Air quality measurements in Arizona can be divided into three categories: criteria pollutants, visibility, and photochemical monitoring. Each category is discussed below. The EPA has set NAAQS (see Section B) for criteria air pollutants: carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, lead, and PM_{10} and smaller. Additional PM monitoring includes the two subsets of PM_{10}: coarse and PM less than 2.5 microns in size. These pollutants are monitored in Arizona by industry, by county air pollution districts, by Indian tribes, and by the ADEQ. Section A presents the 1999 data measurements by criteria pollutant. The data tables in this section are organized by county; site operator information can be found in the site index tables in the supplement to this document. Data recovery information (number of valid samples) is included in the tables. The number of valid samples is important for determining the representativeness of the average data calculations. Section B describes the compliance requirements and status for the criteria pollutants. Visibility monitoring information is presented in Section C.

The data tables in this section are organized by county; site operator information can be found in the site index tables in the supplement to this document. Data recovery information (number of valid samples) is included in the tables. The number of valid samples is important for determining the representativeness of the average data calculations.

Section A – Criteria Pollutants, 1999 Data

Carbon Monoxide

Carbon monoxide, a colorless, odorless, tasteless gas that is produced in the incomplete combustion of fuels, has a variety of adverse health effects that arise from its chemically binding with blood hemoglobin. Carbon monoxide successfully competes with oxygen for binding with hemoglobin and thereby impairs oxygen transport. This impaired transport leads to several central nervous system effects, such as the impairment of time interval discrimination, changes in relative brightness thresholds, increased reaction time, and headache, fatigue and dizziness. Carbon monoxide exposures also contribute to or exacerbate arteriosclerotic heart disease.

In Arizona's metropolitan areas, about 75 percent of carbon monoxide emissions come from on-road motor vehicles, 20 percent from off-road vehicles or equipment such as construction vehicles and lawn and garden equipment, and 5 percent from fuel combustion from commercial and residential heating. This pollutant has low background levels, has its highest concentrations next to the busiest streets, and has elevated neighborhood concentrations in locations that reflect emissions transported from upwind portions of the city. Its concentrations peak in November to January, because its emissions are highest in cold weather, automotive emissions of carbon monoxide vary inversely with temperature, and because the surface layer of the atmosphere is at its most stable. Hourly concentrations tend to be at their maximum between 6 p.m. and midnight and during the morning rush hour.

Controls have reduced carbon monoxide emissions to the point where the standards have been achieved in greater Phoenix in 1996 to 1999, in stark contrast to the first

half of the 1980s, when more than 100 exceedances were recorded each year. Similar improvements have occurred in Tucson, where the last exceedance was recorded in 1984. Of these controls, equipping vehicles with catalytic converters and electronic ignition systems were the most effective, but significant reductions can also be attributed to the Vehicle Inspection and Maintenance Program (beginning in 1976) and oxygenated fuels (beginning in 1989).

Carbon monoxide is monitored continuously with non-dispersive infrared instruments that are deployed in urban neighborhoods and near busy roadways or intersections. In 1999, 15 monitors were operated in greater Phoenix, four in Tucson, and one each in Apache Junction and Casa Grande. Four monitors were operated at two sites in Douglas, Arizona and two sites in Agua Prieta, Mexico as part of a year-long special study of air quality conditions. Table I.5 presents the 1999 carbon monoxide data.

Table 5. 1999 Carbon Monoxide Data (in ppm)

County and City or Site	One-Hour		Eight-Hour Average		Number of Valid Hourly Samples
	Max	Second Highest	Max	Second Highest	
Cochise					
Douglas - ADOT	23.0	19.5	4.9	3.6	8,600
Douglas - Cemetery	9.5	8.4	4.0	4.0	8,595
Maricopa					
Central Phoenix	11.3	9.3	7.2	5.9	8,272
Gilbert [s]	3.8	3.7	2.4	2.4	5,907
Glendale [s]	5.7	5.3	3.8	3.4	5,938
Grand Avenue [s]	18.4	13.5	10.5	8.0	3,486
Greenwood	10.8	9.5	6.7	6.6	8,242
JLG Supersite	8.5	8.2	7.0	6.6	8,664
Maryvale [s]	9.7	9.0	7.2	6.6	6,008
Mesa [s]	7.2	5.8	4.4	4.0	6,453
North Phoenix [s]	7.8	6.3	3.5	3.5	5,930
Post Office [s] (Closed April 1)	8.5	7.4	5.8	5.7	2,104
South Phoenix (Closed August to November)	7.8	7.7	4.6	4.4	5,145
South Scottsdale [s]	6.0	5.8	4.3	4.1	5,754
West Chandler [s]	4.3	4.0	2.9	2.8	5,787
West Indian School Road	11.8	11.7	7.6	7.5	8,474

	Max	Second Highest	Max	Second Highest	Valid Hourly Samples
West Phoenix	12.3	11.9	7.7	7.4	8,345
Pima					
Tucson - Downtown	10.6	6.3	4.3	3.2	8,673
Tucson - Craycroft	5.4	4.7	2.3	2.0	8,665
Tucson - Alvernon	8.5	7.8	4.2	3.8	8,745
Tucson - Cherry	5.2	5.2	3.4	3.4	8,251
Pinal					
Apache Junction - Highway Yard	1.9	1.7	.9	.8	8,057
Casa Grande - Airport	2.1	1.5	.8	.8	7,625
Mexico					
Agua Prieta - Fire Station	26.7	18.1	7.7	7.5	8,265
Agua Prieta - Companie Federale Electric	16.6	14.2	7.4	7.4	7,515

[s] *Seasonal monitor operating from January to March and October to December.*

Lead

Lead, a heavy metal with pronounced toxic effects, is present in the atmosphere as a constituent of fine particles. Chronic lead poisoning attacks the blood, the brain and nervous system, the kidney, and the reproductive system, with such effects as moderate to severe brain and kidney damage, sterility, and abortions, stillbirths, and neonatal deaths. Low-level chronic exposure to lead manifests itself first in the inhibition of the biosynthesis of hemoglobin, resulting in the anemia associated with chronic lead poisoning.

Emissions of lead in Arizona come from the smelting of ore, the combustion of fossil fuels, and, until the mid-1970s, from the use of alkyl lead compounds as anti-knock additives in gasoline. With the phasing out of regular lead gasoline, the automotive emissions of lead to the atmosphere have declined to near zero.

Controls to reduce lead emissions have been extremely effective, with a net 94 percent reduction on a national basis from 1978 to 1987: automotive emissions were reduced 97 percent through the elimination of lead compounds in gasoline; stationary source fuel combustion emissions were reduced 92 percent; and industrial processes and solid waste disposal emissions were reduced substantially as well.

Lead is monitored by analyzing PM_{10} samples collected for 24 hours, generally every sixth day. Total Suspended Particulate (TSP) samplers are the Reference Method, but are no longer used to obtain lead data. Lead is primarily a combustion product, so PM_{10} samples capture ambient lead concentrations adequately. Of the 16 sites where lead was determined in 1999, four are urban (Phoenix, Payson, Douglas, and Nogales), three are located near either a smelter (Hayden) or cement plant (Clarkdale), and nine are background sites (Petrified Forest NP, Chiricahua NM, Grand Canyon – Hance, Grand Canyon – Indian Gardens, Tonto NM, Palo Verde, Organ Pipe Cactus NM, and Hillside).

Quarterly lead averages are not included here but are available on request.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a reddish-brown gas that is formed by the oxidation of nitric oxide (NO), which itself is a by-product of combustion of all fuels. At the lowest nitrogen dioxide exposure levels at which adverse health effects have been detected, respiratory damage has been observed: destruction of cilia, alveolar tissue disruption, and obstruction of the respiratory bronchioles. Animal studies suggest that nitrogen dioxide may be a causal or aggravating agent in respiratory infections. Community exposure studies to lower ambient levels of nitrogen dioxide, however, have demonstrated no significant links with respiratory symptoms or disease. This pollutant is of greater concern in its reduction of visibility (it causes 5 percent of the visibility reduction in Phoenix) and in its contributory role in the photochemical formation of ozone.

Combustion emissions of nitrogen oxides are 95 percent nitric oxide and 5 percent nitrogen dioxide. Because nitric oxide is rapidly oxidized to nitrogen dioxide, nitric oxide emissions serve as a surrogate for nitrogen dioxide. In a recent Phoenix emissions inventory, the transportation sector dominated nitric oxide emissions: 58 percent of the emissions came from cars and trucks, 27 percent came from off-road vehicles such as trains and diesel-powered construction vehicles, and 15 percent from other sources, including power plants, biogenic emissions from soil, and stationary combustion sources. Nitric oxide and nitrogen dioxide concentrations are highest near major roadways. Nitric oxide concentrations decrease rapidly with distance from the roadway, whereas nitrogen dioxide concentrations are more evenly distributed because of their formation through oxidation and their subsequent transport. Concentrations of nitrogen dioxide are highest in the late afternoon and early evening of winter, when rush hour emissions of nitric oxide are converted to nitrogen dioxide under relatively stable atmospheric conditions. Because nitric oxide reacts rapidly with ozone, nocturnal ozone concentrations in cities are often reduced to near-zero levels. This nitric oxide scavenging of ozone does not occur in remote areas. Nocturnal ozone concentrations at background sites are high compared with the urban concentrations.

