Particulate Graphs (continued)











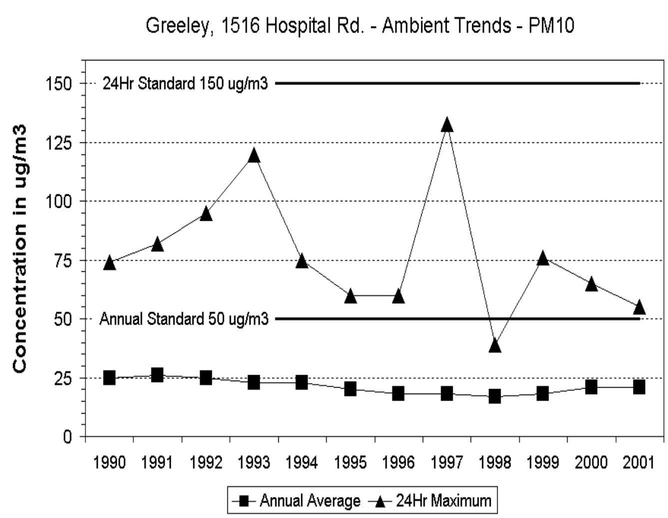
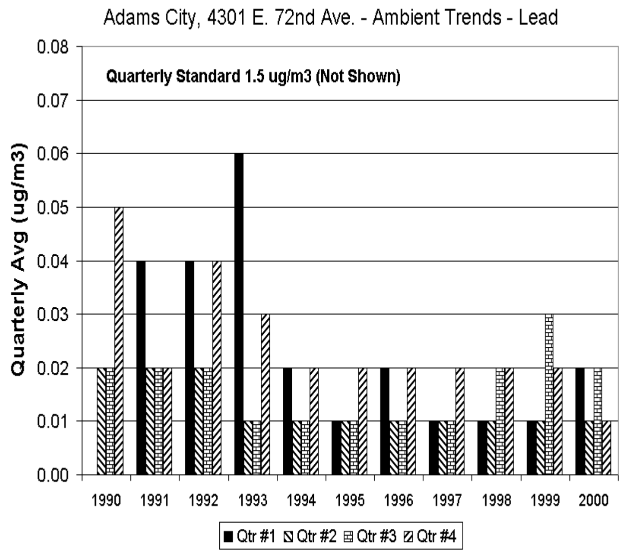
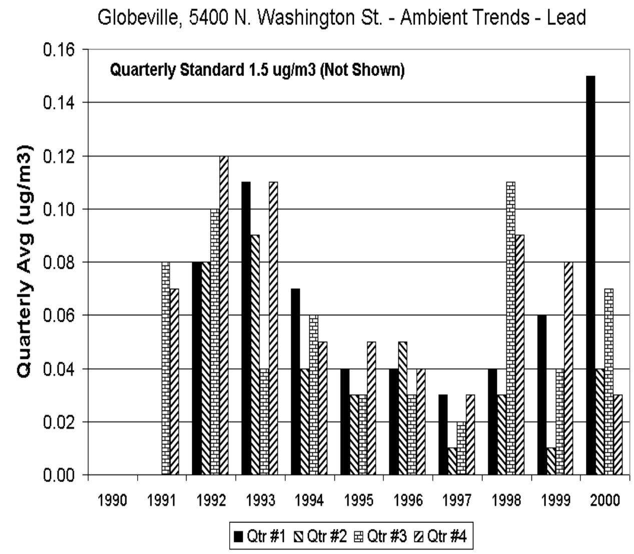
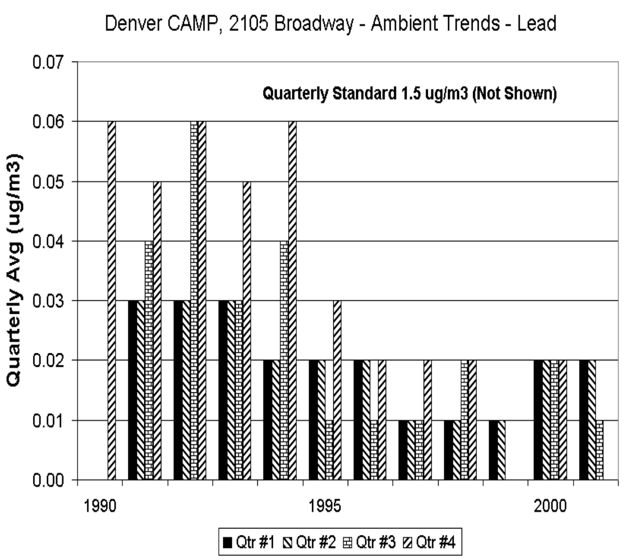


Figure 16 - Northern Front Range Lead Graphs







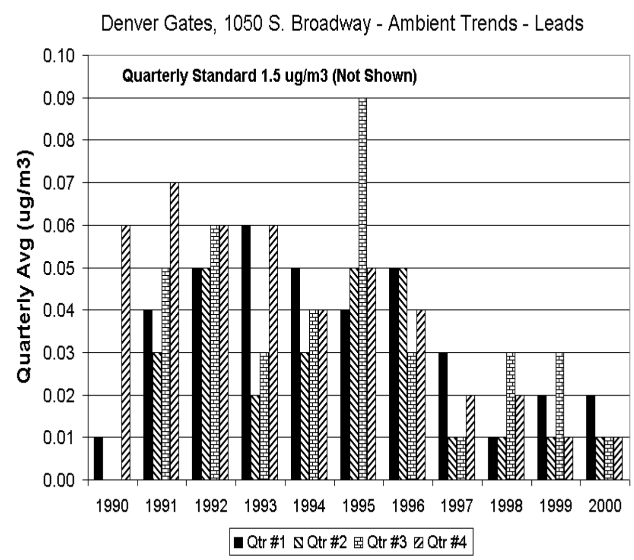


Table 16 - Northern Front Range Continuous Monitors In Operation For 2001

X - Monitors continued in 2001 A – Monitors added in 2001

D – Monitors discontinued in 2001 H – Hourly particulate monitor

Site Name	Location	CO	SO_2	NO_X	O_3	Met
Welby	78th Ave. & Steele St.	X	X	X	X	X
S. Adams Pump	5580 Niagara St.		A			
Highland Res.	8100 S. University Blvd.				X	X
Boulder	2150 28th St.	X				
	1405½ S. Foothills Rd.				X	
Longmont	440 Main St.	X				
Denver CAMP	2105 Broadway	X	X	X		X
Denver NJH	14th Ave. & Albion St.	X				
Denver Carriage	23rd Ave. & Julian St.	X			X	X
Firehouse #6	1300 Blake St.	X				
Auraria Lot R	Auraria Parkway					X
Chatfield Res.	Roxbourgh Park Rd.				X	
Arvada	W. 57th Ave. & Garrison	X			X	X
Welch	12400 W. Hwy. 285				X	X
NREL	20th Ave & Quaker St.				X	
Rocky Flats	16600 W. Hwy. 128				X	X
	11501 Indiana St.					X
	9901 Indiana St.			D		X
	18000 W. Hwy. 72					X
	11190 N. Hwy. 93			D		X
Fort Collins	708 S. Mason St.	X			X	X
Greeley	811 15th Ave.	X			X	

Table 17 - Northern Front Range Carbon Monoxide Values For 2001

Site Name	Location	CO 1-hour Avg. (ppm)		CO 8-hour Avg. (ppm)	
		Max	2nd Max	Max	2nd Max
Welby	78th Ave. & Steele St.	6.1	5.8	3.4	3.3
Boulder	2150 28th St.	9.1	6.8	4.5	3.4
Longmont	440 Main St.	8.7	6.4	4.7	3.5
Denver CAMP	2105 Broadway	14.4	9.3	4.4	4.1
Denver NJH	14th Ave. & Albion St.	9.7	8.5	4.0	3.9
Denver Carriage	23rd Ave. & Julian St.	7.1	6.5	3.8	3.7
Firehouse #6	1300 Blake St.	7.8	7.0	4.6	4.0
Arvada	W. 57th Ave & Garrison St.	6.2	5.0	3.1	3.0
Fort Collins	708 S. Mason St.	7.2	6.8	3.3	3.0
Greeley	811 15th Ave.	6.1	5.9	4.1	3.7

Table 18 - Northern Front Range Ozone Values For 2001

Site Name	Location	Ozone 1-hour Avg. (ppm)		Ozone 8-hour Avg. (ppm)	
		Max	2nd Max	Max	2nd Max
Welby	78th Ave. & Steele St.	0.085	0.083	0.066	0.065
Highland Res.	8100 S. University Blvd.	0.107	0.092	0.082	0.080
Boulder	1405½ S. Foothills Rd.	0.093	0.088	0.076	0.073
Denver NJH	14th Ave. & Albion St.	0.098	0.096	0.078	0.073
Chatfield Res.	Roxborough Park. Rd	0.114	0.104	0.089	0.083
Arvada	W. 57th Ave & Garrison St.	0.106	0.104	0.083	0.078
Welch	12400 W. Hwy. 285	0.091	0.089	0.080	0.068
NREL	20th Ave & Quaker St.	0.115	0.103	0.090	0.083
Rocky Flats	16600 W. Hwy. 128	0.112	0.099	0.087	0.084
Fort Collins	708 S. Mason St.	0.092	0.088	0.074	0.070
Greeley	811 15th Ave.	0.117	0.105	0.084	0.081

Table 19 - Northern Front Range Oxides of Nitrogen and Sulfur Dioxide Values For 2001

Site Name	Location	Nitrogen Dioxide	Nitric Oxide	Sulfur Dioxide		
		Annual Avg. (ppm)	Annual Avg. (ppm)	3-hour 2nd Max (ppm)	24-hour 2nd Max (ppm)	Annual Avg. (ppm)
Commerce City	5580 Niagara St.			0.043	0.010	(0.003)
Welby	78th Ave. & Steele St.	0.026	0.142	0.050	0.012	0.003
Denver CAMP	2105 Broadway	0.037	0.181	0.083	0.026	0.005
Rocky Flats	9901 Indiana St.	(0.010)	0.020			
	11190 N. Hwy. 93	(0.009)	0.022			

( ) indicates less than 75% data for the year.

Figure 17 - Northern Front Range Carbon Monoxide Graphs

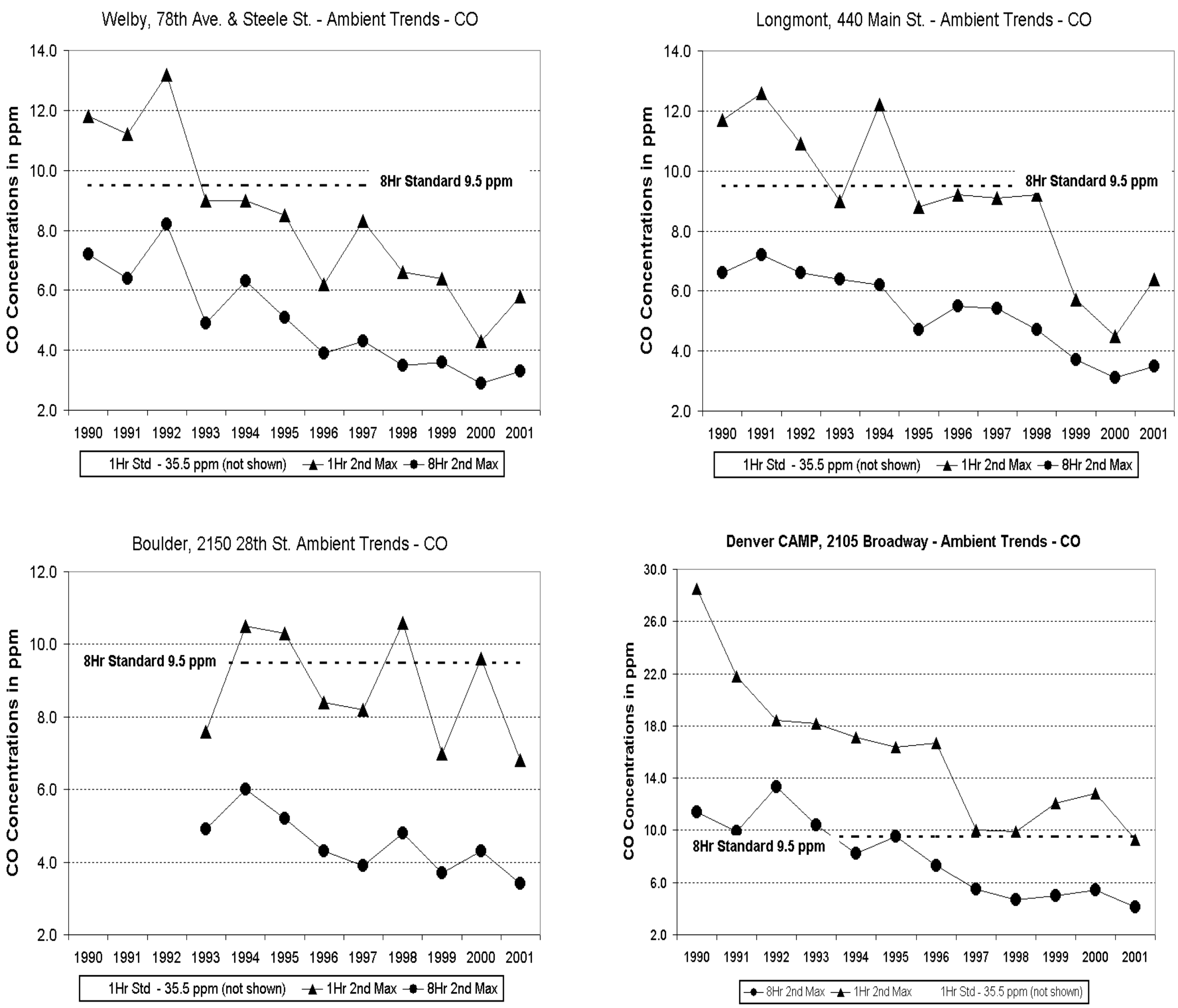
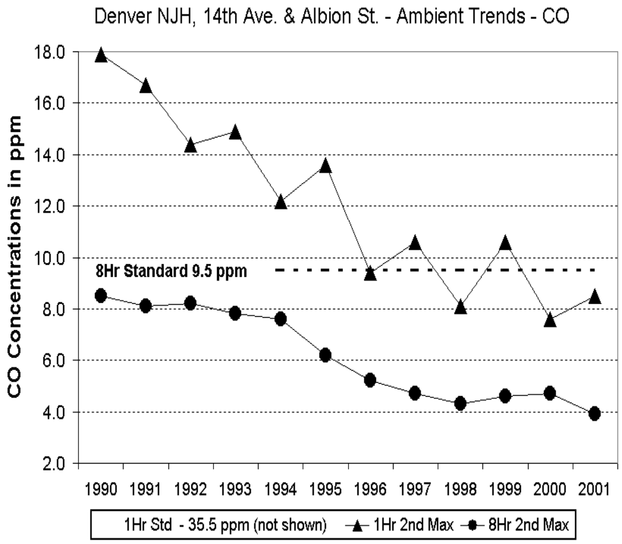
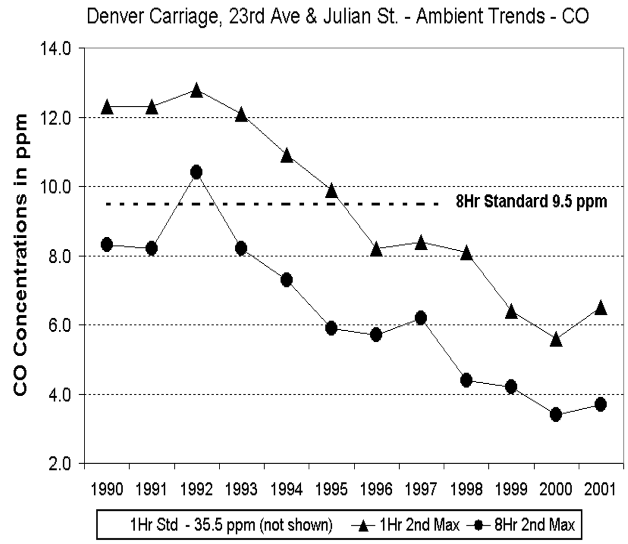
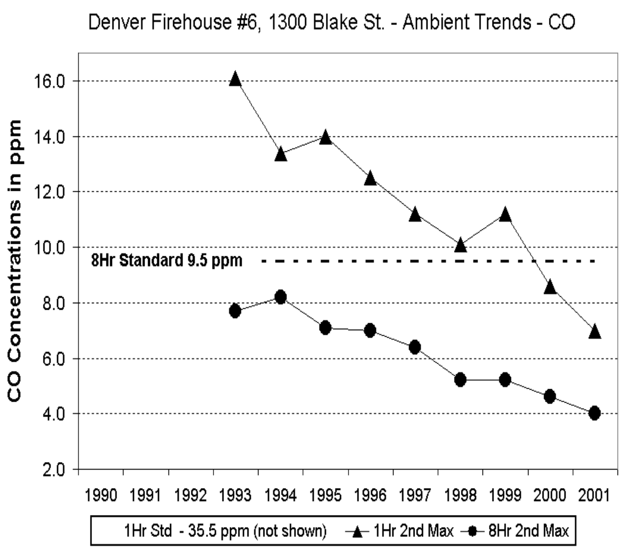
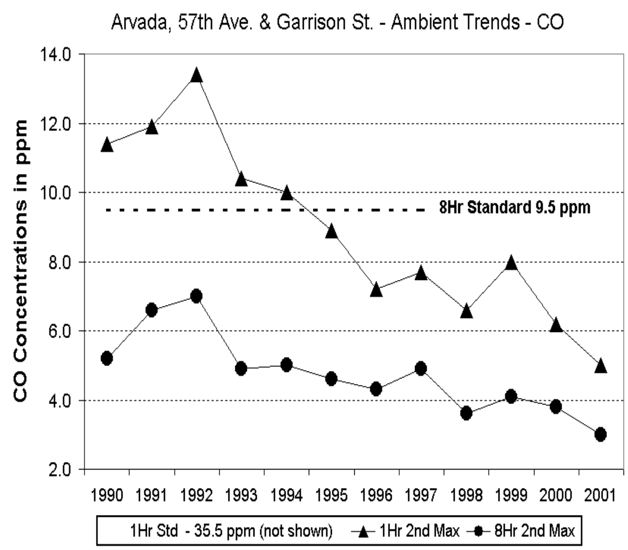