Nitrogen oxides emissions from motor vehicles have been reduced through retardation of spark timing, lowering the compression ratio, exhaust gas recirculation sys-

tems, and three-way catalysts. The Vehicle Inspection and Maintenance Program, with its NOx test for light-duty gasoline vehicles 1981 and newer (in Phoenix only) and its opacity test for diesel vehicles, has also helped. Reformulated gasolines also decrease nitrogen oxides emissions: Federal Phase II gasoline, by 1.5 percent for vehicular and 0.5 percent for off-road equipment; California Phase 2 gasoline, by 6.4 percent for vehicular and 7.7 percent for off road equipment.

Nitrogen dioxide is monitored continuously with chemiluminescence instruments, which also determine nitric oxide concentrations and the sum of the two, NOx concentrations. These instruments are located in urban neighborhoods where the emissions are dense or ozone concentrations tend to be at their maximum. Monitors are also located near major coal fired electrical power plants. Twelve monitors were operated in Arizona in 1999: three near power plants, eight urban, and one background. Table I.6 presents the nitrogen dioxide data collected in Arizona in 1999.

Table 6. 1999 Nitrogen Dioxide Data (in ppm)

County and City or Site	Annual Average	Maximum		Number of Valid Hourly Samples
		One-Hour Average	24-Hour Average	
Apache				
St. Johns – Mesa Parada	Sampling discontinued May 1999			
Springerville – Coyote Hills	.001	.048	.010	7,753
Maricopa				
Central Phoenix	.034	.151	.069	8,102
Palo Verde [s]	.003	.027	.009	2,403
Phoenix – Greenwood, MCESD	.041	.157	.089	7,955
Phoenix – JLG Supersite	.028	.120	.071	8,693
Salt River Pima-Maricopa [s]	.012	.077	.028	4,866
South Scottsdale	.031	.213	.137	8,017
West Phoenix	.031	.148	.070	8,292
Mohave				
Bullhead City – Alonas Way	.010	.053	.030	8,469
Pima				
Tucson – Craycroft	.018	.063	.036	8,647
Tucson – Children's Park	.019	.070	.036	8,029

Sulfur Dioxide

Exposure to sulfur dioxide, a colorless gas with a pungent, irritating odor at elevated concentrations, alters the mechanical function of the upper airway, including increasing the nasal flow resistance and decreasing the nasal mucus flow rate. short-term exposures result in an exaggerated air flow resistance in about 10 percent of the subjects tested, and produce acute bronchioconstriction in strenuously exercising asthmatics.

In Arizona the principal source of sulfur dioxide emissions has been the smelting of sulfide copper ore. Most fuels contain trace quantities of sulfur, and their combustion releases both gaseous sulfur dioxide (SO_2) and particulate sulfate (SO_4^{--}). A recent sulfate inventory for Phoenix has 32 percent of the emissions from point sources, 26 percent from area sources, 23 percent from off-road vehicles and equipment, and 19 percent from on-road motor vehicles. Sulfur dioxide is removed from the atmosphere through dry deposition on plants and its conversion to sulfuric acid and eventually to sulfate. Sulfur dioxide has extremely low background levels, with elevated concentrations found downwind of large point sources. Concentrations in urban areas are low and are homogeneously distributed, with annual averages varying from 3 to 11 μg/m3.

Major controls were installed in Arizona's copper smelters in the 1980s, reducing sulfur dioxide emissions substantially. Vehicular emissions of sulfur dioxide and sulfate have been reduced through lowering the sulfur content in diesel fuel and gasoline.

Sulfur dioxide is monitored continuously with pulsed fluorescence instruments, most of which are clustered around copper smelters or coal fired electric power plants. In 1999, 13 reporting monitors were sited near copper smelters, two near power plants and four in urban areas. Table I.7 presents the sulfur dioxide data collected in Arizona in 1999.

Table 7. 1999 Sulfur Dioxide Data (in $\mu g/m^3$)

County and City or Site	Annual Average	Maximum		Number of Valid Hourly Samples
		Three-Hour Average	24-Hour Average	
Apache				
St. Johns – Mesa Parada	Sampling discontinued May 1999			
Springerville – Coyote Hills	0	133	26	7,735
Gila				
Hayden – Garfield Avenue	19	507	208	8,753
Hayden – Old Jail, ASARCO	20	583	313	8,747

	Average	Three-Hour Average	24-Hour Average	Valid Hourly Samples
Hayden – Junction	13	404	69	8,739
Hayden – Montgomery Ranch	34	655	209	8,761
Hayden – Old Jail, ADEQ	24	475	99	8,015
Miami – Ridgeline	13	200	65	8,423
Miami – Jones Ranch	8	897	152	8,582
Miami – Town Site	8	263	72	8,754
Winkleman	46	1013	231	8,756
Maricopa				
Central Phoenix	10	97	34	7,457
South Scottsdale	5	47	13	7,347
Mohave				
Bullhead City – Alonas Way	4	246	34	8,469
Pima				
Green Valley (Sierrita – Elam Ranch) (Sampling ended Aug. 1999)	3	32	9	5,562
Tucson – Craycroft	4	31	10	8,531
Pinal				
San Manuel – Townsite	4	290	69	N/A
San Manuel – Dorm Site	4	311	54	N/A
San Manuel – LDS Church (Sampling ended Oct. 1999)	9	220	65	6,121
San Manuel – Hospital	8	433	214	N/A

N/A – Not available

Ozone

Ozone, a colorless, slightly odorous gas, is both a natural component of the atmosphere, through its photochemical formation from natural sources of methane, carbon monoxide, hydrocarbons, and nitrogen oxides, and an important air contaminant in urban atmospheres. In the stratosphere, ozone blocks harmful ultraviolet radiation.

In the urban atmosphere, its formation from anthropogenic emissions of hydrocarbons and nitrogen oxides leads to concentrations harmful to people, animals, plants, and materials. Ozone causes significant physiological and pathological changes in both animals and humans at concentrations present in many urban environments. Short-term (one to two hours) exposures to concentrations in the range of 0.1 to 0.4 parts per million induce the following changes in lung function: increased respiratory rates, increased pulmonary resistance, decreased tidal volumes, and changes in lung mechanics. Symptomatic responses in exercising adults include throat dryness, chest tightness, substernal pain, cough, wheeze, pain on deep inspiration, shortness of breath, and headache. These symptoms also have been observed at lower concentrations for longer exposures. Evidence suggests that ozone exposure makes the respiratory airways more susceptible to other bronchioconstrictive challenges. Animal studies suggest that ozone exposure interferes with or inhibits the immune system. Ozone at ambient concentrations injures the stomates, which are the cells that regulate plant respiration, resulting in flecks on the upper leaf surfaces of dichotomous plants and the death of the tips of coniferous needles. Ozone is considered by plant scientists to be the most important of all of the phytotoxic air pollutants, causing more than 90 percent of all plant injury from air pollution on a global basis.

Ozone is formed photochemically by the reaction of volatile organic compounds and nitrogen oxides. Volatile organic compound (VOC) emissions in greater Phoenix come from cars and trucks (31 percent), off-road vehicles and equipment such as lawn mowers (27 percent), small stationary sources (20 percent), biogenic emissions from grass, shrubs, and trees (17 percent), and point sources (5 percent). Nitrogen oxides (NOx) come from cars and trucks (58 percent), off-road vehicles such as construction equipment and trains (27 percent), electric power plants (7 percent), small stationary sources (4 percent), and biogenic emissions from soil (4 percent). Ozone has relatively high background levels, with the daily maximum in remote areas being about one-half to three-quarters of the daily maximum in the urban areas. Within an urban area, the highest ozone concentrations tend to occur on the downwind edge, although high concentrations do occur less frequently in the central city. High ozone concentrations are a summer phenomenon, when sunlight and evaporative hydrocarbon emissions peak. Ozone concentrations are low to near zero at night, rise rapidly through the morning, and peak in the afternoon.

Controls to reduce the precursors of ozone, VOC and NOx, have been carried out successfully for years. Nitrogen oxides and exhaust VOC from vehicles have been reduced through engine modifications and three-way catalytic converters. Evaporative hydrocarbons from vehicles have been reduced through better engineered fuel tanks and auxiliary plumbing combined with carbon absorption canisters. Additional reductions of vehicular VOC have come through the Vehicle Inspection and Maintenance Program, which tests all gasoline vehicles for hydrocarbons (Phoenix and Tucson), through vapor-capturing equipment for gasoline tankers, through vapor recovery systems at retail gas stations (Phoenix area only), and through reformulated gasoline (Maricopa County only). Stationary source hydrocarbons have been reduced

through a variety of better control equipment required by stricter regulations. Despite these efforts, the continued growth in Arizona, combined with the high natural background ozone, will make achieving the eight-hour standard a difficult proposition.

Ozone is monitored continuously with ultraviolet absorption instruments in urban neighborhoods for population exposure, in areas downwind of urban areas for maximum concentration monitoring, and in remote areas for background information. In 1999, 34 reporting ozone monitors were in operation; five were for background, 22 for urban neighborhoods, and 10 for maximum concentrations downwind of urban areas. Tables I.8 and I.9 present the ozone data collected in Arizona in 1999.

Table I.8. 1999 Ozone Data (in ppm), One-Hour Averages

County and City or Site	One-Hour Average				Number of Valid Hourly Samples
	Maximum	2nd Highest	3rd Highest	4th Highest	
Apache					
St. Johns – Mesa Parada	Sampling discontinued May 1999				
Cochise					
Chiricahua National Monument	.082	.082	.078	.076	7678
Coconino					
Grand Canyon National Park – Hopi Pt.	.086	.083	.083	.081	7955
Gila					
Rye [s]	.096	.090	.088	.086	5161
Maricopa					
Blue Point	.108	.106	.105	.104	8564
Central Phoenix	.109	.103	.103	.097	8124
Fountain Hills	.114	.113	.105	.103	8618
Glendale [s]	.108	.101	.097	.097	6838
Humboldt Mt. [s]	.098	.095	.094	.094	7031
Lake Pleasant [s]	.095	.094	.093	.092	7171
Maryvale [s]	.112	.101	.098	.095	7134
Mesa – Falcon Field [s]	.105	.099	.099	.098	7167

	Maximum	2nd Highest	3rd Highest	4th Highest	Valid Hourly Samples
Mesa	.124	.111	.109	.108	8327
Mt. Ord – MCESD [s]	.103	.097	.097	.096	6970
North Phoenix	.110	.108	.102	.101	8319
Palo Verde [s]	.090	.087	.085	.084	4969
Phoenix –Emergency Management [s]	.117	.109	.109	.107	7180
Phoenix – JLG Supersite	.073	.073	.072	.072	8452
Pinnacle Peak	.119	.119	.101	.095	8614
Rio Verde [s]	.111	.101	.100	.100	4882
Salt River Pima – Maricopa [s]	.116	.106	.104	.097	4964
South Phoenix [s]	.090	.088	.087	.086	6943
South Scottsdale	.089	.087	.086	.083	8124
West Chandler [s]	.097	.087	.083	.082	7013
West Phoenix	.115	.109	.109	.108	8281
Pima					
Saguaro Park	.090	.088	.082	.079	8215
Tucson – Craycroft	.095	.092	.084	.082	8695
Tucson – Children's Park	.092	.089	.081	.080	8699
Tucson – Downtown	.078	.076	.076	.073	8672
Tucson – Fairgrounds	.085	.084	.080	.079	8663
Tucson – Tangerine	.087	.080	.078	.077	8687
Pinal					
Apache Junction – Highway Yard	.112	.111	.109	.099	8447
Casa Grande Airport	.090	.087	.084	.084	8436
Yavapai					
Hillside [s]	.090	.090	.089	.087	6420

	Maximum	2nd Highest	3rd Highest	4th Highest	Valid Hourly Samples
Yuma					
Yuma [s]	.103	.089	.087	.086	5334

[s] *Seasonal monitor operating from April to October.*

Table I.9. 1999 Ozone Data (in ppm), Eight-Hour Averages

County and City or Site	Eight-Hour Average				Number of Daily Exceedances	Number of Sample Days
	Maximum	2nd Highest	3rd Highest	4th Highest		
Apache						
St. Johns – Mesa Parada	Sampling discontinued May 1999					
Cochise						
Chiricahua National Monument	.080	.076	.073	.072	0	320
Coconino						
Grand Canyon National Park – Hopi Pt.	.082	.080	.080	.077	0	331
Gila						
Rye	.084	.080	.080	.080	0	215
Maricopa						
Blue Point	.092	.091	.089	.088	7	358
Central Phoenix	.088	.081	.080	.078	1	338
Fountain Hills	.091	.089	.088	.086	6	362
Glendale [s]	.083	.083	.082	.081	0	289
Humboldt Mt. [s]	.091	.088	.088	.086	7	295
Lake Pleasant [s]	.084	.083	.082	.081	0	298
Maryvale [s]	.086	.085	.080	.080	2	298
Mesa –Falcon Field [s]	.084	.083	.083	.082	0	301
Mesa	.096	.090	.085	.084	3	357

	Maximum	2nd Highest	3rd Highest	4th Highest	Daily Exceedances	of Sample Days
Mt. Ord – MCESD [s]	.094	.091	.088	.088	8	291
North Phoenix	.088	.087	.085	.084	3	355
Palo Verde [s]	.082	.081	.081	.080	0	207
Phoenix –Emergency Management [s]	.097	.094	.088	.087	7	301
Phoenix – JLG Supersite	.066	.065	.063	.061	0	352
Pinnacle Peak	.090	.089	.087	.085	4	362
Rio Verde [s]	.093	.089	.087	.087	7	205
Salt River Pima – Maricopa [s]	.085	.085	.083	.082	2	207
South Phoenix [s]	.077	.077	.077	.075	0	296
South Scottsdale	.077	.076	.072	.072	0	351
West Chandler [s]	.075	.072	.071	.069	0	234
West Phoenix	.099	.092	.092	.091	5	355
Pima						
Saguaro Park	.085	.073	.071	.069	1	342
Tucson – Children's Park	.085	.074	.072	.071	1	362
Tucson – Craycroft	.085	.082	.072	.071	1	362
Tucson – Downtown	.071	.068	.064	.064	0	361
Tucson – Fairgrounds	.081	.071	.069	.068	0	361
Tucson – Tangerine	.082	.074	.073	.073	0	362
Pinal						
Apache Junction – Highway Yard	.091	.089	.081	.080	2	353
Casa Grande Airport	.083	.083	.079	.078	0	351
Yavapai						
Hillside [s]	.089	.088	.085	.084	3	267

	Maximum	2nd Highest	3rd Highest	4th Highest	Daily Exceedances	of Sample Days
Yuma						
Yuma [s]	.087	.081	.079	.079	1	222

[s] *Seasonal monitor operating from April to October.*

Particulate Matter Smaller Than 10 Microns (PM_{10}) and Smaller Than 2.5 Microns ($PM_{2.5}$)

"Particulate matter" is a collective term describing very small solid or liquid particles that vary considerably in size, geometry, chemical composition, and physical properties. Produced by both natural processes (pollen, wind erosion) and human activity (soot, fly ash, dust from paved and unpaved roads), particulates contribute to visibility reduction, pose a threat to public health, and cause economic damage through soiling. Some fine particulates ($PM_{2.5}$) are formed by the condensation of vapors or by their subsequent growth through coagulation or agglomeration. Others are emitted directly from the sources, either combustion or from mechanical grinding of soils. Coarse particulates (2.5 to 10 microns) are formed through mechanical processes such as the grinding of matter and the atomization of liquids. Fine particulates can also be classified as primary (produced within and emitted from a source with little subsequent change) or secondary (formed in the atmosphere from gaseous emissions). Secondary particulate nitrates and sulfates, for example, form in the atmosphere from the oxidation of sulfur dioxide and nitric oxide gases. Most atmospheric carbon, on the other hand, is primary, having been emitted directly from combustion sources, although some of the organic carbon in the aerosol is secondary, having been formed by the complex photochemistry of gaseous volatile organic compounds.

The health effects of particulates depend on their size, shape, and chemical composition. Particles larger than 10 microns are deposited in the upper respiratory tract. Particles from 2.5 to 10 microns are inhalable and are deposited in the upper parts of the respiratory system. Particles smaller than 2.5 microns are respirable and enter the pulmonary tissues to be deposited there. Particles in the size range of 0.1 to 2.5 microns are most efficiently deposited in the alveoli, where their effective toxicity is greater than larger particles because of the higher relative content of toxic heavy metals, sulfates, and nitrates. Epidemiological studies have shown causal relationships between particulates and excess mortality, aggravation of bronchitis and small reversible changes in pulmonary function in children. Acidic aerosols have been linked to the inability of the upper respiratory tract and pulmonary system to remove harmful particles.

The Arizona Comparative Environmental Risk Project, a multi disciplinary investigation into human exposure to all environmental risks, which was completed in 1995,

ranked outdoor air quality in general and PM in particular, as the highest environmental risk in the state. Annual premature deaths from exposure to PM_{10} concentrations in Arizona were estimated at 963, including 667 in Maricopa County and 88 in Tucson. Increased percentages of hospital admissions for respiratory disease (1 to 4 percent, depending on the city), of asthma episodes (5 to 14 percent), of lower respiratory symptoms (5 to 15 percent), and of coughs (2 to 6 percent) were attributed to the prevailing (1991) annual PM_{10} concentrations. Chronically high particulates concentrations in the ambient air continue to pose a serious health threat to many Arizonans.