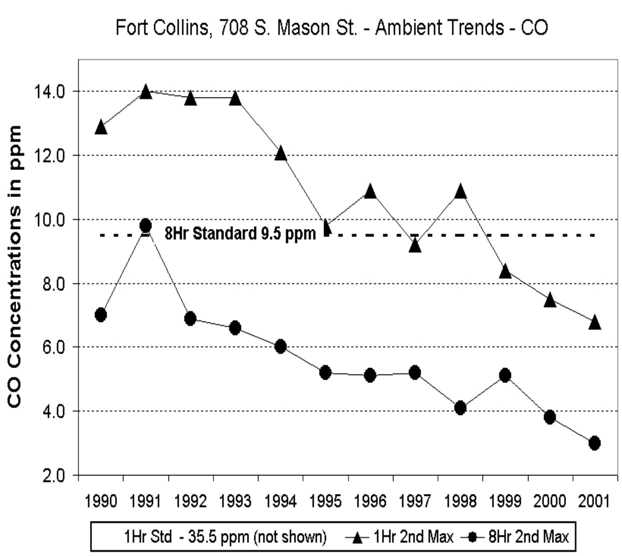
Figure 17 - Northern Front Range Carbon Monoxide Graphs (continued)











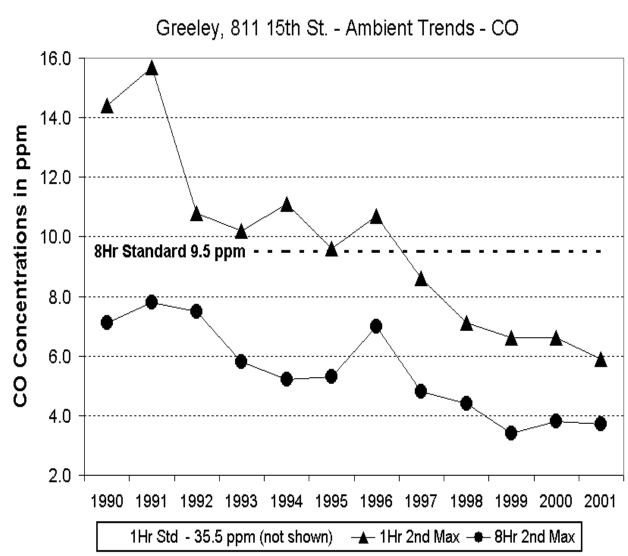
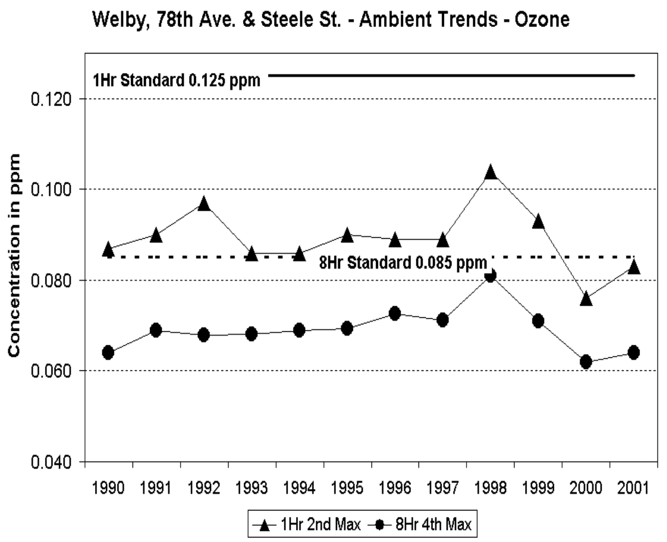
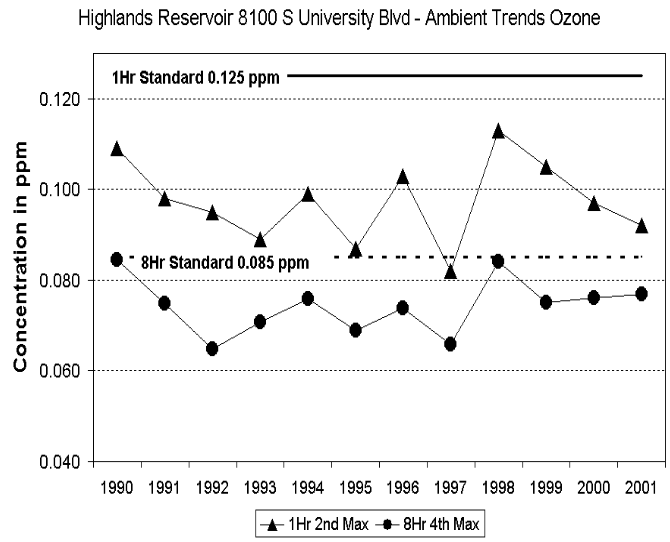
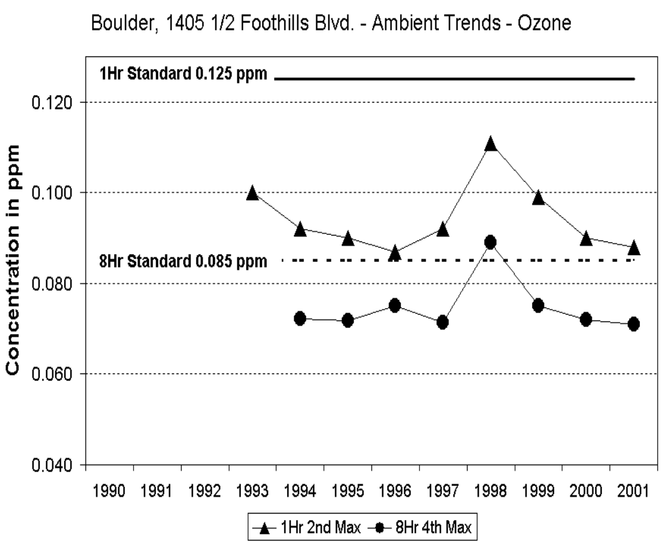
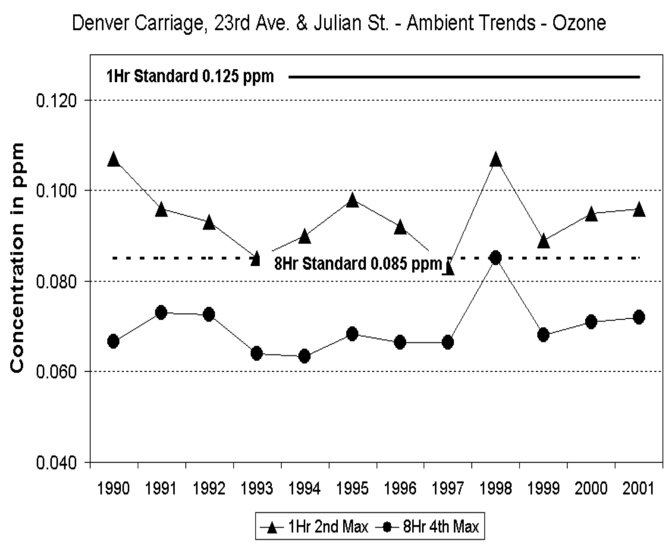


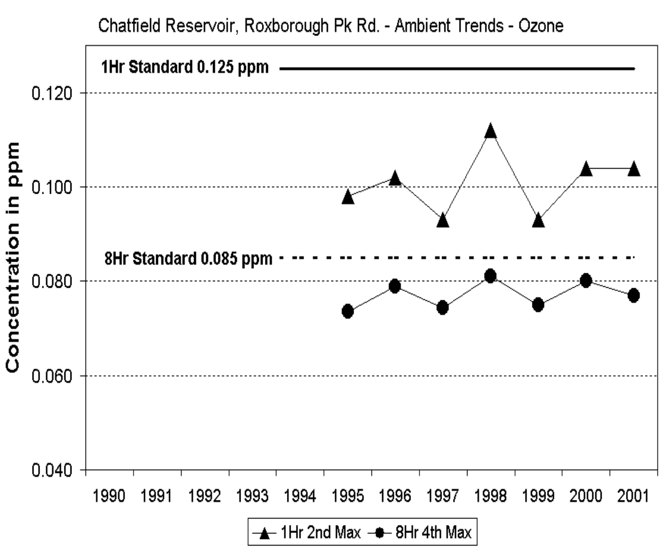
Figure 18 - Northern Front Range Ozone Graphs











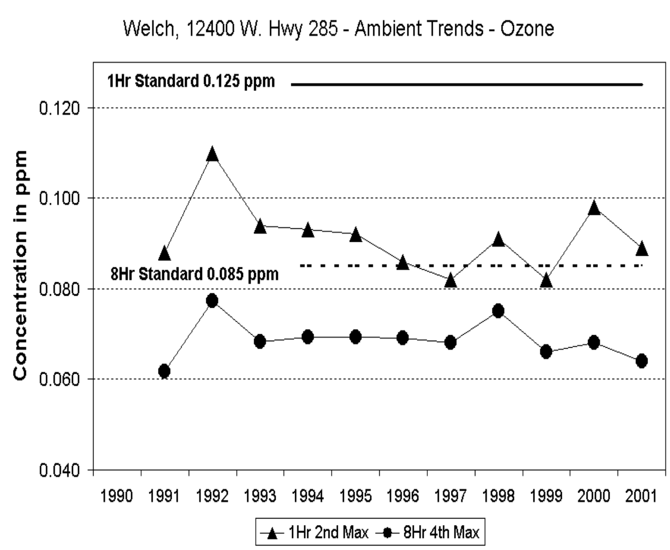
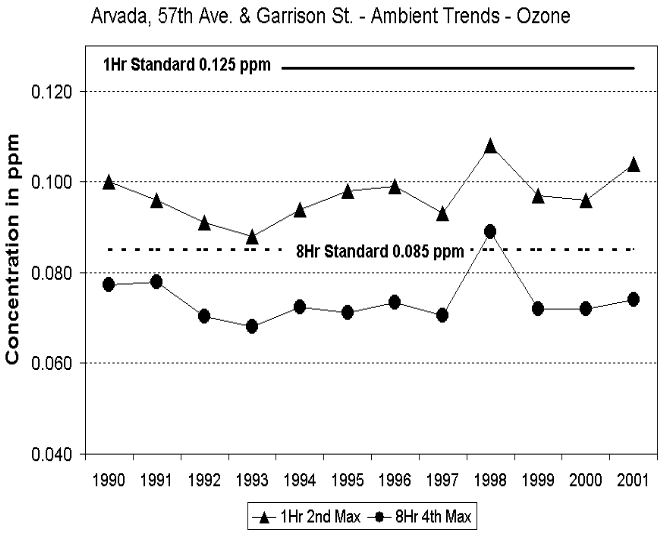
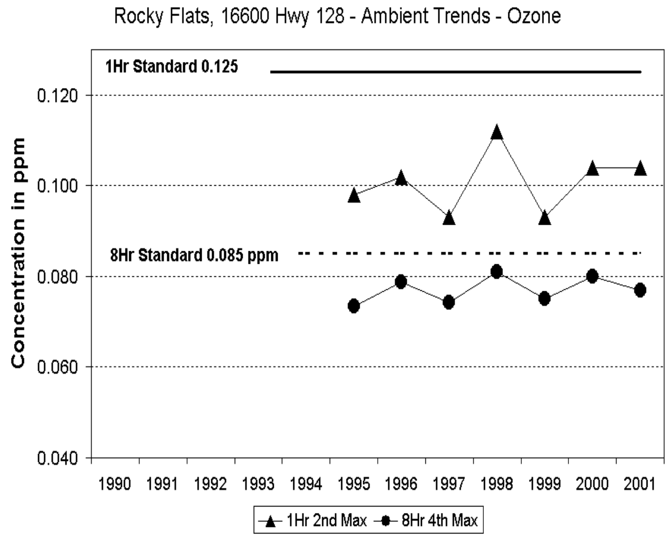
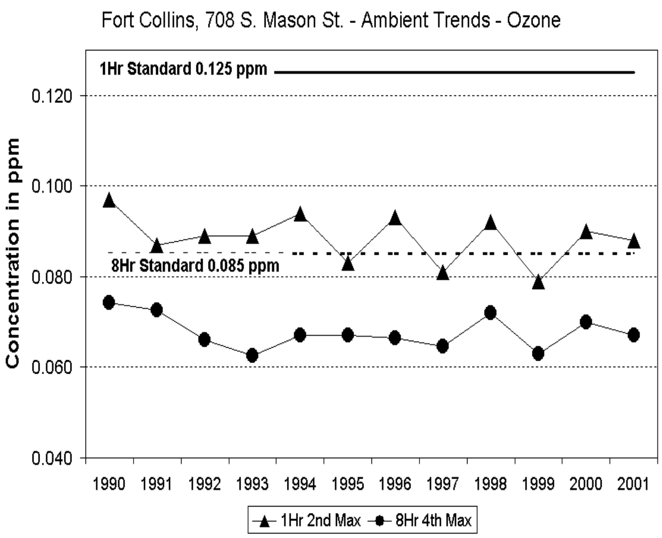
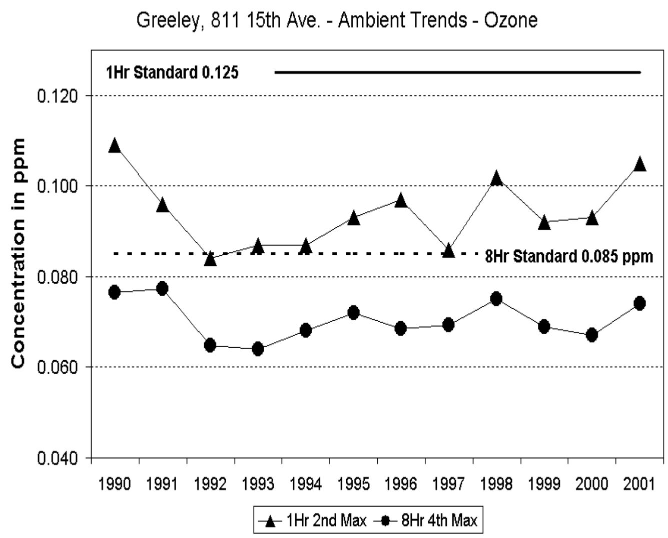