Coarse particulate emissions are mostly geological and are dominated by dusts from three activities: reentraining dust from paved roads, driving on unpaved roads, and earthmoving associated with construction. Soil dust from these sources and others contribute more than 70 percent of the coarse particulates in Phoenix. On days with winds in excess of 15 miles per hour, wind erosion of soil contributes to this loading. With a more diverse chemical composition, fine particulates (PM2.5) emissions are more evenly distributed among a larger number of sources. At the Phoenix JLG Supersite, receptor modeling indicates gasoline and diesel engine exhaust account for more than two-thirds of the PM2.5 emissions. Soil dust contributes another 10.5 percent. In other urban and rural areas, this mixture of sources will vary: agricultural and mining areas, for example, will be more heavily influenced by emissions from these activities.

$PM_{2.5}$ concentrations tend to be at their highest in the central portions of urban areas, diminishing to background levels at the urban fringe. In contrast, PM10 concentrations are not smoothly spatially distributed, because each monitoring site is strongly influenced by the degree of localized emissions of coarse particulates. Background concentrations of PM10 are about 40 percent of the urban maxima (20 μg/m3 for an annual average background versus about 50 μg/m3 for the urban maximum). Background concentrations of PM2.5 are about 5 μg/m3, in contrast to the urban maxima of 12 to 15 μg/m3. Concentrations of both size ranges of particulates tend to be higher in the late fall and winter, when atmospheric dispersion is at a seasonal low. PM10 maximum concentrations can occur in any season, provided nearby sources of coarse particulates are present or when strong and gusty winds suspend soil disturbed by human activities. Hourly concentrations of particulates tend to peak during those hours of the poorest dispersion, which occur from sunset to mid-morning.

Controls to reduce particulates have been in place for decades, beginning with an ordinance that required watering to reduce dust from construction in Pima County in the 1960s. Maricopa County's umbrella dust abatement rule, Rule 310, has gone through many additions through the years, and now is regulating construction dust, track-out dust from construction sites, and dust from unpaved parking lots. Efforts to reduce dust resuspended from paved roads have concentrated on eliminating track-out from construction sites, curbing and stabilizing road shoulders, and investigating more efficient street sweepers. Secondary fine particulates have been reduced by vehicular emission controls that have reduced their precursor gases. Reducing

gaseous hydrocarbon emissions has led to a significant reduction in the primary carbon emitted in motor vehicle exhaust. In Maricopa County, the Governor's Agricultural Best Management Practices Advisory Committee is developing best management practices for agricultural activities intended to reduce particulate emissions from tilling, harvesting, and other activities. In a recent PM10 control plan, the Maricopa Association of Governments received commitments to implement 77 new measures, including better enforcement of the dust rules, agricultural best management practices, diesel engine replacement and retirement programs, cleaner burning fireplaces, and stricter standards for utility equipment.

Particulates are monitored by pulling ambient air through a filter, generally for 24 hours every sixth day, weighing the filter before and after, and measuring the volume of air sampled. Prior to 1999 the concentrations were calculated using this information and a uniform temperature and pressure. For 1999, EPA required concentrations to be calculated using local (at the monitor) temperature and pressures. For 2000, the concentrations will revert to the standard temperature and pressure calculation.

The monitoring instruments are fitted with different aerodynamic devices to segregate different particle size fractions. Particulates can also be monitored continuously, with a Tapered Element Oscillating Microbalance (TEOM) instrument.

The 1999 PM_{10} data reported below in Table I.10 represent 85 monitors throughout Arizona. To support special border studies, three ADEQ monitors were located in Mexico, two in Agua Prieta and one in Nogales, Sonora. Please note that TEOM data are not included in this table.

The EPA began a nationwide program to measure Particulate Matter 2.5 microns and smaller ($PM_{2.5}$) using Federal Reference Method (FRM) monitors made to EPA specifications in anticipation of the acceptance of a new standard for fine particulates. The fine particulate portion of the PM_{10} measurement made by dichot monitors has been measured for many years in Arizona and has served as an approximation for the $PM_{2.5}$ measurement. Table I.11 lists both Dichot Fine and FRM measurements for 1999.

County and City or Site	Method	Annual Average	24-Hour Average		Number of Valid Samples
			Max	2nd Highest	
Apache					
Petrified Forest NP	IMPROVE	9.7 [a]	71	20	51
St. Johns – Carrizo Draw (Sampling discontinued 5/99)	Dichot	N/A	56	28	25

County and City or Site	Method	Annual Average	24-Hour Average		Number of Valid Samples
			Max	2nd Highest	
St. Johns – Mesa Parada (Sampling discontinued 5/99)	Dichot	N/A	44	37	25
Springerville – Coalyard	Dichot	11.3	49	31	121
Springerville – Coyote Hills	Dichot	8.1	25	21	121
Cochise					
Chiricahua NM	IMPROVE	9.7 [a]	28	23	52
Douglas – ADOT	Dichot	35.2	91	68	56
Douglas – Cemetery	Dichot	59.7	199	116	54
Douglas – Red Cross	Dichot	35.2 [a]	83	75	49
Douglas – Vortac	Dichot	15.0 [a]	44	40	48
Naco	Dichot	N/A	85	27	2
Paul Spur	Partisol	29.3	78	77	55
Coconino					
Flagstaff – ADOT	Partisol	18.0 [a]	62	30	40
Flagstaff –Middle School	Dichot	14.0	35	26	55
Grand Canyon – Hance	IMPROVE	13.4 [a]	25	24	42
Grand Canyon – Indian Gardens	IMPROVE	9.7 [a]	22	17	44
Sedona	Dichot	N/A	17	15	15
Tusayan	Dichot	N/A	14	13	12
Gila					
Hayden – Old Jail	Dichot	35.3	84	75	59
Miami – Golf Course	Dichot	22	43	42	56
Miami – Ridgeline	Dichot	13	34	24	60
Payson	Partisol	22.4 [a]	47	40	47
Tonto NM	IMPROVE	12.5 [a]	36	26	50
Graham					

County and City or Site	Method	Annual Average	24-Hour Average		Number of Valid Samples
			Max	2nd Highest	
Safford	Hi-vol/ dichot	N/A	125	83	30
Maricopa					
ASU West	Dichot	30.7	55	53	59
Central Phoenix	Hi-Vol	43.6 [a]	85	85	45
Chandler	Hi-Vol	59.6	110	100	59
Estrella	Dichot	34.4	80	73	59
Gilbert	Hi-Vol	45.4	90	88	55
Glendale	Hi-Vol	36.3	77	63	58
Higley	Dichot	61.2	208	110	57
Maryvale	Hi-Vol	44.7	104	96	60
Mesa	Hi-Vol	35.3	80	71	60
North Phoenix	Hi-Vol	34.5	70	63	57
Palo Verde	Dichot	21.7	83	46	53
Phoenix – Durango Complex	Hi-Vol	69.4 [a]	148	143	29
Phoenix – JLG Super Site	Dichot	35.1	78	70	58
Phoenix – Greenwood, ADEQ	Dichot	53.1	111	111	55
Phoenix – Greenwood, MCESD	Hi-Vol	55.8	117	115	59
South Phoenix	Hi-Vol	N/A	67	62	18
South Scottsdale	Hi-Vol	40.1	87	80	57
Tempe	Dichot	36.0	82	78	55
West Chandler	Hi-Vol	48.2	104	92	59
West Phoenix	Hi-Vol	51.3	111	103	57
Mohave					
Bullhead City – Alonas Way	Hi-Vol	29.5	122	61	52
Bullhead City – Hwy. 95	Dichot	12.7	26	22	55

County and City or Site	Method	Annual Average	24-Hour Average		Number of Valid Samples
			Max	2nd Highest	
Fort Mohave	Partisol	12.3 [a]	30	23	41
Kingman – Praxair	Hi-Vol	15.5	46	434	105
Navajo					
Joseph City – Third and Tanner	Hi-Vol	17.3	57	42	52
Show Low	Partisol	16.2 [a]	38	37	42
Pima					
Ajo	Partisol	20.8	41	40	54
Tucson – Corona de Tucson, PDEQ	Hi-Vol	18.4	51	46	59
Tucson – Corona de Tucson, ADEQ	Dichot	N/A	48	23	24
Green Valley – PDEQ	Hi-vol	17.9	38	33	59
Organ Pipe Cactus National Monument	Dichot	10.0 [a]	18	16	51
Rillito – ADEQ	Partisol/ Dichot	35.8 [a]	98	68	54
Rillito – APCC	Hi-Vol	30.7	123	73	117
South Tucson – PDEQ	Hi-Vol	48.4	214 [b]	207 [b]	217
South Tucson – ADEQ	Dichot	N/A	45	36	9
Tucson – Broadway and Swan	Hi-Vol	31.6	89	51	60
Tucson – Central U of A, ADEQ	Teflon Dichot	26.0	54	53	59
Tucson – Craycroft, ADEQ	Dichot	26.0	55	53	60
Tucson – Downtown (Sampling discontinued 5/99)	Hi-Vol	35.3	129	117	184
Tucson – Orange Grove, PDEQ	Hi-Vol	45.8	235	176 [b]	134
Tucson – Prince Road	Hi-Vol	43.7	118	80	61

County and City or Site	Method	Annual Average	24-Hour Average		Number of Valid Samples
			Max	2nd Highest	
Tucson – Santa Clara	Hi-Vol	34.0	97	76	60
Tucson – Tangerine	Hi-Vol	18.4	41	36	56
Pinal					
Apache Junction – South County Courthouse	Hi-Vol	27.5	63	55	59
Apache Junction – North County Courthouse	Hi-Vol	25.8	64	55	59
Apache Junction – Mill	Hi-Vol	68.0	136	133	52
Casa Grande	Hi-Vol	35.3	64	64	60
Casa Grande – County Fairgrounds, Eleven Mile Corner	Hi-Vol	71.0	368	161	57
Coolidge	Hi-Vol	39.6	83	79	60
Eloy	Hi-Vol	45.9	141	101	58
Mammoth	Hi-Vol	22.5	50	42	54
Pinal Air Park – Marana	Hi-Vol	31.5	60	59	52
Stanfield	Hi-Vol	56.6	106	104	59
Santa Cruz					
Nogales – Post Office	Dichot	52.5 [a]	169	164	50
Yavapai					
Clarkdale – SE of CTI Flyash Silo (#1)	Dichot	28.1	53	49	60
Clarkdale – NW of Cement Plant (#2)	Dichot	22.6	48	47	60
Clarkdale – ADEQ	Dichot	15.3	30	27	53
Hillside	Dichot	7.5 [a]	22	16	47
Nelson	Dichot	12.4	32	31	58

County and City or Site	Method	Annual Average	24-Hour Average		Number of Valid Samples
			Max	2nd Highest	
Prescott	Hi-vol/ Partisol	N/A	20	17	20
Yarnell	Hi-Vol	N/A	17.1	9.1	22
Yuma					
Yuma Juvenile Center	Dichot	37.0	102	88	56
Mexico					
Agua Prieta – CFE	Dichot	101.2 [a]	180	172	43
Agua Prieta Fire Station	Dichot	63.0 [a]	126	122	46
Nogales Fire Station	Dichot	59.8	180	141	56

[a] *Annual average based on less than 75 percent data recovery per quarter.*
[b] *Flagged as influenced by natural events in EPA AIRS database.*
N/A – Not Available

Table I.11. 1999 $PM_{2.5}$ Data (in $\mu g/m^3$)

County and City or Site	Method	Annual Average	24-Hour Average		Total Valid Samples
			Max	2nd High	
Apache					
St. Johns – Mesa Parada (Sampling discontinued 5/99)	Dichot	N/A	10.7	7.8	25
St. Johns – Carrizo Draw (Sampling discontinued 5/99)	Dichot	N/A	10.3	8.4	25
Cochise					
Douglas – ADOT	Dichot	8.3	23.3	22.3	56
Douglas – Cemetery	Dichot	14.8 [a]	104.5	28.0	54
Douglas – Red Cross	Dichot	7.9 [a]	17.0	16.3	49
Douglas – Red Cross	FRM	9.2 [a]	23.0	18.9	37
Douglas – Vortac	Dichot	5.0 [a]	9.8	9.5	48

County and City or Site	Method	Annual Average	24-Hour Average		Total Valid Samples
			Max	2nd High	
Coconino					
Flagstaff Middle School	Dichot	4.9	13.3	9.7	55
Flagstaff Middle School	FRM	8.4	36.5	24.9	54
Tusayan	Dichot	N/A	7.1	7.1	12
Gila					
Hayden – Old Jail	Dichot	9.6	22.1	20.1	59
Miami – Golf Course	Dichot	6.2	11.7	10.6	56
Miami – Ridgeline	Dichot	4.6	8.7	8.4	60
Payson Well Site – Primary	FRM	9.8 [a]	28.7	25.5	87
Graham					
Safford	Dichot	N/A	12.9	8.9	10
Maricopa					
ASU West	Dichot	9.0	16.3	16.1	59
Higley	Dichot	11.1	72.3	21.3	57
Estrella	Dichot	8.8	20.4	19.3	59
Palo Verde	Dichot	5.6 [a]	10.6	10.5	53
Phoenix – Desert West	FRM	11.4	41.7	38.8	263
Phoenix – Greenwood	Dichot	15.3	37.6	29.8	55
Phoenix – Magnet Traditional School	FRM	13.1	44.9	38.7	292
Phoenix – JLG Super Site	Dichot	10.7	25.8	25.4	58
Phoenix – JLG Super Site	FRM	12.2	37.8	34.1	327
Tempe Community Center	Dichot	10.0	20.5	20.4	54
Tempe Community Center	FRM	10.8	26.4	25.2	114
Mohave					
Bullhead City	Dichot	3.9	8.2	7.2	55
Pima					

County and City or Site	Method	Annual Average	24-Hour Average		Total Valid Samples
			Max	2nd High	
Corona de Tucson	Dichot	N/A	8.2	7.5	24
Organ Pipe National Monument	Dichot	3.7 [a]	8.9	6.5	51
Rillito	Dichot	8.7 [a]	14.7	12.1	41
South Tucson	Dichot	N/A	12.9	11.9	9
Tucson – Children's Park	FRM	8.7	22.8	22.4	105
Tucson – Craycroft	Dichot	7.5	33.0	12.6	60
Tucson – Orange Grove	FRM	9.6	56.2	44.5	278
Tucson – U of A Central	Dichot	7.1	12.6	11.8	59
Pinal					
Apache Junction	FRM	7.4	18.6	15.5	119
Casa Grande	FRM	9.5	19.4	18.1	60
Santa Cruz					
Nogales Post Office	Dichot	15.9 [a]	67.4	47.2	50
Nogales Post Office	FRM	12.5	45.9	39.1	56
Yavapai					
Clarkdale – SE of CTI Flyash Silo (#1)	Dichot	5.3	10.0	9.0	60
Clarkdale – School	Dichot	4.7	8.0	7.5	53
Clarkdale – NW of Cement Plant (#2)	Dichot	4.9	11.1	10.6	60
Hillside	Dichot	3.2	6.9	6.3	47
Nelson	Dichot	4.1	8.5	8.0	58
Yuma					
Yuma – Juvenile Center	Dichot	7.9	15.7	15.3	56
Mexico					
Nogales Fire Station	Dichot	17.1	54.5	48.2	56

County and City or Site	Method	Annual Average	24-Hour Average		Total Valid Samples
			Max	2nd High	
Agua Prieta – CFE	Dichot	34.2 [a]	97.2	88.3	43
Agua Prieta – Fire Station	Dichot	16.4 [a]	42.3	41.5	46

[a] *Annual average based on less than 75 percent data recovery per quarter.*
N/A – Not available

Section B – Criteria Pollutants, Compliance

Carbon Monoxide

There are two NAAQS for carbon monoxide: an eight-hour standard (most critical for compliance) and a one-hour standard. The eight-hour standard is 9 ppm; the one-hour standard is 35 ppm. According to the Code of Federal Regulations, compliance for both standards is determined by having no more than one exceedance per calendar year. Attainment of the standard is determined by EPA at all sites in the nonattainment (or monitoring) area by evaluating two calendar years of data from each site. The highest of the second-highest values for the two-year period must not exceed the standard of 9 ppm (greater than or equal to 9.5 ppm to adjust for rounding) for the eight-hour standard or 35 ppm (greater than or equal to 35.5 ppm) for the one hour standard.

1999 one-hour CO NAAQS compliance values by county

	Exceedances	Violations
Maricopa	0	0
Pima	0	0
Pinal	0	0

21 of 21 monitors in compliance

No exceedances of the one-hour standard were recorded in 1999. The eight-hour standard was exceeded on Nov. 30, 1999 at the ADEQ Grand Avenue monitor in Phoenix, but this was the only exceedance at this monitor during the 1998-1999 period. Therefore, no violation of the standard occurred and the monitor is in compliance. The data are presented in Tables I.12 and I.13. Values in bold exceed the standard.