Figure 18 - Northern Front Range Ozone Graphs (continued)









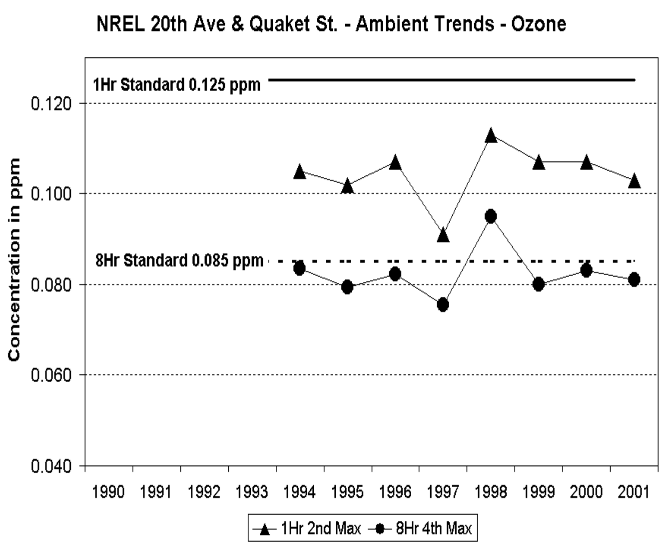


Figure 19 - Northern Front Range Sulfur Dioxide Graphs

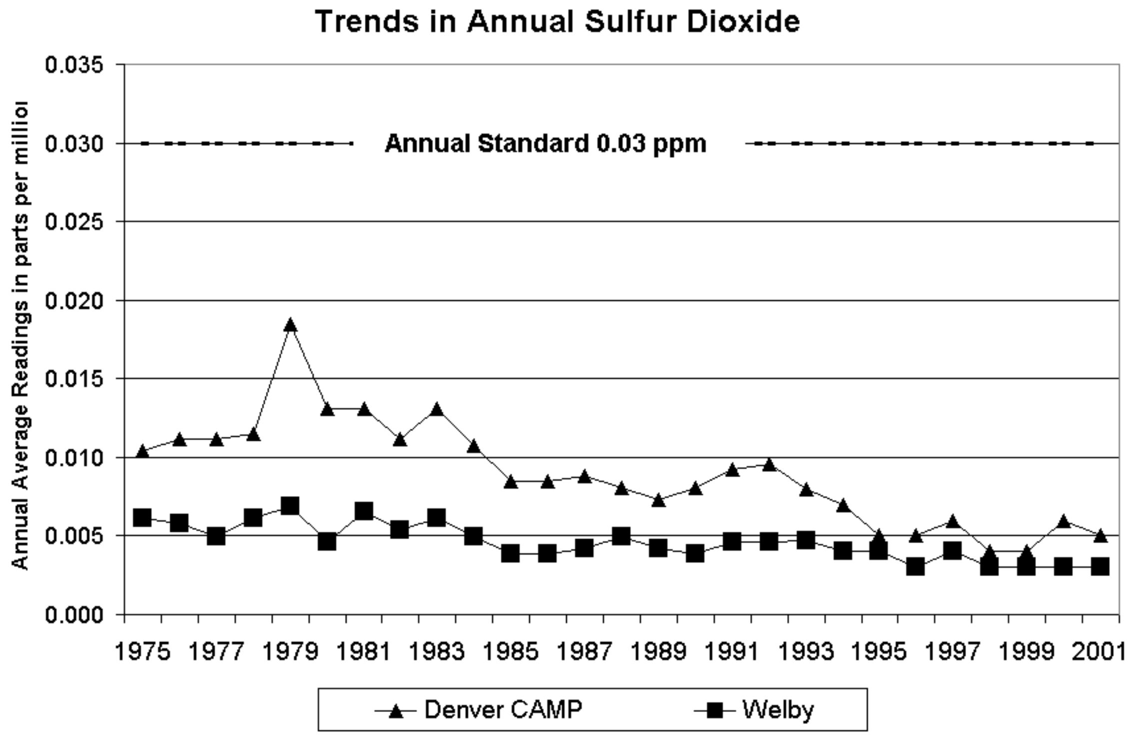


Figure 20 - Northern Front Range Nitrogen Dioxide Graphs

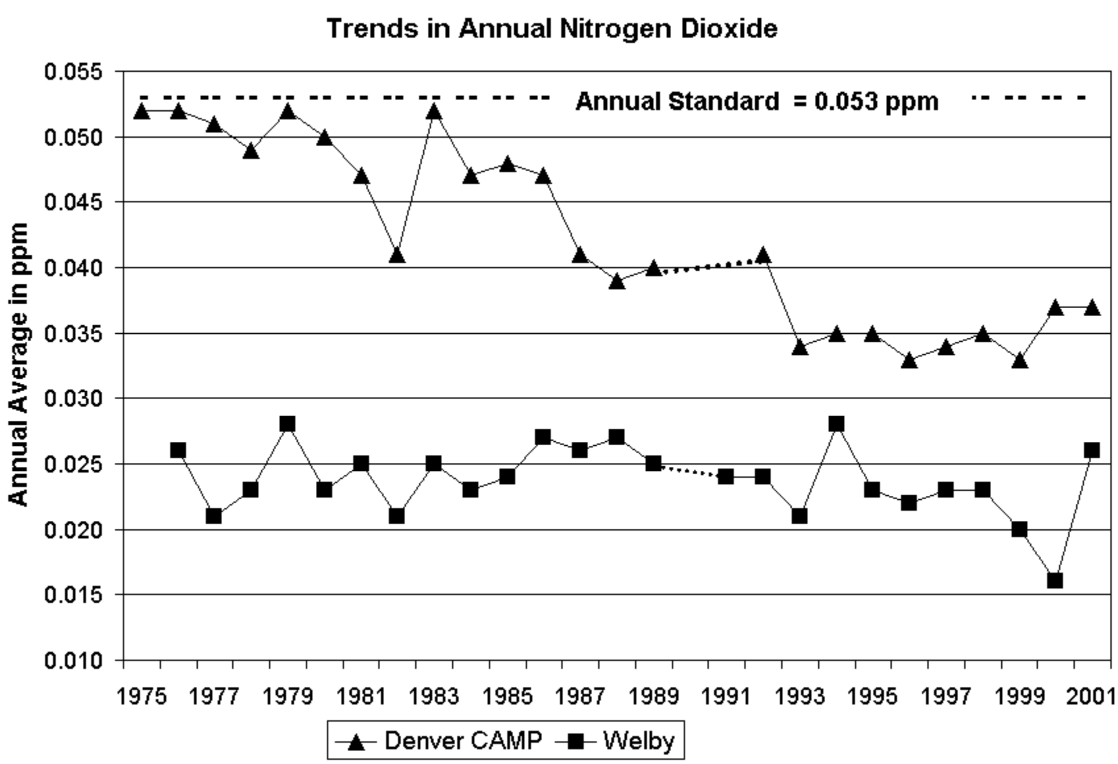


Table 20 - Denver Visibility Standard Exceedance Days
(Transmissometer Data)
January 2001 – December 2001

Month	Days	EX POOR	POOR	FAIR	GOOD	Missing	(>70% RH)
January	31	2	12	14	0	1	2
February	28	8	6	5	0	1	8
March	31	7	11	6	0	1	6
April	30	4	13	8	2	0	3
May	31	1	8	14	1	1	6
June	30	1	7	17	3	0	2
July	31	0	11	8	4	6	2
August	31	0	4	11	3	9	4
September	30	4	12	8	3	1	2
October	31	2	22	7	0	0	0
November	30	1	13	12	1	0	3
December	31	2	10	17	0	0	2
TOTALS	**365**	**32**	**129**	**127**	**17**	**20**	**40**

Figure 21
Denver Visibility Data
January 2001 - December 2001

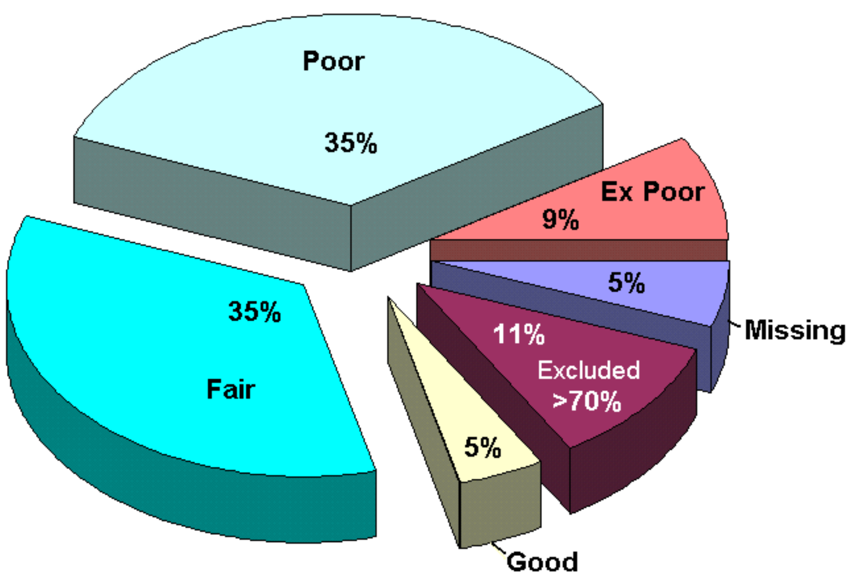


Table 21 - Fort Collins Visibility Standard Exceedance Days
(Transmissometer Data)
January 2001 – December 2001

Month	Days	EX POOR	POOR	FAIR	GOOD	Missing	(>70% RH)
January	31	0	6	3	16	2	4
February	28	0	4	8	5	2	9
March	31	0	4	10	8	5	4
April	30	1	5	10	10	0	4
May	31	0	5	10	12	0	4
June	30	0	4	14	8	1	3
July	31	0	5	12	11	4	0
August	31	0	9	12	9	0	1
September	30	0	12	9	7	0	2
October	31	0	9	8	5	7	2
November	30	0	11	7	4	3	4
December	31	0	8	8	9	3	3
TOTALS	**365**	**1**	**82**	**111**	**104**	**27**	**40**

Figure 22

Fort Collins Visibility Data

January 2001 - December 2001

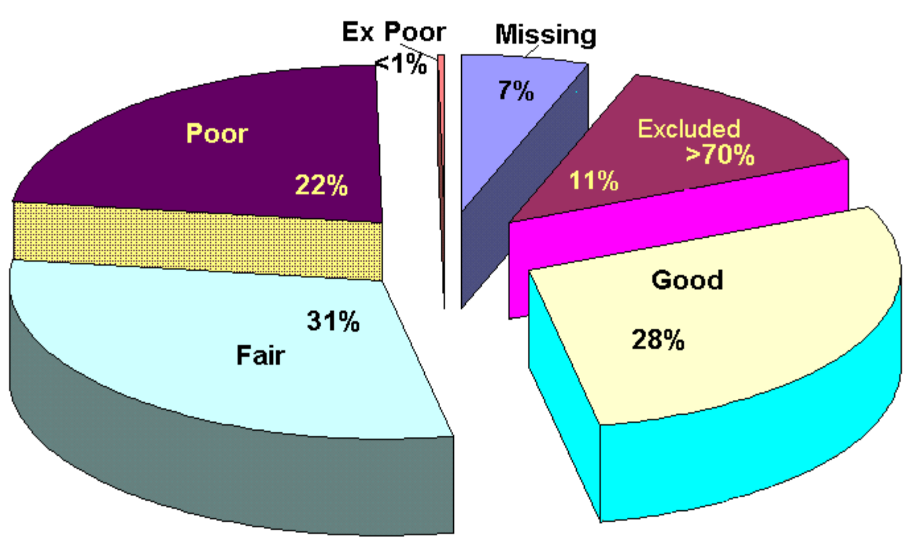
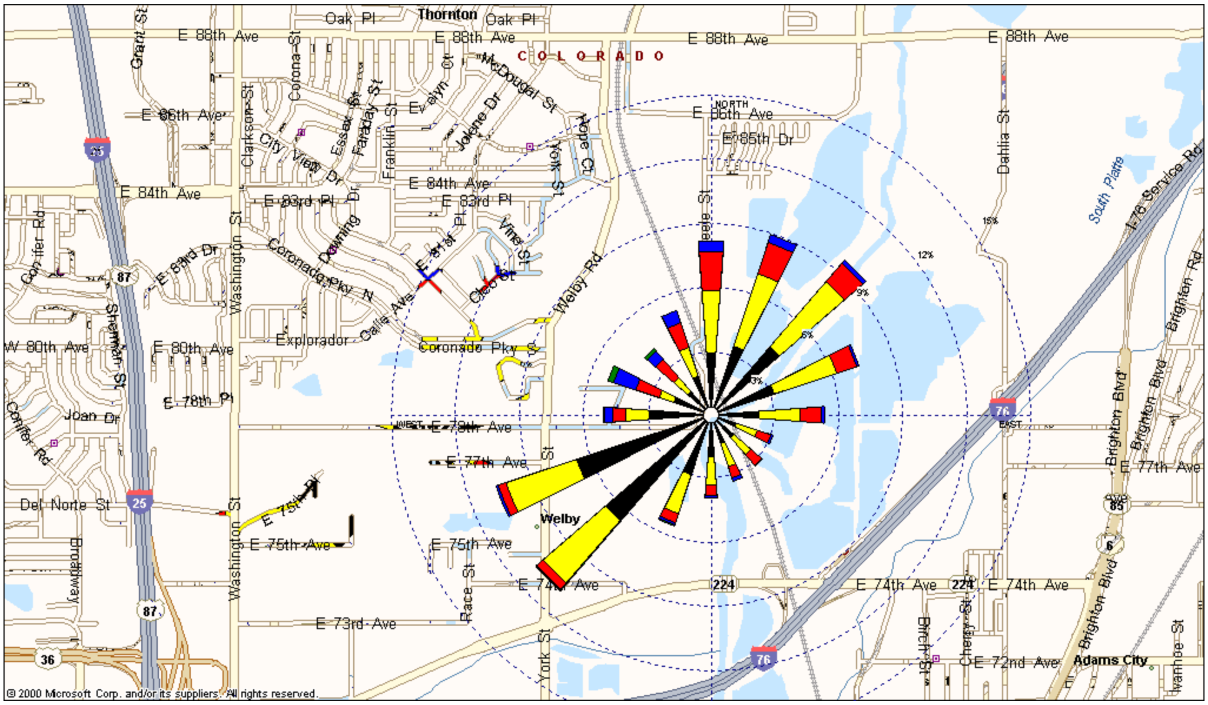


Figure 23 - Northern Front Range Wind Roses

Welby, 78th Ave. and Steele St.



Highland Reservoir, 8100 S. University Blvd.

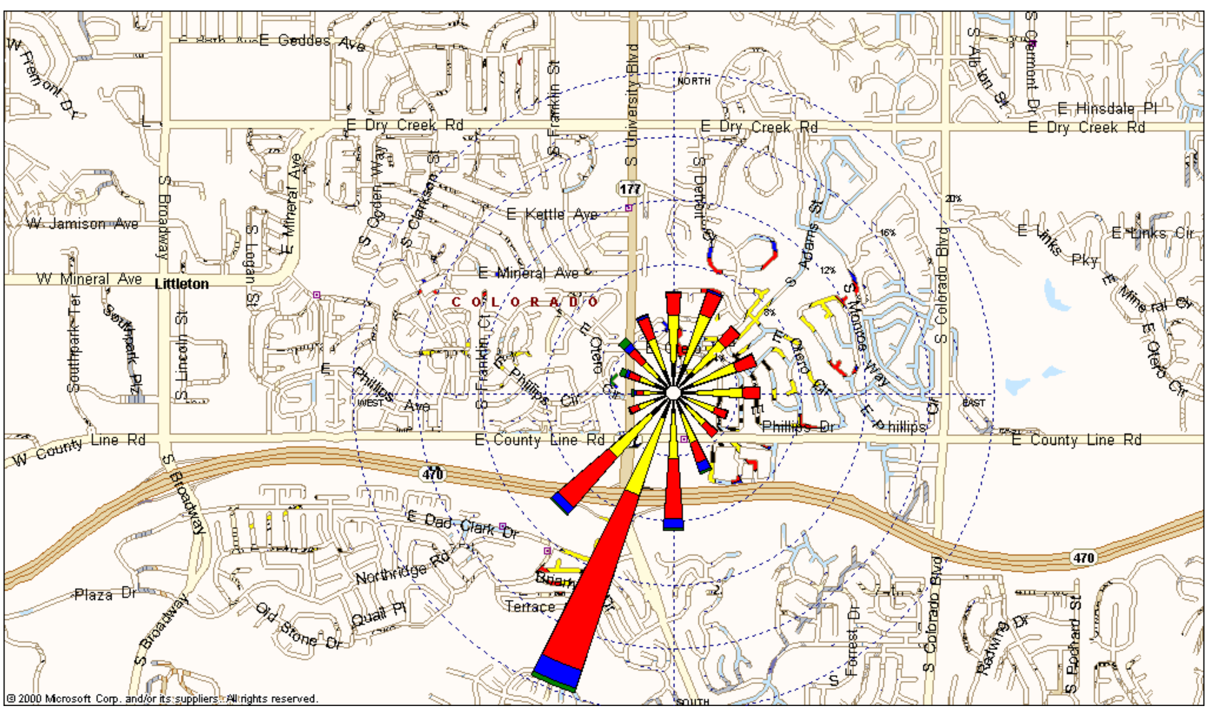
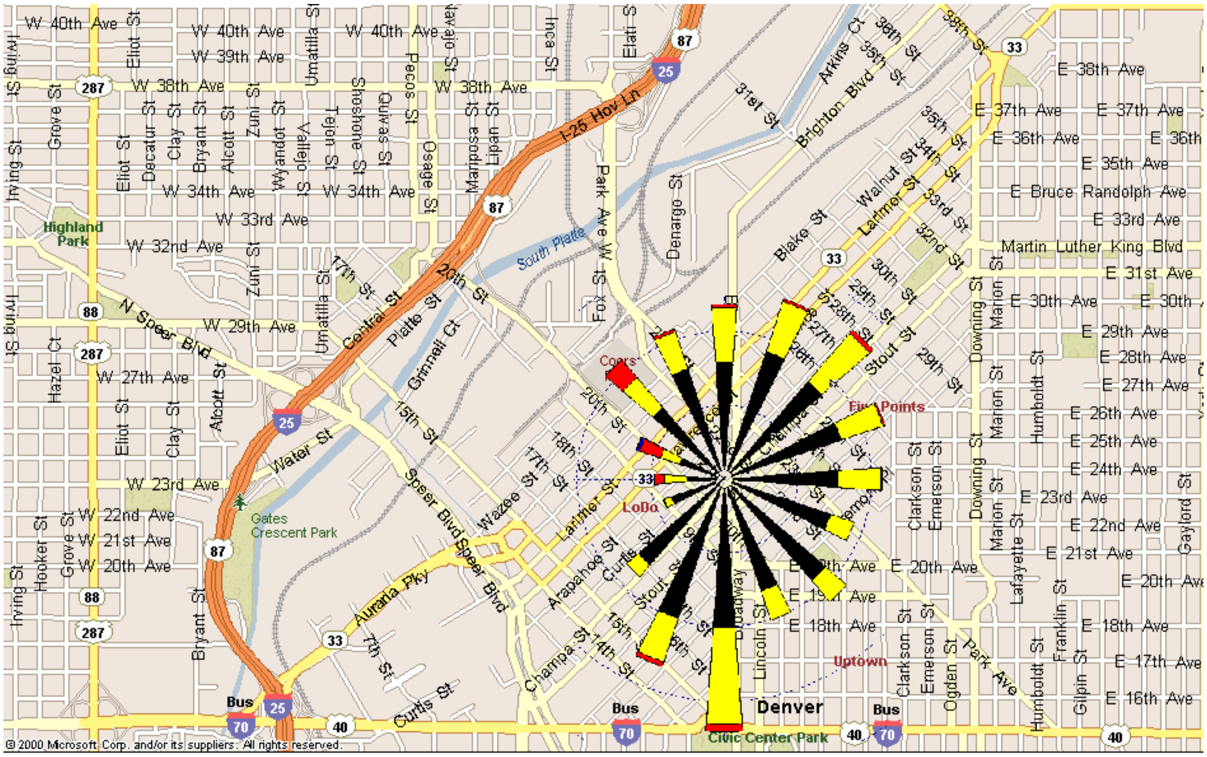


Figure 23 - Northern Front Range Wind Roses (continued)

Denver CAMP, 2105 Broadway



Denver Carriage, 23rd Ave. and Julian St.

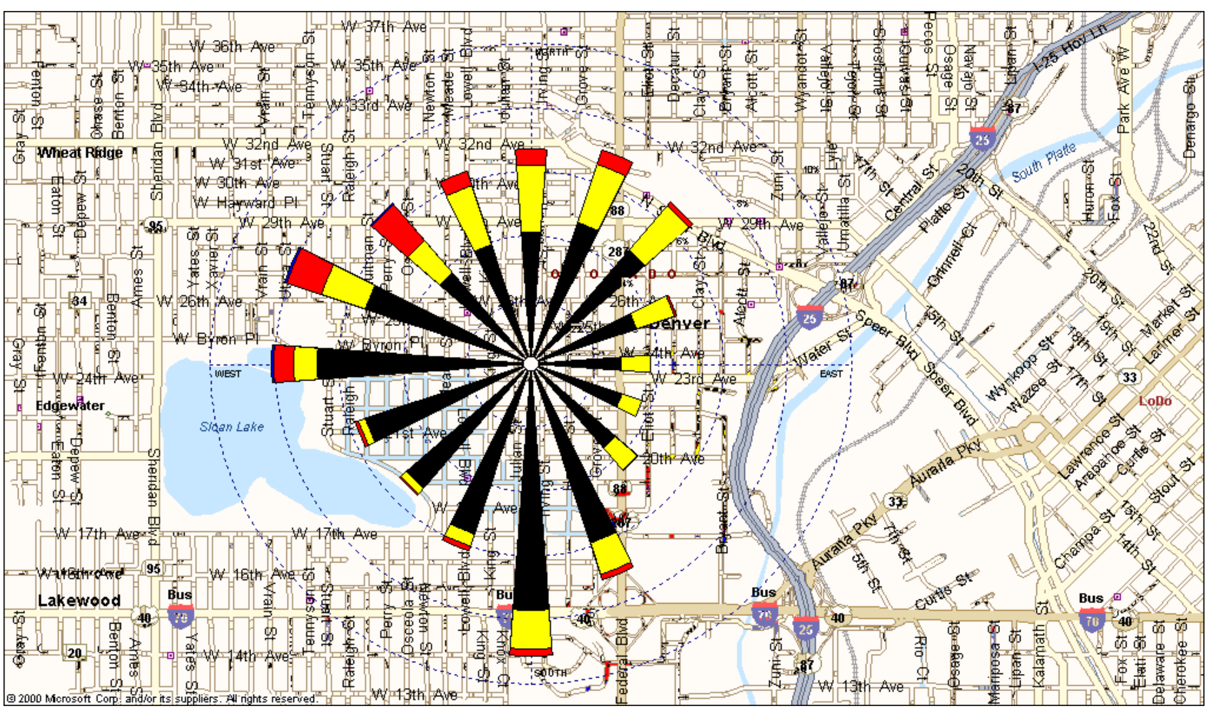
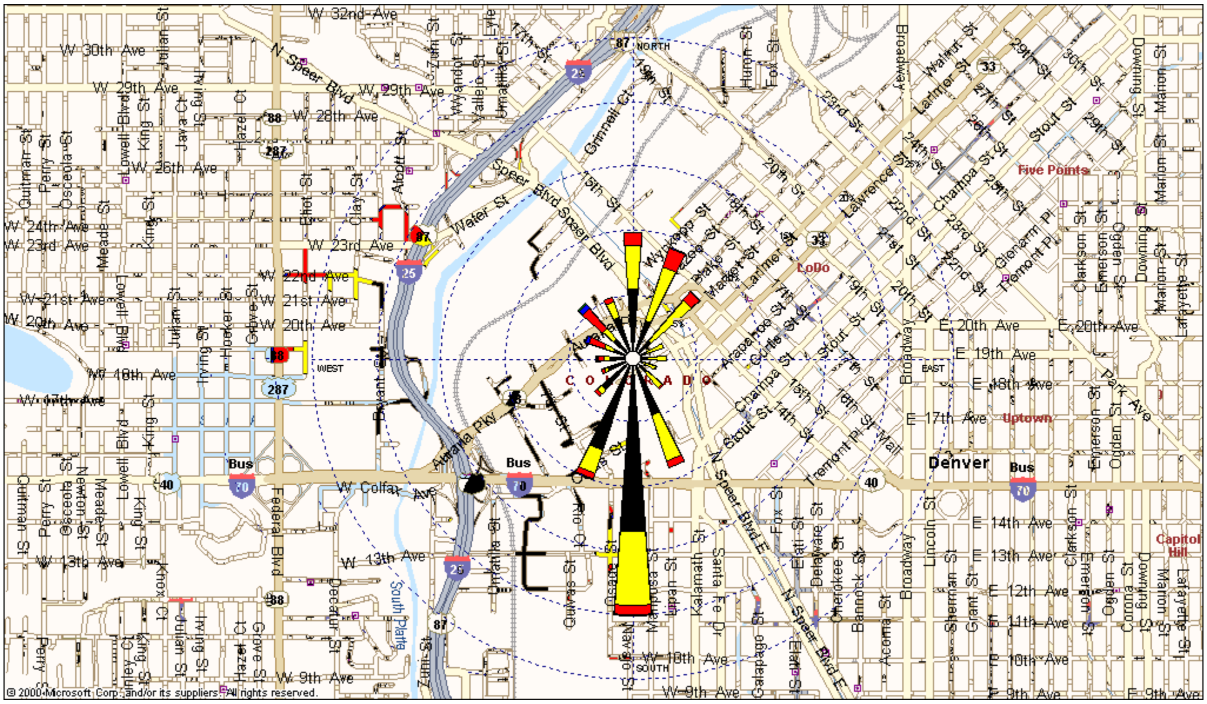


Figure 23 - Northern Front Range Wind Roses (continued)

Denver, Auraria Parking Lot



Arvada, 57th Ave. & Garrison St.

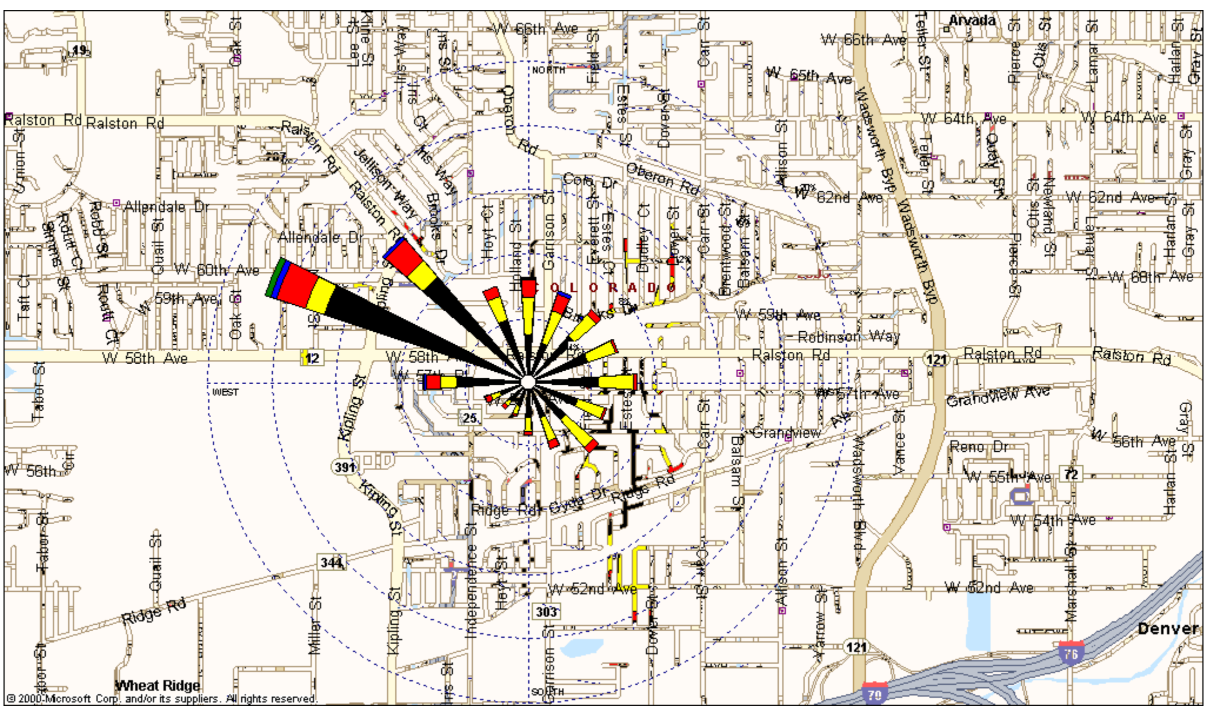
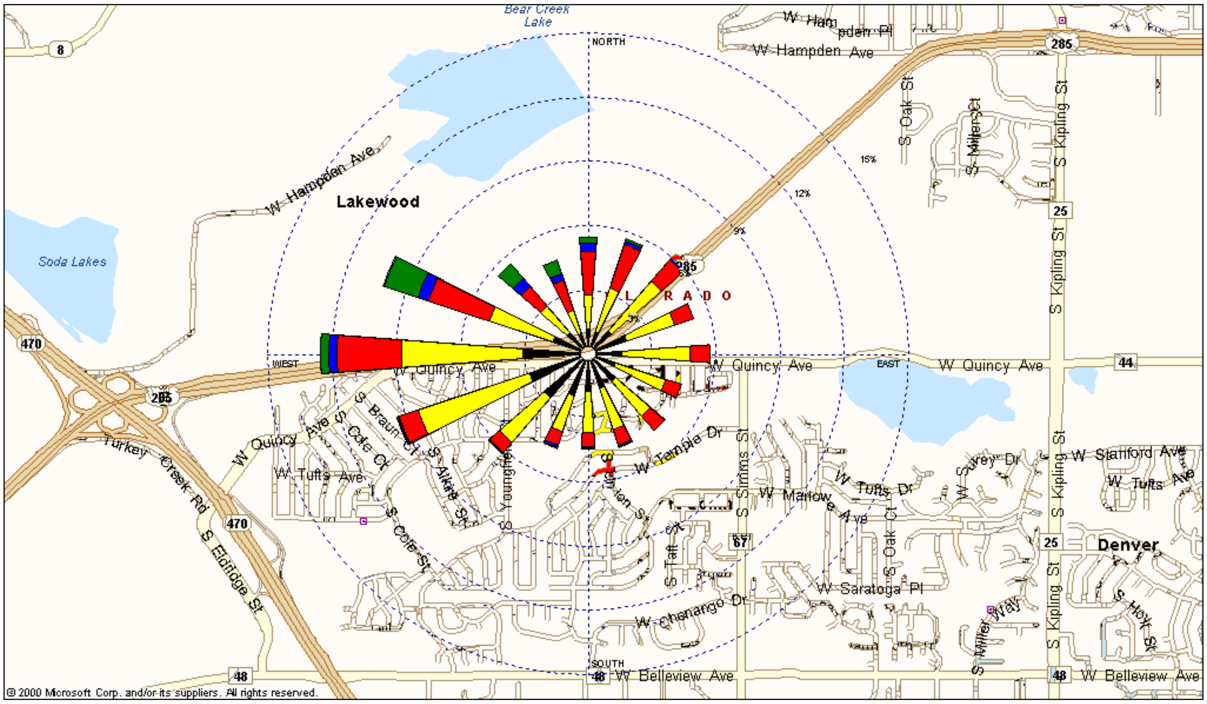