Table I.12.1998-1999 One-Hour Carbon Monoxide Compliance (in ppm)

County and City or Site	1998 One-Hour Avg		1999 One-Hour Avg		Compliance Value
	Max	2nd High	Max	2nd High	
Maricopa					
Central Phoenix	9.1	**8.9**	11.3	**9.3**	9.3
Gilbert	3.5	**3.3**	3.8	**3.7**	3.7

County and City or Site	1998 One-Hour Avg		1999 One-Hour Avg		Compliance Value
	Max	2nd High	Max	2nd High	
Glendale	5.0	**4.9**	5.7	**5.3**	13.4
Grand Avenue	10.7	**9.6**	18.4	**13.4**	9.5
Greenwood	9.4	**8.9**	10.8	**9.5**	9.5
JLG Supersite	9.6	**8.9**	8.5	**8.2**	8.9
Maryvale	7.5	**7.5**	9.7	**9.0**	9.0
Mesa	6.5	**6.1**	7.2	**5.8**	6.1
North Phoenix	8.0	**7.3**	7.8	**6.3**	7.3
Post Office	9.4	**9.3**	8.5	**7.4**	9.3
South Phoenix	8.2	**7.9**	7.8	**7.7**	7.9
South Scottsdale	5.5	**5.2**	6.0	**5.8**	5.8
West Chandler	4.1	**4.0**	4.3	**4.0**	4.0
West Indian School Road	9.7	**9.4**	11.8	**11.7**	11.7
West Phoenix	10.7	**9.6**	12.3	**11.9**	11.9
Pima					
Tucson – Downtown	7.6	**7.5**	10.6	**6.3**	7.5
Tucson – Craycroft	4.8	**4.6**	5.4	**4.7**	4.7
Tucson – Alvernon	7.8	**7.6**	8.5	**7.8**	7.8
Tucson – Cherry	5.9	**5.1**	5.2	**5.2**	5.2
Pinal					
Apache Junction Highway Yard	2.0	**2.0**	1.9	**1.7**	2.0
Casa Grande Airport	3.9	**3.6**	2.1	**1.5**	3.6

Table I.13. 1998-1999 Eight-Hour Carbon Monoxide Compliance (in ppm)

County and City or Site	1998 Eight-Hour Avg.		1999 Eight-Hour Avg		Compliance Value
	Max	2nd High	Max	2nd High	
Maricopa					
Central Phoenix	7.1	**7.1**	7.2	**5.9**	7.1
Gilbert	2.7	**2.7**	2.4	**2.4**	2.7
Glendale	3.4	**3.3**	3.8	**3.4**	3.4
Grand Avenue	7.3	**6.8**	10.5	**8.0**	8.0
Greenwood	7.5	**7.3**	6.7	**6.6**	7.3
JLG Supersite	7.2	**6.6**	7.0	**6.6**	6.6
Maryvale	6.1	**6.1**	7.2	**6.6**	6.6
Mesa	4.4	**4.3**	4.4	**4.0**	4.3
North Phoenix	6.1	**5.9**	3.5	**3.5**	5.9
Post Office	8.2	**6.9**	5.8	**5.7**	6.9
South Phoenix	5.4	**5.4**	4.6	**4.4**	5.4
South Scottsdale	3.7	**3.6**	4.3	**4.1**	4.1
West Chandler	2.9	**2.9**	2.9	**2.8**	2.9
West Indian School Road	8.1	**8.1**	7.6	**7.5**	8.1
West Phoenix	7.7	**7.7**	7.7	**7.4**	7.7
Pima					
Tucson – Downtown	4.3	**3.9**	4.3	**3.2**	3.9
Tucson – Craycroft	2.6	**2.3**	2.3	**2.0**	2.3
Tucson – Alvernon	4.0	**4.0**	4.2	**3.8**	4.0
Tucson – Cherry	4.3	**3.1**	3.4	**3.4**	3.4
Pinal					
Apache Junction Highway Yard	1.3	**1.3**	.9	**.8**	1.3
Casa Grande Airport	1.5	**1.5**	.8	**.8**	1.5

Lead

In 1999, the NAAQS for lead, 1.5 micrograms per cubic meter (μg/m3) averaged for a calendar quarter, was not exceeded at any Arizona monitor.

Nitrogen Dioxide

The NAAQS for nitrogen dioxide is 0.053 parts per million for an annual average. The standard is attained when the annual arithmetic mean concentration in a calen-

1999 lead quarterly average NAAQS compliance values by county

	Exceedances	Violations
Apache	0	0
Cochise	0	0
Coconino	0	0
Gila	0	0
Maricopa	0	0
Pima	0	0
Pinal	0	0
Santa Cruz	0	0
Yavapai	0	0

16 of 16 monitors in compliance

1999 NO_2 quarterly average NAAQS compliance values by county

	Exceedances	Violations
Apache	0	0
Maricopa	0	0
Mohave	0	0
Pima	0	0

13 of 13 monitors in compliance

1999 SO_2 annual NAAQS compliance values by county

	Exceedances	Violations
Apache	0	0
Gila	0	0
Maricopa	0	0
Mohave	0	0
Pima	0	0
Pinal	0	0

20 of 20 monitors in compliance

dar year is less than or equal to 0.053 ppm. To demonstrate attainment, the annual mean must be based upon hourly data that are at least 75 percent complete. The 1999 nitrogen dioxide annual averages near Arizona power plants ranged from 2 percent to 19 percent of the standard; in the urban areas, 22 percent to 77 percent. All Arizona sites were in compliance with the NAAQS. Refer to Table I.6 for the 1999 averages.

Sulfur Dioxide

There are three NAAQS for sulfur dioxide, two primary (annual average and 24-hour block average) and one secondary (three-hour block average). The annual average standard is 80 μg/m3 (approximately 0.03 ppm) and the maximum 24-hour block average standard is 365 μg/m3 (approximately 0.14 ppm). To demonstrate attainment, neither standard can be exceeded in a calendar year. Also, the averages must be based upon hourly data that are 75 percent complete. A 24-hour block average is considered valid if at least 75 percent of the hourly averages for the 24-hour period are available. The 24-hour averages are determined from successive non-overlapping 24-hour blocks that begin at midnight each day.

The secondary three-hour standard is 1300 μg/m3 (approximately 0.50 ppm) and is not to be exceeded more than once per calendar year. The three-hour averages are determined from successive non-overlapping three-hour blocks starting at midnight each calendar day.

In Arizona, the maximum concentration sites, all near copper smelters, comply with these standards; the concentrations being no higher than 65 percent of the three-hour, 90 percent of the 24-hour, and 55 percent of the annual average standards. Sites near power plants are close to background levels, with annual averages from less than 1 to 8 μg/m3. Refer to Table I.7 for the 1999 averages.

Ozone

The NAAQS include a standard for one-hour ozone and a standard for eight-hour ozone. The one-hour standard is 0.12 ppm. Compliance with this standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm (0.124 ppm for rounding) is equal to or less than one. A daily exceedance is defined as any day having one or more hourly averages equal to or greater than 0.125 ppm. Hourly averages for at least 75 per-

1999 SO_2 24-hour NAAQS compliance values by county

	Exceedances	Violations
Apache	0	0
Gila	0	0
Maricopa	0	0
Mohave	0	0
Pima	0	0
Pinal	0	0

20 of 20 monitors in compliance

1999 SO_2 three-hour NAAQS compliance values by county

	Exceedances	Violations
Apache	0	0
Gila	0	0
Maricopa	0	0
Mohave	0	0
Pima	0	0
Pinal	0	0

20 of 20 monitors in compliance

cent of the hours sampled (18 to 24 hours per day) must be present. The most recent three calendar years of daily averages are used to determine if the annual standard is met.

Arizona had no exceedances of the one-hour standard 1999. The last exceedance of the one-hour standard occurred in 1996 in Phoenix.

1997-1999 one-hour ozone compliance values by county

	# of Daily Exceedances			Sites in Violation
	1997	1998	1999	
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Maricopa	0	0	0	0
Pima	0	0	0	0
Pinal	0	0	0	0
Yavapai	0	0	0	0
Yuma	0	0	0	0

35 of 35 monitors in compliance for 1997-1999

1997-1999 eight-hour ozone compliance values by county

	# of Eight-Hour Exceedances			Sites in Violation
	1997	1998	1999	
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Maricopa	42	84	62	6
Pima	0	0	0	0
Pinal	0	0	0	0
Yavapai	0	0	0	0
Yuma	0	0	0	0

27 of 34 monitors in compliance for 1997-1999

The eight-hour ozone standard proposed by EPA was developed in response to human exposure studies that showed adverse health effects occur at lower ozone concentrations extending over several hours. The new ozone standard was promulgated in 1997, but in a May 14, 1999 decision by the U. S. Court of Appeals for the District of Columbia, it was remanded to EPA for further consideration. However, monitoring agencies have been recording the eight-hour averages to gather information on occurrence and ability to comply with an eight-hour standard.

The eight-hour ozone standard is 0.08 ppm (0.084 for rounding) for a daily maximum eight-hour average. This standard is met when the average of the annual fourth-highest daily maximum eight-hour average ozone concentration is less than or equal to 0.08 ppm. The most recent three calendar years are used to assess compliance with the standard. Values in bold in Table I.14 exceed the standard.

Table I.14. 1997-1999 Eight-Hour Ozone Compliance (in ppm)

Values in bold exceed the standard.