Figure 23 - Northern Front Range Wind Roses (continued)

Welch, 12400 W. Hwy. 285



Rocky Flats, 16600 W. Hwy. 128

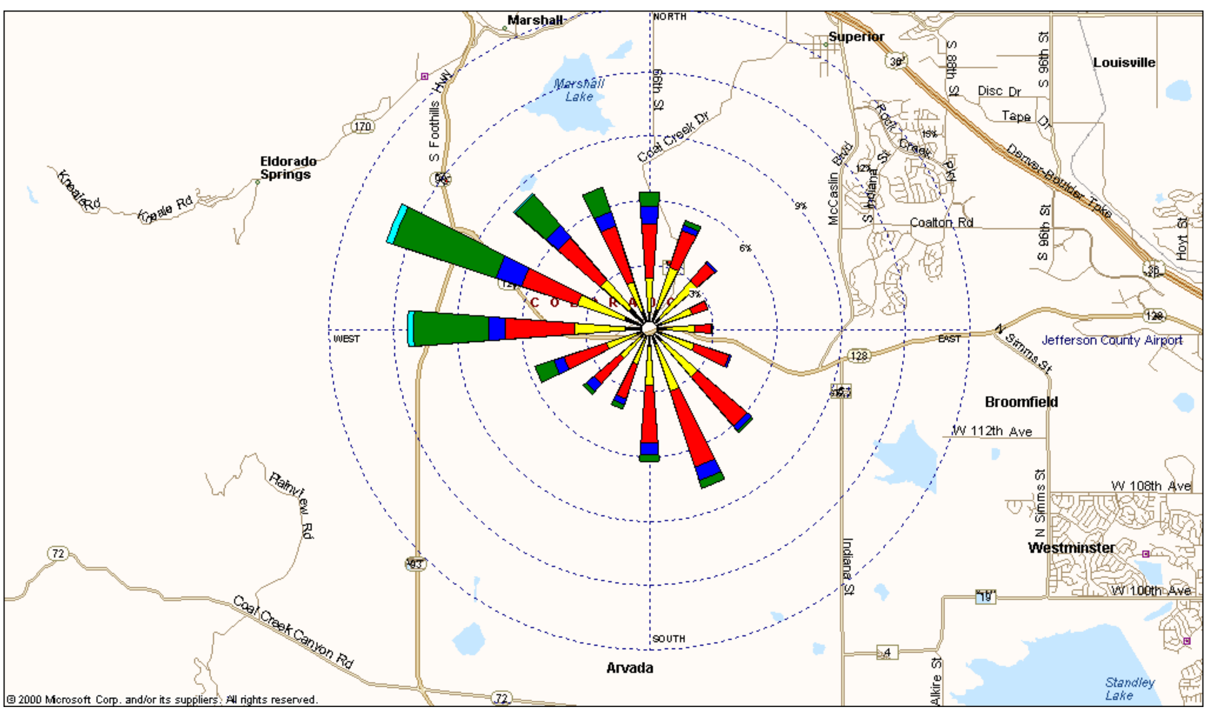
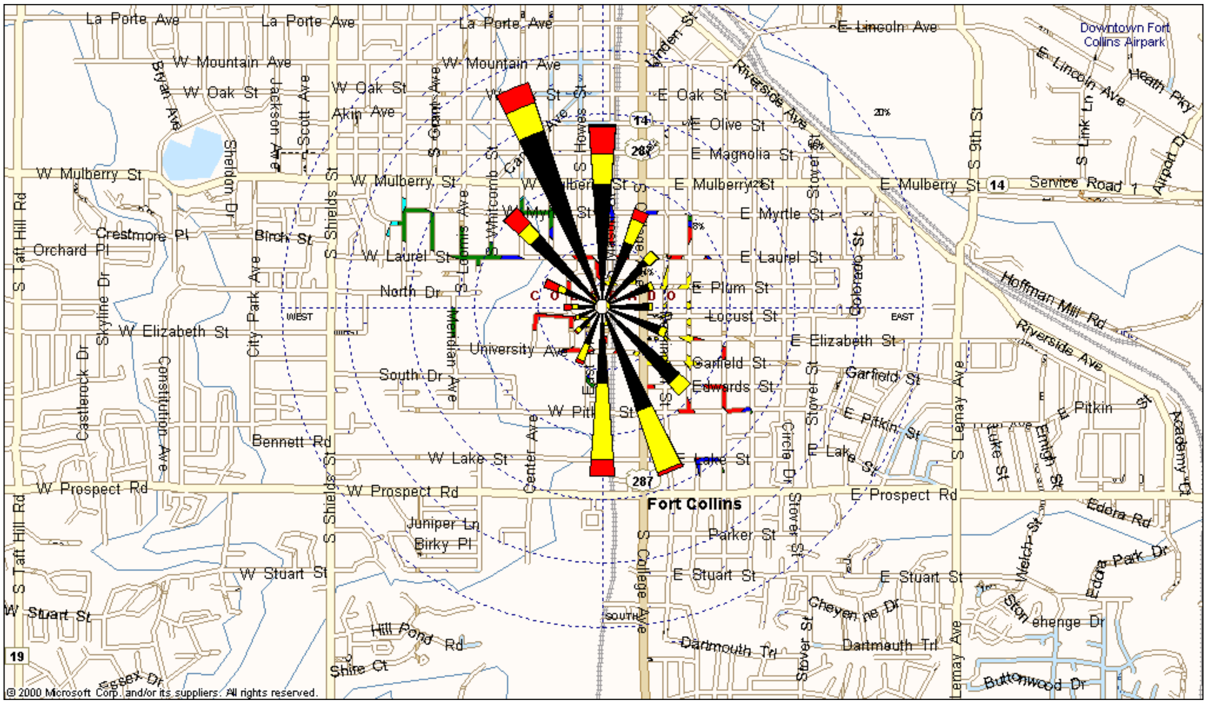


Figure 23 - Northern Front Range Wind Roses (continued)

Fort Collins, 708 S. Mason St.



5.3 Southern Front Range Communities

The Southern Front Range Communities are those along the I-25 corridor from south of the city of Castle Rock to the southern Colorado border. The cities with monitoring in the area are Colorado Springs, Pueblo, Cripple Creek, Cañon City and Alamosa. These last three cities are not strictly in the Front Range, I-25 corridor but fit better with those cities than they do the Mountain Communities. Colorado Springs is the only city in the area that is monitored for carbon monoxide and ozone. The other cities are only monitored for particulates. In the past the APCD has conducted particulate monitoring in both Walsenburg and Trinidad but that monitoring was discontinued in 1979 and 1985 respectively.

Table 22 - Southern Front Range Monitors In Operation For 2001

X - Monitors continued in 2001 A – Monitors added in 2001

D – Monitors discontinued in 2001 H – Hourly particulate monitor

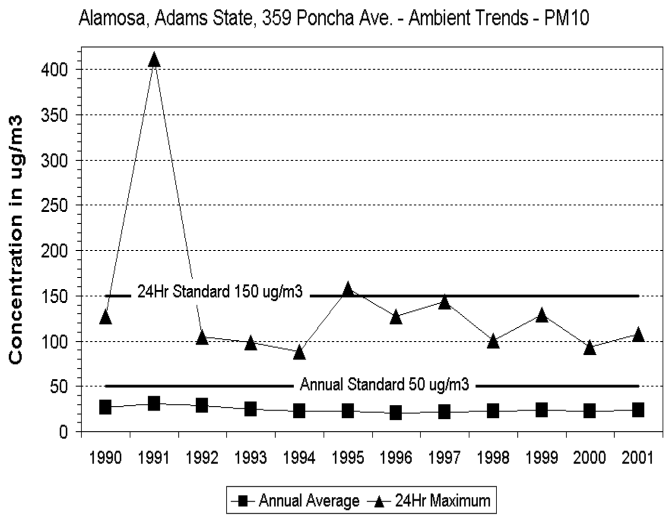
County	Site Name	Location	CO	O_3	TSP	Pb	PM_{10}	$PM_{2.5}$	Met
Alamosa	Alamosa	359 Poncha Ave.					X		
El Paso	Colorado Springs	I-25 & Uintah St.	X						
		3730 Meadowlands					X	X	
		101 W Costilla St.			X	X	X	X	
		USAF Rd. 640		X					
		690 W. Hwy. 24	X						
Fremont	Cañon City	7th Ave & Macon St.					X		
Pueblo	Pueblo	211 D St.					X	X	
Teller	Cripple Creek	209 Bennett Ave.					X		
		Warren Ave. & 2nd St.							X

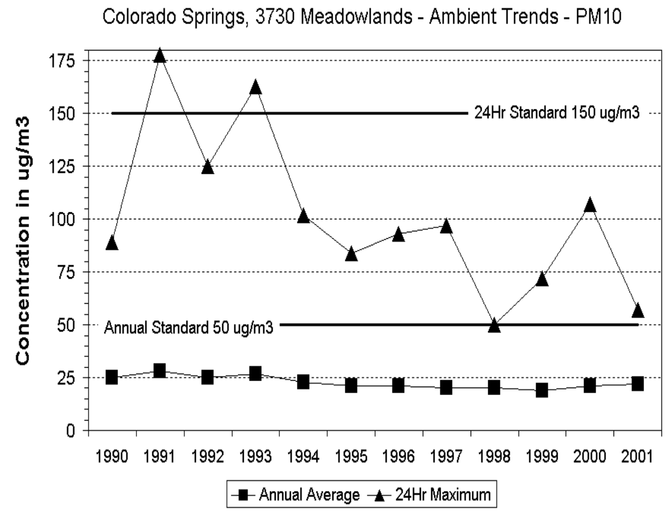
Table 23 - Southern Front Range Maximum Particulate Values For 2001

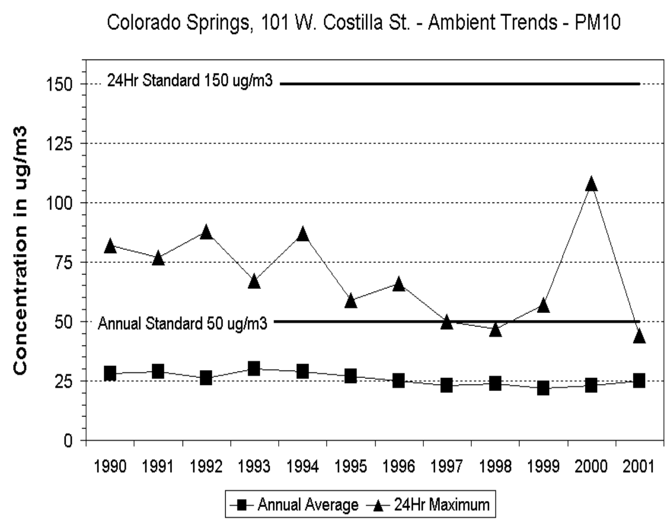
Site Name	Location	PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)	
		24-Hr	Annual	24-Hr	Annual
Alamosa	359 Poncha Ave.	108	(24)		
Colorado Springs	3730 Meadowlands	57	22	31.7	7.5
	101 W. Costilla St.	43	(25)	18.7	7.8
Cañon City	7th Ave & Macon St.	40	15		
Pueblo	211 D St.	78	25	28.5	8.5
Cripple Creek	209 Bennett Ave.	67	(23)		

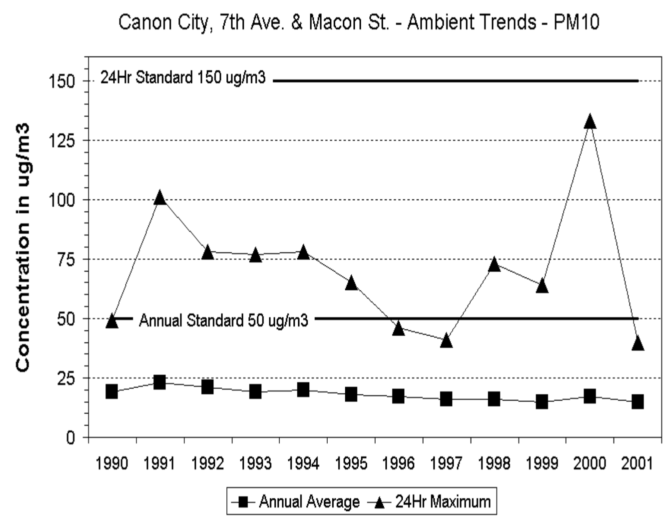
( ) indicates less than 75% data for the year.

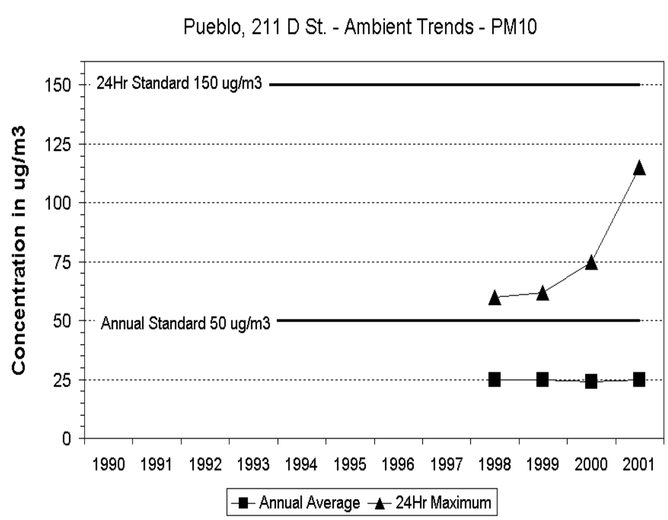
Figure 24 - Southern Front Range Particulate Graphs











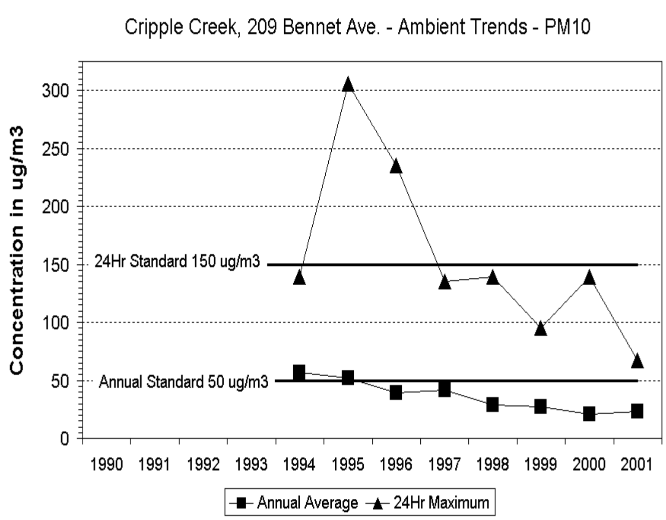


Table 24 - Southern Front Range TSP and Lead Values For 2001

Site Name	Location	TSP ($\mu g/m^3$)		Lead ($\mu g/m^3$)	
		24-Hr	Annual Geometric Mean	24-Hr	Maximum Quarter
Colorado Springs	101 W. Costilla St.	117	54	0.05	0.01