County and City or Site	Fourth-Highest Eight-Hour Average			Three-Year Average
	1997	1998	1999	
Cochise				
Chiricahua National Monument	.065	.068	.072	.068
Coconino				
Grand Canyon National Park	.073	.073	.077	.074
Gila				
Rye	.056	.065	.080	.067
Maricopa				
Blue Point	.083	.089	.087	**.086**
Central Phoenix	.077	.079	.078	.078
Fountain Hills	.088	.086	.086	**.086**
Glendale	.076	.070	.081	.075
Humboldt Mt.	.081	.090	.086	**.085**
Lake Pleasant	N/A	.082	.081	N/A
Maryvale	.078	.086	.077	.080
Mesa – Falcon Field	.081	.083	.082	.082
Mesa	.084	.080	.083	.082
Mt. Ord – MCESD	.084	.088	.087	**.086**
North Phoenix	.091	.089	.084	**.088**
Palo Verde	.077	.080	.080	.079
Phoenix –Emergency Management	.085	.081	.086	.084
Phoenix – JLG Supersite	.079	.079	.061	.073
Pinnacle Peak	.082	.086	.083	.083
Rio Verde	.085	.079	.086	.083

County and City or Site	Fourth-Highest Eight-Hour Average			Three-Year Average
	1997	1998	1999	
Salt River – Pima	.082	.087	.082	.083
South Phoenix	.075	.080	.075	.076
South Scottsdale	.076	.078	.072	.075
West Chandler	.077	.074	.069	.073
West Phoenix	.078	.086	.091	**.085**
Pima				
Saguaro Park	.080	.076	.071	.075
Tucson – Children's Park	.065	.072	.072	.069
Tucson – Craycroft	.077	.073	.071	.073
Tucson – Downtown	.065	.062	.064	.063
Tucson – Fairgrounds	.066	.071	.068	.068
Tucson – Tangerine	.070	.070	.073	.071
Pinal				
Apache Junction – Highway Yard	.082	.083	.080	.081
Casa Grande Airport	.072	.069	.078	.073
Yavapai				
Hillside	.076	.083	.084	.081
Yuma				
Yuma	.079	.089	.079	.082

N/A – Not available

Particulate Matter – PM_{10}

The NAAQS for PM_{10} are 50 $\mu g/m^3$ for the annual arithmetic mean concentration and 150 $\mu g/m3$ for the 24-hour average concentration. The annual standard is met when the three year average of the annual means is less than or equal to 50 $\mu g/m^3$. The annual average is determined by calculating quarterly (three month) averages of the samples collected during that quarter; a minimum of 75 percent of the samples must be present to produce a valid annual average. The four quarterly averages are then used to produce the annual average. Compliance with the 24-hour PM_{10} standard is attained when the expected exceedance rate of occurrence of samples greater than or equal to 150 $\mu g/m^3$ is one or less per year measured over three years. The same requirements of 75 percent completeness and three consecutive years of data apply. Tables I.15 and I.16 present the 1997-1999 data.

1997-1999 PM_{10} annual average compliance values by county

	# of Exceedances			Sites in Violation
	1997	1998	1999	
Apache	0	0	0	0
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Maricopa	3	2	3	3
Mohave	0	0	0	0
Navajo	0	0	0	0
Pima	0	0	0	0
Pinal	1	1	1	1
Santa Cruz	0	0	0	0
Yavapai	0	0	0	0
Yuma	0	0	0	0

62 of 66 monitors in compliance for 1997-1999

1997-1999 PM_{10} maximum 24-hour compliance values by county

	Eight-Hour Exceedances			Sites in Violation
	1997	1998	1999	
Apache	0	0	0	0
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Maricopa	17	0	1	0
Mohave	0	0	0	0
Navajo	0	0	0	0
Pima	0	0	0	0
Pinal	0	1	3	1
Santa Cruz	0	1	2	0
Yavapai	0	0	0	0
Yuma	0	0	0	0

72 of 73 monitors in compliance for 1997-1999

Table I.15. 1997-1999 Annual Average PM_{10} Compliance (in $\mu g/m^3$)

Values in bold exceed the standard.

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Apache				
Petrified Forest NP	9	7	10 [a]	9 [a]
St. Johns – Mesa Parada	7	7	Sampling discontinued May 1999	
St. Johns – Carrizo Draw	8	10		
Springerville – Coalyard	10	9	11	10
Springerville – Coyote Hills	8	8	8	8
Cochise				
Chiricahua NM	9	10	10 [a]	10 [a]
Douglas	26	31	36 [a]	31 [a]
Naco	33	34	N/A	N/A
Paul Spur	39	36	30	35

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Coconino				
Flagstaff – ADOT	15	12	16 [a]	14 [a]
Flagstaff –Middle School	15	13	14	14
Grand Canyon – Hance	N/A	10	13 [a]	N/A
Grand Canyon – Indian Gardens	14	10	10 [a]	11 [a]
Sedona	11	10	N/A	N/A
Gila				
Hayden – Old Jail	36	28	35	33
Miami – Golf Course	27	23	22	24
Miami – Ridgeline	14	11	13	13
Payson	25	24	21 [a]	23
Tonto NM	12	11	13 [a]	12 [a]
Graham				
Safford	29	27	N/A	N/A
Maricopa				
Central Phoenix	44	N/A	43.6 [a]	N/A
Chandler	**61**	45	**60**	**55**
Estrella	35	25	34	31
Gilbert	49	42	45	45
Glendale	38	29	36	34
Higley	**64**	**50**	**61**	**58**
Maryvale	49	36	45	43
Mesa	43	29	35	36
North Phoenix	38	29	35	34
Palo Verde	20	19	22	20

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Phoenix – JLG Supersite	39	31	34	35
Phoenix – Greenwood, ADEQ	N/A	43	54	N/A
Phoenix – Greenwood, MCESD	**61**	**50**	**56**	**56**
Phoenix – ASU West	34	25	31	30
South Scottsdale	41	34	40	38
Tempe	36	31	35	34
West Chandler	45	34	48	42
West Phoenix	51	39	51	47
Mohave				
Bullhead City – Alonas Way	21	22	30	24
Bullhead City – Hwy. 95	N/A	11	13	N/A
Fort Mohave	15	12	12 [a]	13
Kingman – Praxair	12	12	16	13
Navajo				
Joseph City – Third and Tanner	15	11	17	14
Show Low	16	11	16 [a]	14
Pima				
Ajo	20	21	21	21
Corona de Tucson	15	14	18	16
Green Valley	16	14	18	16
Organ Pipe Cactus National Monument	10	8	10 [a]	9
Rillito – ADEQ	26	29	35 [a]	30
Rillito – APCC	40	30	31	34
South Tucson	33	36	48	39
Tucson – Broadway and Swan	28	24	32	28

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Tucson – Central U of A, ADEQ (teflon)	27	23	26	25
Tucson – Craycroft, ADEQ	26	21	26	24
Tucson – Downtown (closed May 27, 1999)	29	29	35	31
Tucson – Orange Grove	31	24	46	34
Tucson – Prince Road	34	33	44	37
Tucson – Santa Clara	27	25	34	29
Tucson – Tangerine	15	12	18	15
Pinal				
Apache Junction – South County Courthouse	25	26	28	26
Apache Junction – North County Courthouse	25	25	26	25
Casa Grande	32	31	35	33
Casa Grande – County Fairgrounds, Eleven Mile Corner	**52**	**52**	**71**	**58**
Coolidge	39	37	40	39
Eloy	38	44	46	43
Mammoth	22	22	23	22
Pinal Air Park – Marana	26	27	30	28
Stanfield	42	41	57	47
Santa Cruz				
Nogales Post Office	31	38	**54** [a]	41
Yavapai				
Clarkdale – SE of CTI Flyash Silo (#1)	24	25	28	26
Clarkdale – NW of Cement Plant (#2)	24	19	23	22
Clarkdale – ADEQ	15	15	15	15
Hillside	12	12	8 [a]	11
Nelson	14	11	13	13

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Yuma				
Yuma Juvenile Center	36	39	37	37

[a] *Annual average based on less than 75 percent data recovery per quarter.*

N/A - Data not available or annual average not able to be calculated due to insufficient data.

Table I.16. 1997-1999 Maximum 24-Hour Average PM_{10} Compliance (in mg/m^3)

Values in bold exceed the standard.