Figure 25 - Southern Front Range Lead Graph

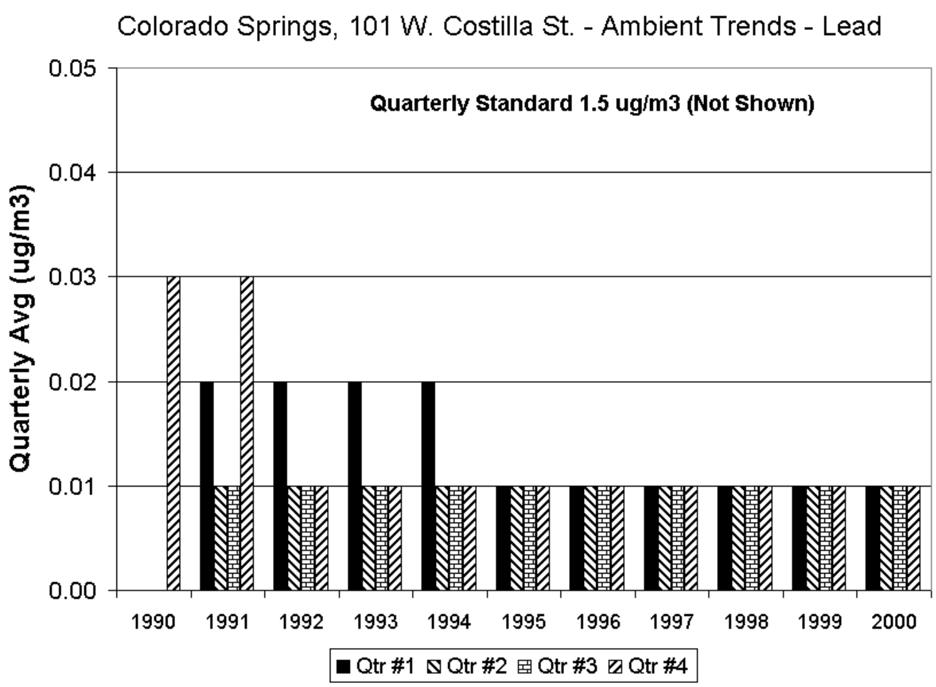


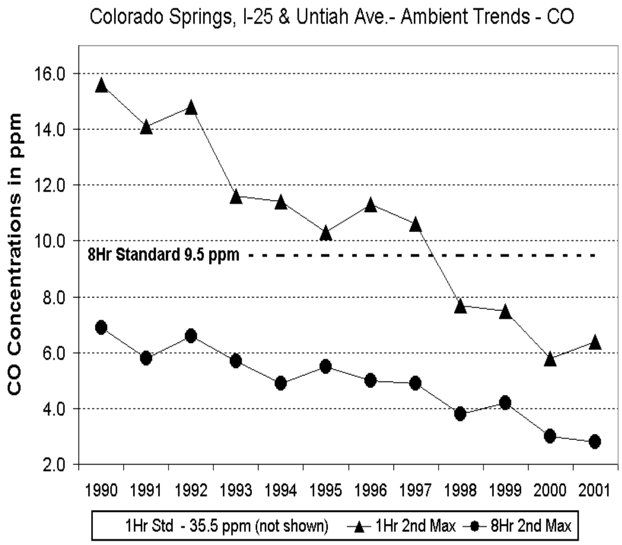
Table 25 - Southern Front Range Carbon Monoxide Values For 2001

Site Name	Location	CO 1-hour Avg. (ppm)		CO 8-hour Avg. (ppm)	
		Maximum	2nd Maximum	Maximum	2nd Maximum
Colorado Springs	I-25 & Uintah	7.3	6.4	2.9	2.8
	690 Hwy. 24	9.5	9.3	4.8	4.4

Table 26 - Southern Front Range Ozone Values For 2001

Site Name	Location	Ozone 1-hour Avg. (ppm)		Ozone 8-hour Avg. (ppm)	
		Maximum	2nd Maximum	Maximum	4th Maximum
Colorado Springs	USAFA Rd. 640	0.087	0.085	0.072	0.071

Figure 26 - Southern Front Range Carbon Monoxide Graphs



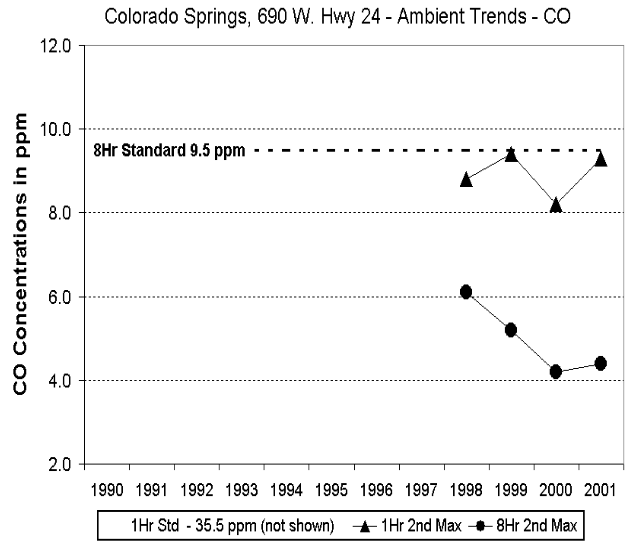


Figure 27 – Southern Front Range Ozone Graph

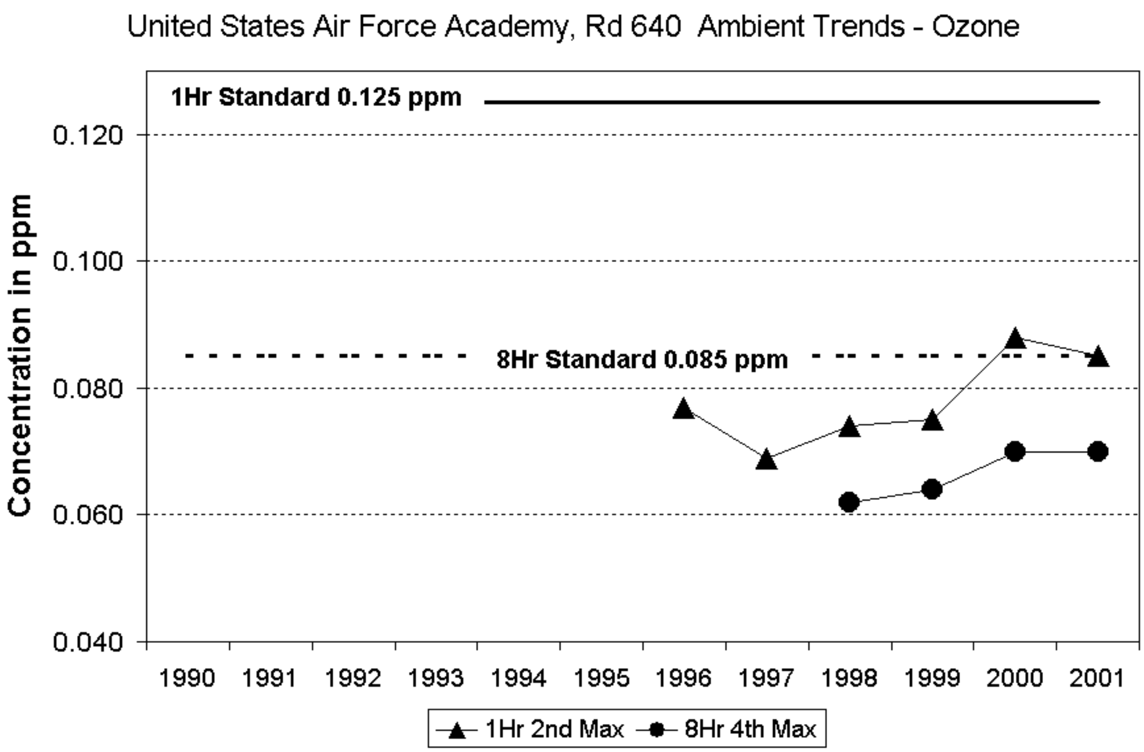
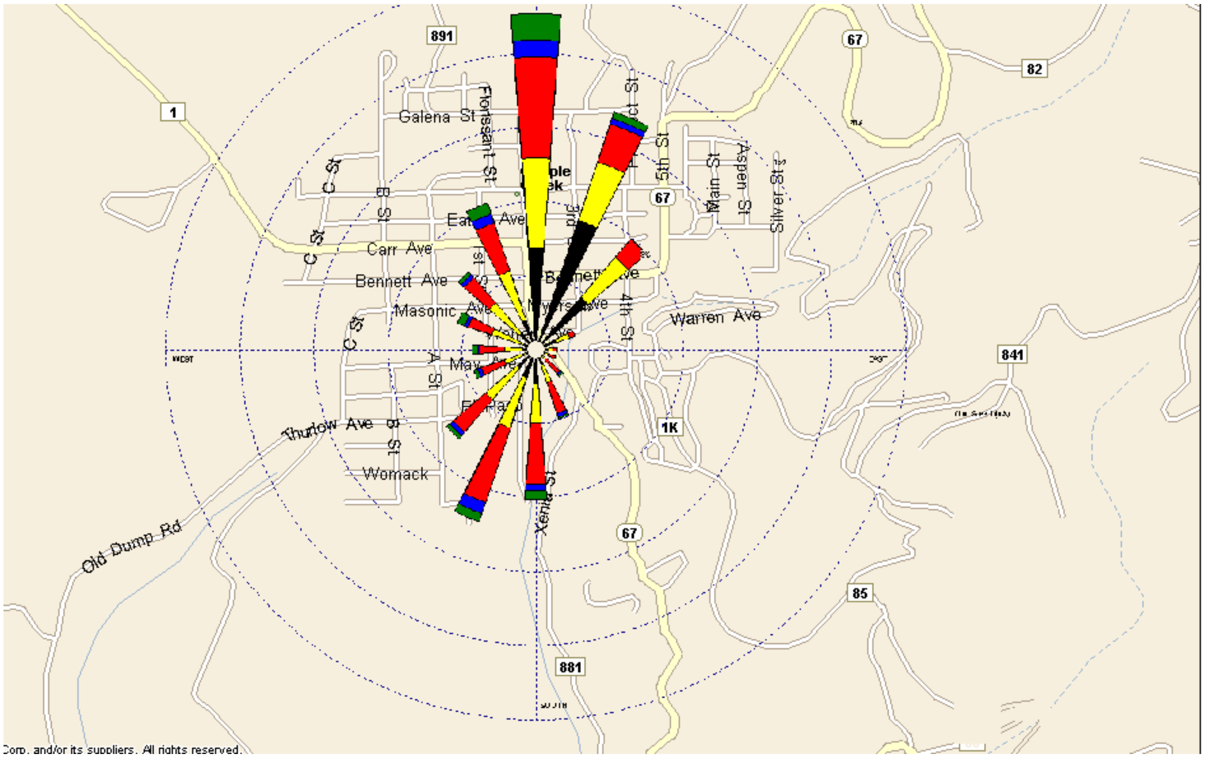


Figure 28 - Southern Front Range Wind Rose

Cripple Creek, Warren Ave. & 2nd St.



5.4 Mountain Communities

The Mountain Communities are generally the towns near the Continental Divide. They are all small towns in tight mountain valleys. Their primary monitoring concern is with particulate pollution from wood burning and road sanding. These communities range from Steamboat Springs in the north, to Silverthorne and Breckenridge in the I-70 corridor, Aspen, Leadville, Crested Butte, Mt. Crested Butte and Gunnison in the central mountains to Telluride in the southwest.

Table 27 - Mountain Communities Monitors In Operation For 2001

X - Monitors continued in 2001   A – Monitors added in 2001

D – Monitors discontinued in 2001   H – Hourly particulate monitor

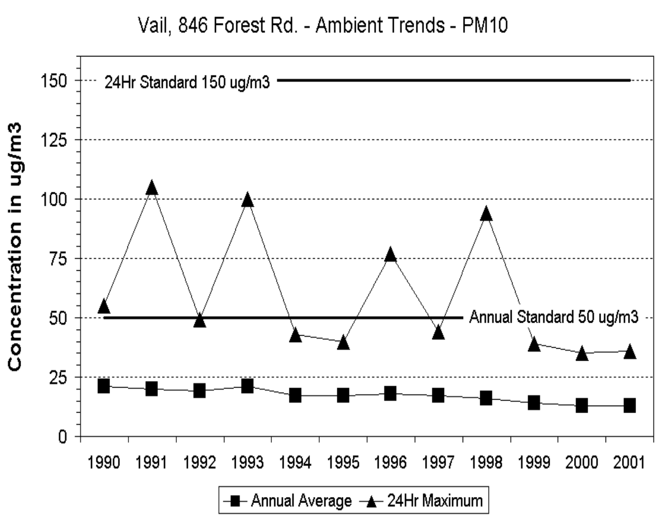
County	Site Name	Location	TSP	Pb	PM_{10}	$PM_{2.5}$	Met
Eagle	Vail	846 Forest Rd.			D		
Gunnison	Crested Butte	Colo. 135 & Whiterock			X		
	Mt. Crested Butte	9 Emmons Loop			X	X	
	Gunnison	211 Wisconsin Ave.			A		
Lake	Leadville	510 Harrison St.	X	X			
Pitkin	Aspen	420 Main St.			X		
Routt	Steamboat	136 6th St			X	X	
	Springs	137 10th St.					X
San Miguel	Telluride	333 W. Colorado Ave.			X/H	X	
		Coonskin Parking Lot					X
Summit	Breckenridge	County Justice Center			X		
	Silverthorne	430 Rainbow Dr.			X		

Table 28 - Mountain Communities Particulate Values For 2001

Site Name	Location	PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)	
		24-Hr	Annual	24-Hr	Annual
Vail	846 Forest Rd.	36	(13)		
Crested Butte	Colo. 135 & Whiterock	77	28		
Mt. Crested Butte	9 Emmons Loop	75	23	17.1	6.4
Gunnison	211 Wisconsin Ave.	77	17		
Aspen	420 Main St.	66	(23)		
Steamboat Springs	136 6th St	100	23		
Telluride	333 W. Colorado Ave.	59	18	46.8	6.4
Breckenridge	County Justice Center	107	(24)		
Silverthorne	430 Rainbow Dr.	27	(16)		

( ) indicates less than 75% data for the year.

Figure 29 – Mountain Communities Particulate Graphs



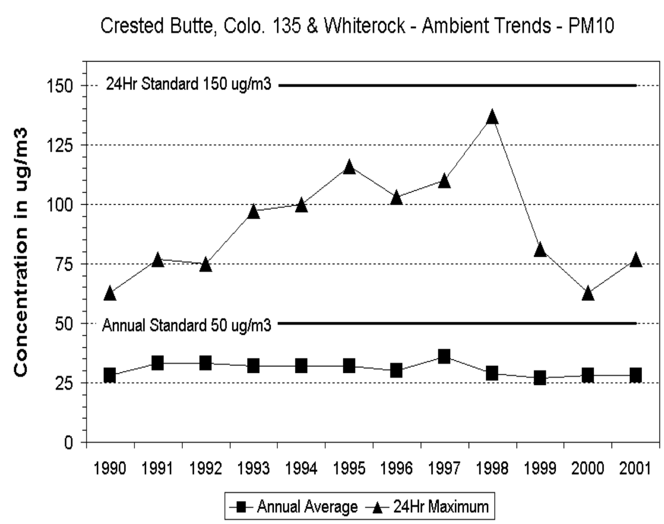
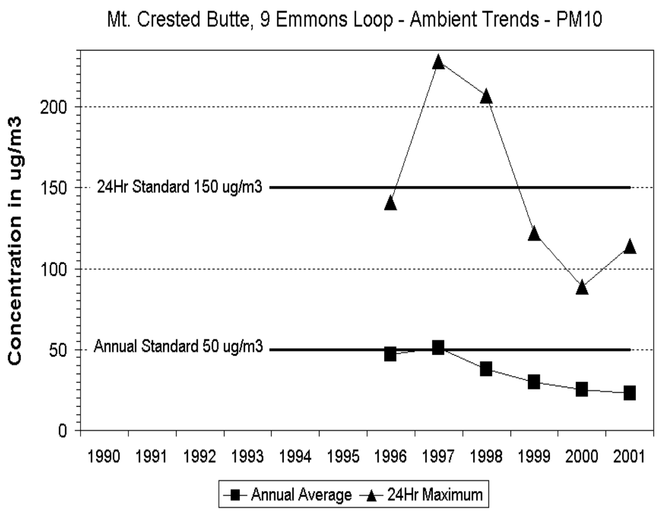
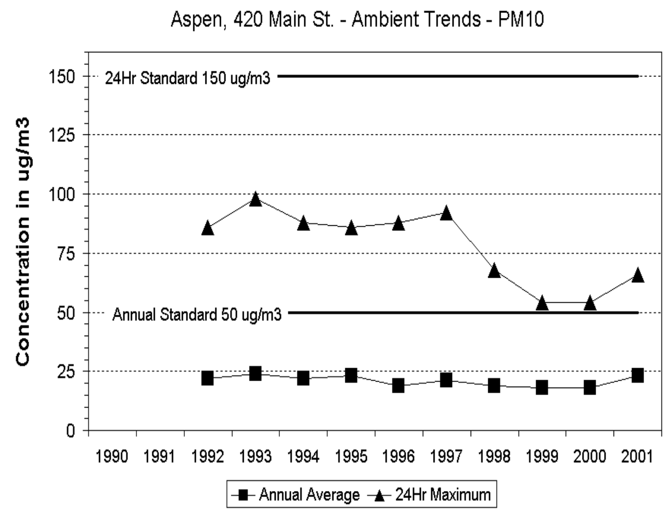
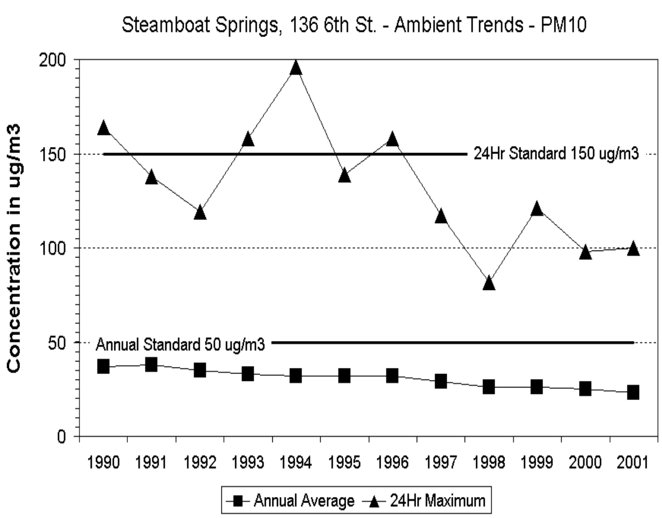
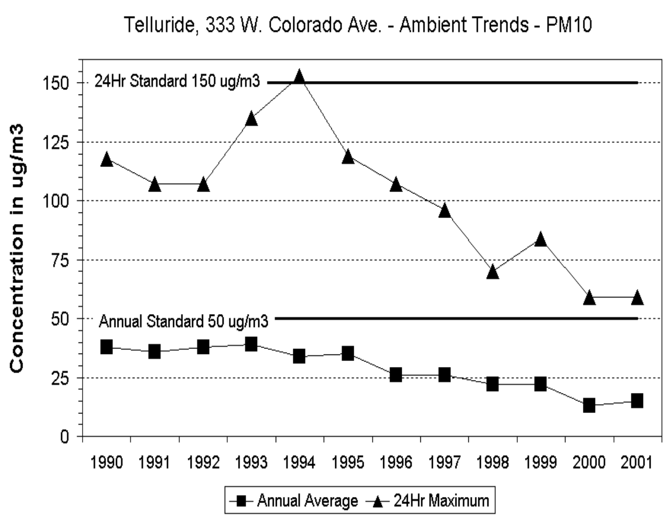


Figure 29 – Mountain Communities Particulate Graphs (continued)









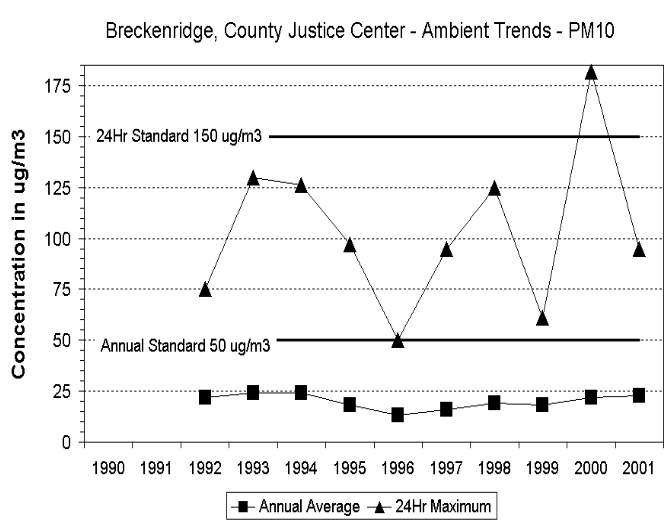


Table 29 - Mountain Communities TSP and Lead Concentrations For 2001

Site Name	Location	TSP (µg/m^3)		Lead (µg/m^3)	
		24-Hr	Annual Geometric Mean	24-Hr	Maximum Quarter
Leadville	510 Harrison St.	111	36	0.30	0.07

Figure 30 – Mountain Communities Lead Graphs

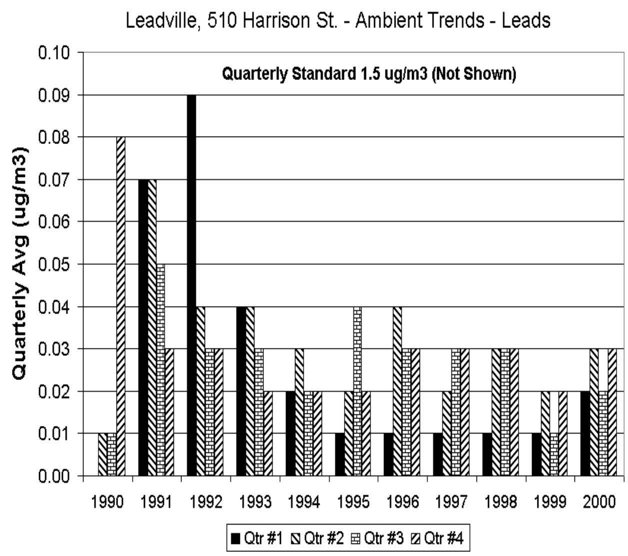
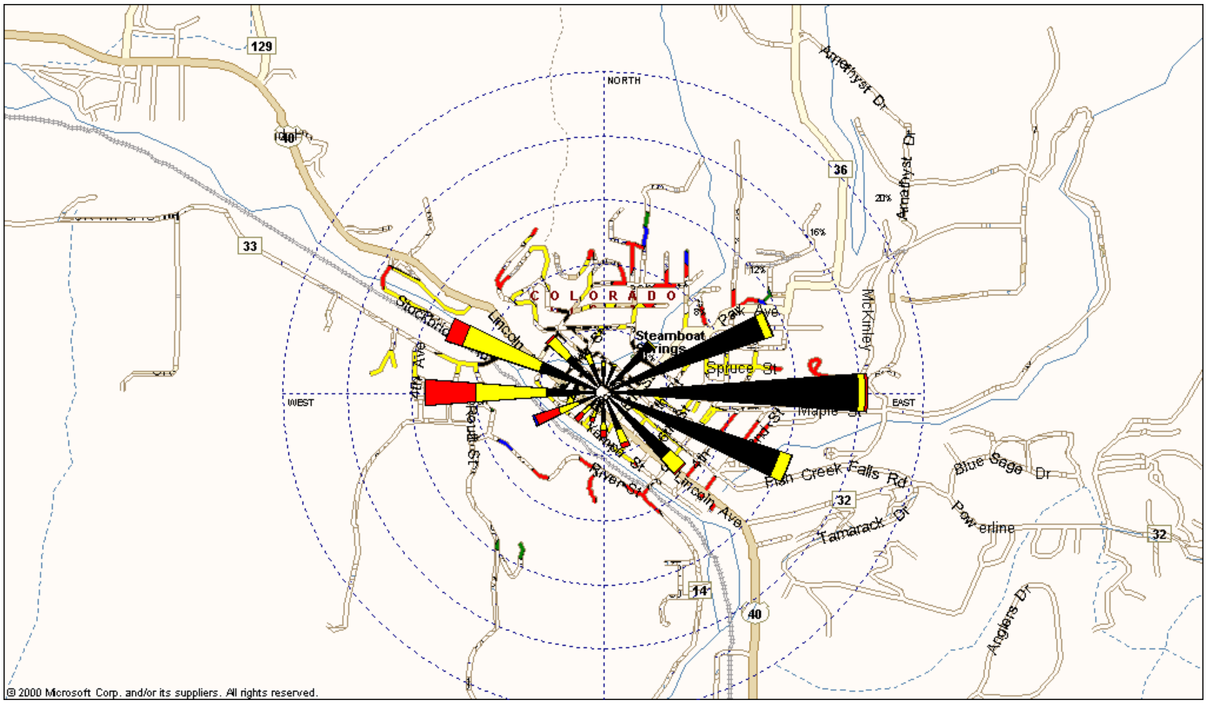
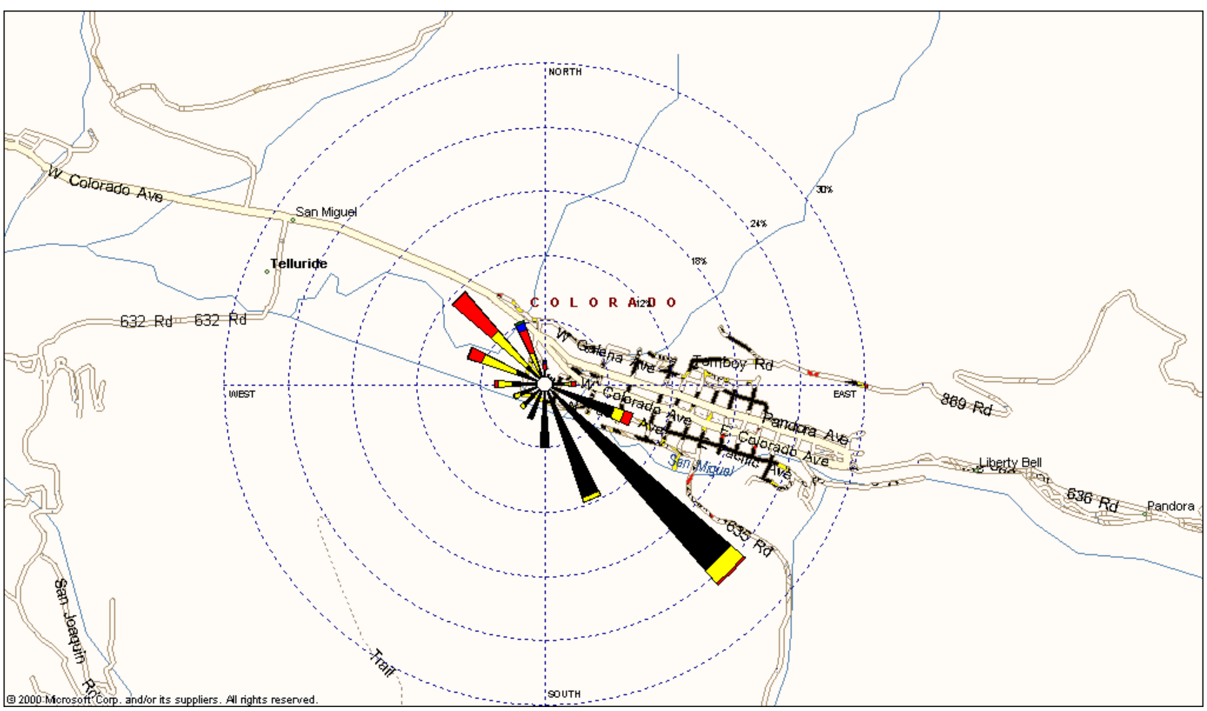


Figure 31 - Mountain Communities Wind Roses

Steamboat Springs, 137 10th St.



Telluride, Coonskin Parking Lot



5.5 Western Communities

The Western Communities are generally smaller towns in fairly broad river valleys. Grand Junction is the only large city in the area and the only location that monitors for carbon monoxide on the western slope. The other locations monitor only for particulates. They are located in Palisade, Delta, Montrose, Durango and Pagosa Springs.

Table 30 - Western Communities Monitors In Operation For 2001
X - Monitors continued in 2001 A – Monitors added in 2001
D – Monitors discontinued in 2001 H – Hourly particulate monitor

County	Site Name	Location	TSP	CO	PM_{10}	$PM_{2.5}$	Met
Archuleta	Pagosa Springs	486 San Juan			D	D	D
		309 Lewis St.			A	A	
Delta	Delta	560 Dodge St.			X	X	
Garfield	Glenwood Springs	806 Cooper Ave.			D		
	Rifle	200 3rd Ave.			D		
	Parachute	100 E. 2nd Ave.			X		
La Plata	Durango	1060 2nd Ave			X	X	
		623 E. 5th St.			X		
		277 3rd St.			X		
Mesa	Grand Junction	515 Patterson Rd.	A		X	X	
		12th Ave. & North St.		X	X/H		X
		924 4th St.	A				
Montrose	Montrose	125 S. Townsend St.			X		
	Olathe	327 4th St.			D		

Table 31 - Western Communities Particulate Values For 2001

Site Name	Location	PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)	
		24-Hr	Annual	24-Hr	Annual
Pagosa Springs	486 San Juan	123	(34)	14.3	(6.8)
	309 Lewis St.	66	(22)	13.0	(5.7)
Delta	560 Dodge St.	69	25	19.8	(7.3)
Glenwood Springs	806 Cooper Ave.	36	(17)		
Rifle	200 3rd Ave.	45	(26)		
Parachute	100 E. 2nd St.	54	18		
Durango	1060 2nd Ave	88	34		
	623 E. 5th St.	38	15		
	277 3rd St.	65	15		
Grand Junction	515 Patterson Rd.	37	20	23.9	7.9
	12th Ave. & North St.	36	(21)		
Montrose	125 S. Townsend St.	59	(20)		
Olathe	327 4th St.	97	(30)		

( ) indicates less than 75% data for the year.

Figure 32 - Western Communities Particulate Graphs

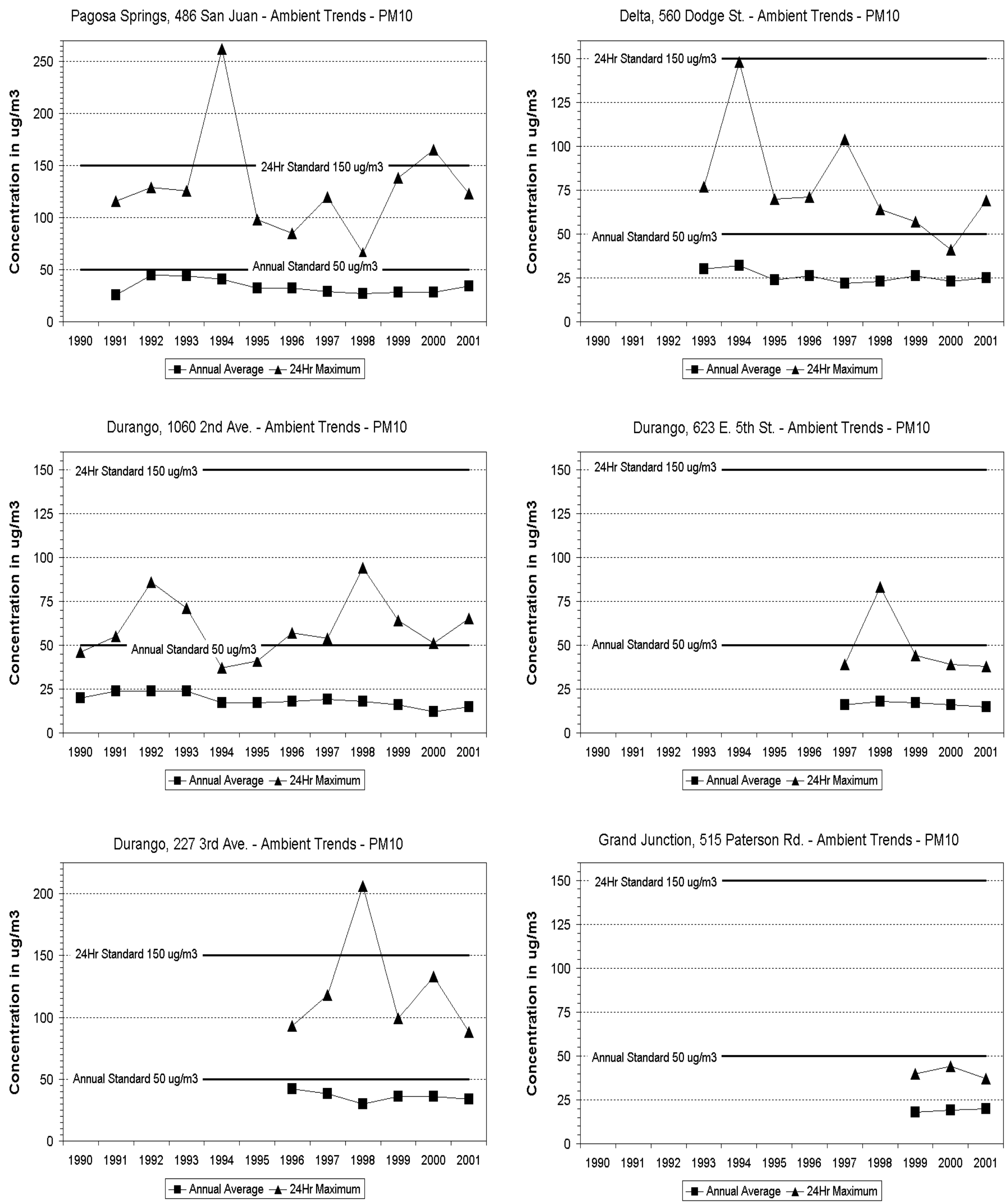
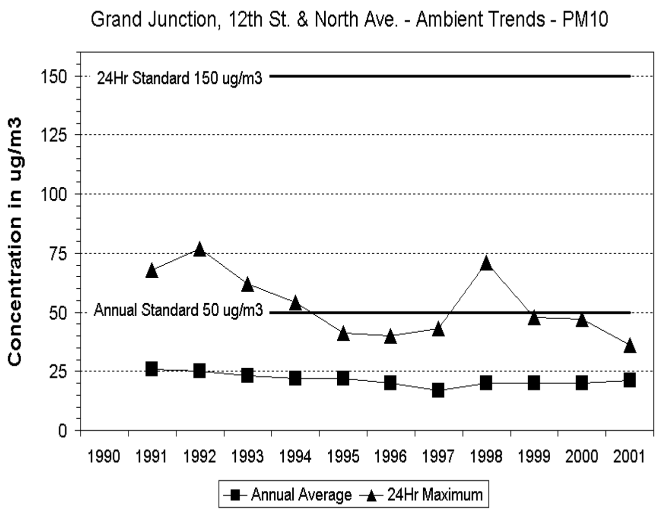


Figure 32 – Western Communities Particulate Graphs (continued)



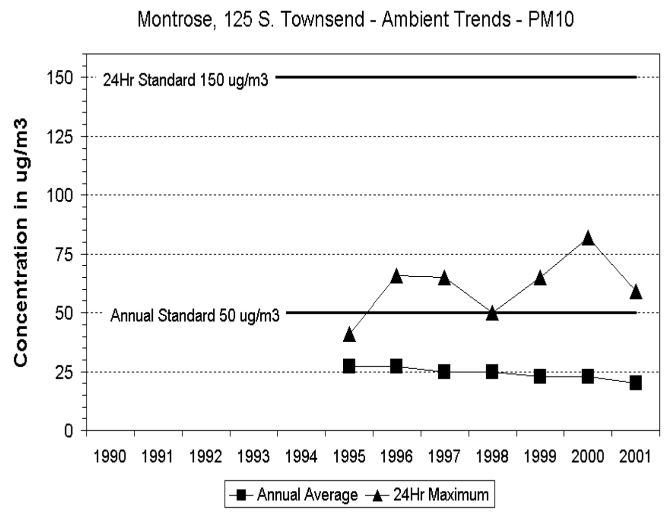


Table 32 - Western Communities TSP Concentrations For 2001

Site Name	Location	TSP ($\mu g/m^3$)	
		24-Hr	Annual Geometric Mean
Grand Junction	515 Patterson Rd.	89	(41)
	924 4th St.	264	(99)

( ) indicates less than 75% data for the year.

Table 33 - Western Communities Carbon Monoxide Values For 2001

Site Name	Location	CO 1-hour Avg. (ppm)		CO 8-hour Avg. (ppm)	
		Maximum	2nd Maximum	Maximum	2nd Maximum
Grand Junction	12th Ave & North St.	6.2	6.1	3.8	3.7

Figure 33 – Western Communities Carbon Monoxide

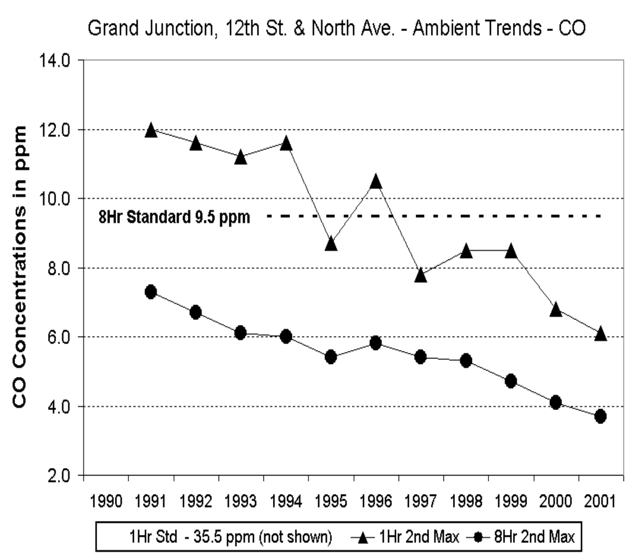
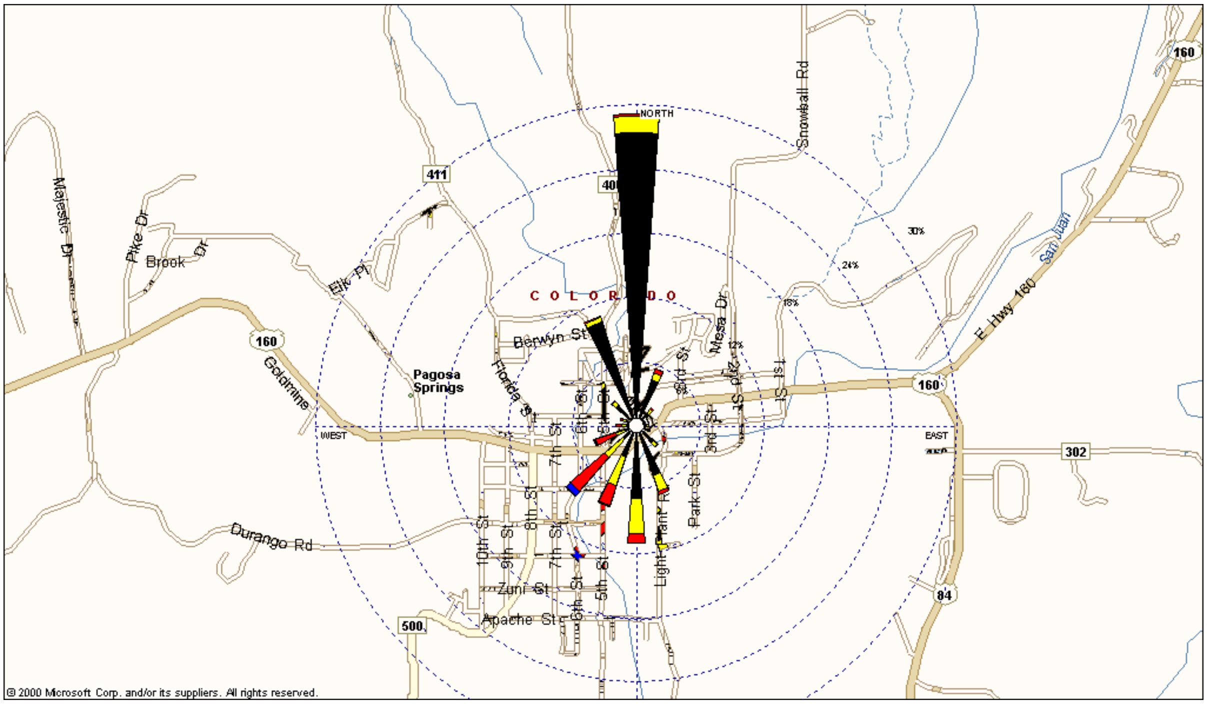
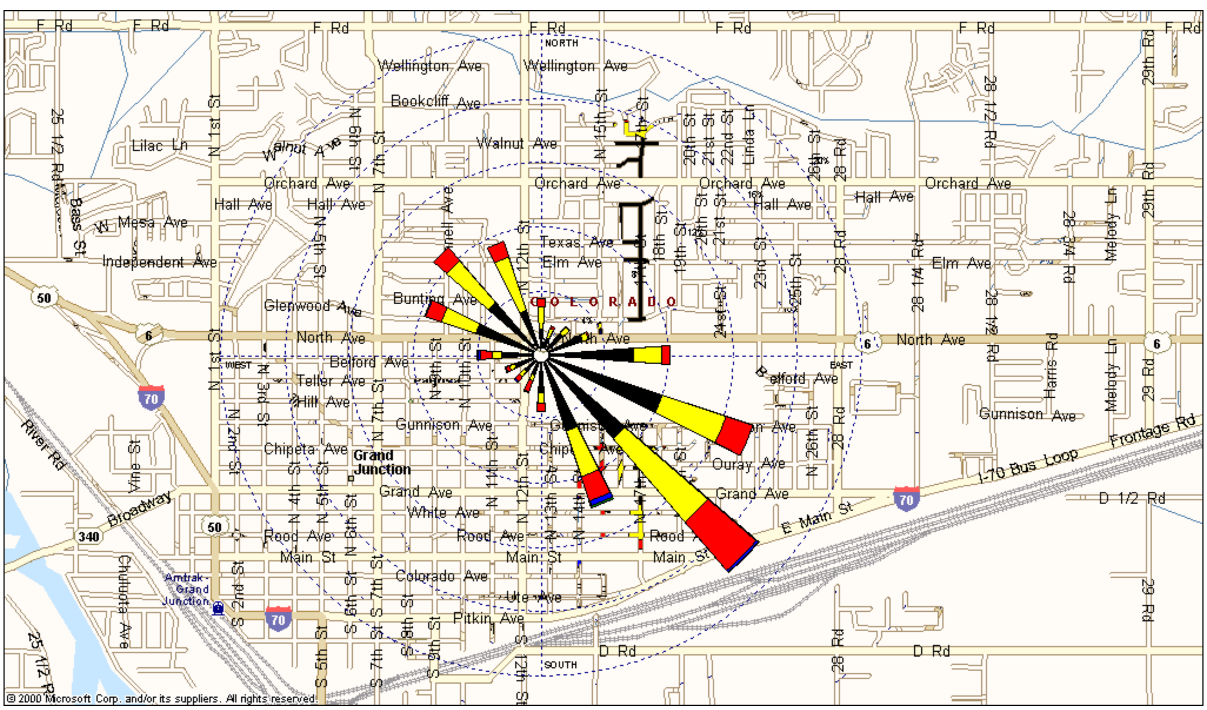


Figure 34 - Western Communities Wind Roses

Pagosa Springs, 486 San Juan



Grand Junction, 12th St. & North Ave



REFERENCES

1. National Primary and Secondary Ambient Air Quality Standards, Title 40 Code of Federal Regulation, Pt. 50. 1999 ed.

2. National Primary and Secondary Ambient Air Quality Standards for Carbon Monoxide, Title 40 Code of Federal Regulations, Pt. 50.8. 1999 ed.

3. Environmental Protection Agency, Air Quality Criteria for Carbon Monoxide, U.S. Government Printing Office, Washington, October 1979, EPA-600/8-79-022.

4. Air Pollution Control Division, Colorado Implementation Plan for Carbon Monoxide Support Document, Chapter #6, Colorado Department of Public Health and Environment, October, 1994.

5. Environmental Protection Agency, Latest Findings on National Air Quality:2000 Status and Trends, Carbon Monoxide, April 4, 2002.

6. Environmental Protection Agency, National Ambient Standards for Ozone: Final Rule, Title 40 Code of Federal Regulations Pt. 50, July 18, 1997.

7. Hempel and Hawley, The Encyclopedia of Chemistry, 3rd Ed., Van Nostrand Reinhold Co., New York City; 1973.

8. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Ozone, April 4, 2002.

9. National Primary and Secondary Ambient Air Quality Standards for Sulfur Dioxide, Title 40 Code of Federal Regulations, Pt. 50.5. 1999 ed.

10. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Sulfur Dioxide, April 4, 2002.

11. Environmental Protection Agency Strategies and Air Standards Division, Preliminary Assessment of Health and Welfare Effects Associated with Nitrogen Oxides for Standards Setting Purposes, U.S. Government Printing Office, Washington: October 1981, pp i-iii.

12. Environmental Protection Agency, Aerometric Information Retrieval System, Quick Look Report, Nitrogen Dioxide, September 2001.

13. Air Pollution Control Division, Mobile Sources Vehicles Travel Projections, January 1997

14. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Nitrogen Dioxide, April 4, 2002.

15. National Primary and Secondary Ambient Air Quality Standards for Particulate Matter, Title 40 Code of Federal Regulation, Pt. 50.7. 1999 ed.

16. The Perils of Particulates, American Lung Association, New York, New, York, March 1994.

17. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Particulate Matter, April 4, 2002.

18. Air Quality – Particulate Matter, www.fort-collins.co.us/airquality/particulate-matter.php, April 18, 2002.

19. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Particulate Matter, April 4, 2002.

20. National Primary and Secondary Ambient Air Quality Standards for Lead, Title 40 Code of Federal Regulation, Pt. 50.7. 1999 ed.

21. Royce, Overview of Radon, Lead and Asbestos Exposure, American Family Physicians Supplement, November 1991, Vol. 44 S52-S62.

22. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Lead, April 4, 2002.

23. Clean Air Act as amended in 1977, section 169a (42 USC 7491)

24. Visibility Protection for Federal Class I Areas, codified at Title 40 Code of Federal Regulations, Pt. 51.300-309.

25. Environmental Protection Agency, Air Quality Criteria for Oxides of Nitrogen, December, 1982, AP 600/8-82-029aF.

26. Marrow, P.E. and M.J. Utell, Technology and Methodology of Clinical Exposure to Aerosols, Aerosols, S.D. Lee, Editor, Lewis Publishers, Inc., 1986, pp 671-681.

27. Hacknay J.D., W.S. Linn and E.L. Avol, Controlled Exposures of Human Volunteers to Particulate Pollution: Recent Findings and Current Research Questions, Aerosols, S.D. Lee, Editor, Lewes Publications, Inc., 1986, 699-709.

28. Loiy, P.J. and M. Lipann, Measurements of Exposures to Acid Sulfuric Aerosols, Aerosols, S.D. Lee, Editor, Lewes Publications, Inc., 1986, 699-709.

29. W.C. Malm, et Visibility and Particulate Measurements in the Western United States, presented at the 78th Annual Meeting of APCA, June 1985.

30. Agency for toxic Substances and Disease Registry, ToxFAQs for Arsenic, www.astr.cdc.gov/tfacts2.html

31. Agency for toxic Substances and Disease Registry, ToxFAQs for Cadmium, www.astr.cdc.gov/tfacts5.html

32. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends, Toxic Air Pollutants, April 4, 2002.

33. Environmental Protection Agency, Aerometric Information Retrieval System, Maximum Values Report, Carbon Monoxide, July 2002

34. Environmental Protection Agency, Aerometric Information Retrieval System, Maximum Values Report, Ozone, July, 2002.

35. Environmental Protection Agency, Aerometric Information Retrieval System, Maximum Values Report, Sulfur Dioxide, July, 2002.

36. Environmental Protection Agency, Aerometric Information Retrieval System, Quick Look Report, Nitrogen Dioxide, September 2001.

37. Environmental Protection Agency, Aerometric Information Retrieval System, Maximum Values Report, Particulates, July, 2002.

38. Environmental Protection Agency, Aerometric Information Retrieval System, Maximum Values Report, Lead, July, 2002.

39. Environmental Protection Agency, National Air Quality and Emissions Trends Report, 2000, Carbon Monoxide, September, 2001.

40. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends, Ozone, April 4, 2002.

41. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends, Sulfur Dioxide, April 4, 2002.

42. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends, Nitrogen Dioxide, April 4, 2002.

43. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends, Particulate Matter, April 4, 2002.

44. Environmental Protection Agency, Latest Findings on National Air Quality: 2000 Status and Trends , Lead, April 4, 2002.