County and City or Site	1997		1998		1999		Expected Exceedance Rate
	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	
Apache							
Petrified Forest NP	43	0	17	0	71 [a]	0	0
St. Johns – Mesa Parada	18	0	17	0	44 [a]	0	Sampling discontinued May 1999
St. Johns – Carrizo Draw	18	0	36	0	56 [a]	0	
Springerville – Coyote Hills	22	0	25	0	25	0	0
Springerville – Coalyard	34	0	26	0	49	0	0
Cochise							
Chiricahua NM	35	0	35	0	28 [a]	0	0
Douglas – High School/Red Cross	55	0	105	0	83 [a]	0	0
Naco	113	0	116	0	85	0	0
Paul Spur	77	0	82	0	78	0	0
Coconino							
Flagstaff – ADOT	40	0	33	0	62 [a]	0	0
Flagstaff – Middle School	32	0	30	0	35	0	0
Grand Canyon – Hopi Pt./Hance	31	0	30	0	25 [a]	0	0
Grand Canyon – Indian Gardens	82	0	31	0	22 [a]	0	0

County and City or Site	1997		1998		1999		Expected Exceedance Rate
	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	
Sedona	24	0	54	0	17	0	0
Gila							
Hayden – Old Jail, ADEQ	**158**	1	78	0	84	0	< 1.0
Miami – Golf Course	67	0	51	0	43	0	0
Miami – Ridgeline	33	0	27	0	34	0	0
Payson	81	0	69	0	47 [a]	0	0
Tonto NM	42	0	31	0	36 [a]	0	0
Graham							
Safford	95	0	98	0	125 [a]	0	0
Maricopa							
ASU West	**164**	1	55	0	55	0	< 1.0
Central Phoenix	108	0	70	0	85 [a]	0	0
Chandler	**221**	1	136	0	110	0	< 1.0
Estrella	**179**	1	56	0	80	0	< 1.0
Gilbert	**170**	1	133	0	90	0	< 1.0
Glendale	**170**	1	61	0	77	0	< 1.0
Higley	**288**	2	135	0	**208**	1	1.0
Maryvale	**345**	2	92	0	104	0	< 1.0
Mesa	129	0	64	0	80	0	0
North Phoenix	**152**	1	67	0	70	0	< 1.0
Palo Verde	124	0	47	0	83	0	0
Phoenix – JLG Super Site	131	1	69	0	78	0	< 1.0
Phoenix – Greenwood, ADEQ	148	0	106	0	111	0	0
Phoenix – Greenwood, MCESD	**220**	1	121	0	117	0	< 1.0

County and City or Site	1997		1998		1999		Expected Exceedance Rate
	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	
South Phoenix	160	1	77	0	67	1	1.0
South Scottsdale	**154**	1	81	0	87	0	< 1.0
Tempe	90	0	70	0	82	0	0
West Chandler	**194**	2	78	0	104	0	< 1.0
West Phoenix	**224**	1	107	0	111	0	< 1.0
Mohave							
Bullhead City – Alonas Way	51	0	76	0	122	0	0
Bullhead City – Hwy. 95	30	0	27	0	26	0	0
Fort Mohave	68	0	39	0	30 [a]	0	0
Kingman – Praxair	34	0	70	0	46	0	0
Navajo							
Joseph City – Third and Tanner	35	0	26	0	57	0	0
Show Low	127	0	27	0	38 [a]	0	0
Pima							
Ajo	65	0	65	0	41	0	0
Corona de Tucson – PDEQ	34	0	41	0	51	0	0
Green Valley – PDEQ	42	0	32	0	38	0	0
Organ Pipe Cactus National Monument	75	0	22	0	18 [a]	0	0
Rillito – ADEQ	129	0	74	0	98 [a]	0	0
Rillito – APCC	77	0	79	0	123	0	0
South Tucson – PDEQ	72	0	79	0	**214**	2 [x]	0
Tucson – Broadway and Swan	58	0	49	0	89	0	0
Tucson – Central U of A, ADEQ (teflon)	58	0	48	0	54	0	0

County and City or Site	1997		1998		1999		Expected Exceedance Rate
	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	
Tucson – Craycroft, ADEQ	63	0	51	0	55	0	0
Tucson – Downtown	72	0	90	0	129	0	Closed May 27, 1999
Tucson – Orange Grove, PDEQ	68	0	44	0	**235**	4 [x]	0
Tucson – Prince Road	62	0	83	0	118	0	0
Tucson – Santa Clara	64	0	50	0	97	0	0
Tucson – Tangerine	40	0	29	0	41	0	0
Pinal							
Apache Junction – South County Courthouse	81	0	63	0	64	0	0
Apache Junction – North County Courthouse	81	0	61	0	64	0	0
Casa Grande	76	0	74	0	64	0	0
Casa Grande – County Fairgrounds, Eleven Mile Corner	140	0	162	1	**368**	3	**2**
Coolidge	102	0	143	0	84	0	0
Eloy	82	0	110	0	142	0	0
Mammoth	46	0	49	0	50	0	0
Pinal Air Park – Marana	65	0	67	0	60	0	0
Stanfield	**135**	0	113	0	107	0	0
Santa Cruz							
Nogales Post Office	126	0	155	1	169[a]	2	1.0
Yavapai							
Clarkdale – SE of CTI Flyash Silo (#1)	50	0	51	0	53	0	0

County and City or Site	1997		1998		1999		Expected Exceedance Rate
	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	Max 24-hour	No. of Exc.	
Clarkdale – NW of Cement Plant (#2)	33	0	82	0	48	0	0
Clarkdale – ADEQ	63	0	26	0	30	0	0
Hillside	85	0	20	0	22 [a]	0	0
Nelson	53	0	53	0	32	0	0
Yuma							
Yuma Juvenile Center	108	0	109	0	102	0	0

[a] *Less than 75 percent data recovery per quarter.*

[x] *Exceedances at the Orange Grove and South Tucson sites in Pima County are flagged as due to natural events and are excluded from the compliance calculation.*

Particulate Matter – PM2.5

The proposed NAAQS for particulate matter 2.5 microns and smaller in diameter ($PM_{2.5}$) are under review due to the District of Columbia Court of Appeals May 1999 decision. However, these standards will be used to assess the compliance of the monitors operating in Arizona. The standards are 15.0 micrograms per cubic meter ($\mu g/m^3$) for the annual arithmetic mean concentration and 65 $\mu g/m^3$ for the 24-hour average concentrations.

The annual $PM_{2.5}$ standard is met when the three-year average of annual means is less than or equal to 15.0 $\mu g/m^3$. This three-year average is determined by calculating the quarterly averages for each year (with 75 percent data recovery in each quarter) to determine the calendar year average and then averaging the three years together.

The 24-hour standard is met when the three-year average of the 98th percentile values is less than or equal to 65 $\mu g/m^3$. There must also be 75 percent data completeness for each year.

1997-1999 $PM_{2.5}$ annual average compliance values by county

	# of Exceedances			Sites in Violation
	1997	1998	1999	
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Maricopa	0	0	1	0
Mohave	0	0	0	0
Pima	0	0	0	0
Santa Cruz	0	0	1	0
Yavapai	0	0	0	0
Yuma	0	0	0	0

24 of 24 monitors in compliance for 1997-1999

1997-1999 $PM_{2.5}$ 24-hour average compliance values by county

	# of Exceedances			Sites in Violation
	1997	1998	1999	
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Maricopa	0	0	0	0
Mohave	0	0	0	0
Pima	0	0	0	0
Santa Cruz	0	0	1	0
Yavapai	0	0	0	0
Yuma	0	0	0	0

24 of 24 monitors in compliance for 1997-1999

Please note that the data in the Table I.17 are from dichot monitors only since the Federal Reference Method program to monitor $PM_{2.5}$ did not begin until 1999. Values in bold exceed the standard.

Table I.17. 1997-1999 Annual Average $PM_{2.5}$ Compliance (in $\mu g/m^3$)

Values in bold exceed the standard.

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Apache				
St. Johns – Mesa Parada	4	3.4	N/A	Sampling discontinued May 1999
St. Johns – Carrizo Draw	4	3.7	N/A	
Cochise				
Douglas	6	6.8	7.9 [a]	6.9 [a]
Coconino				
Flagstaff Middle School	5	4.7	4.9	4.9
Gila				
Hayden – Old Jail, ADEQ	9	8.9	9.7	9.2
Miami – Golf Course	8	6.3	6.2	6.8
Miami – Ridgeline	6	4.2	4.6	4.9
Payson	12	10.9	9.8 [a]	10.9 [a]
Maricopa				
Estrella	8	7.1	8.9	8.0
Higley	10	9.4	11.1	10.2
Palo Verde	5	5.5	5.6 [a]	5.4
Phoenix – Greenwood, ADEQ	14.2 [a]	14.7 [a]	**15.3**	14.7 [a]
Phoenix – Super Site	12	10.9	10.8	11.2
Phoenix – ASU West	9	8.3	9.1	8.8
Tempe Community Center	10	9.4	10.1	9.8
Mohave				
Bullhead City	N/A	3.5	4.0	N/A
Pima				
Organ Pipe National Monument	4	3.7	3.9 [a]	3.9 [a]
Rillito	6	N/A	8.8 [a]	N/A

County and City or Site	Annual Averages			Three-Year Average
	1997	1998	1999	
Tucson – Orange Grove	9	7.3	9.6	8.6
Tucson – Craycroft	7	6.3	7.5	6.9
Tucson – U of A Central	8	7.5	7.2	7.6
Santa Cruz				
Nogales Post Office	13	12.5	**16.0** [a]	13.8 [a]
Yavapai				
Clarkdale – SE of CTI Flyash Silo (#1)	5	5.1	5.3	5.1
Clarkdale – School	4	4.5	4.7	4.4
Clarkdale – NW of Cement Plant (#2)	5	4.7	4.9	4.9
Hillside	3	3.1	3.2	3.1
Nelson	5	3.6	4.1	4.2
Yuma				
Yuma – Juvenile Center	6	8.3	7.9	7.4

[a] *Annual average based on less than 75 percent data recovery per quarter.*

N/A – Data not available or annual average not able to be calculated due to insufficient data.

Table I.18. 1997-1999 24-Hour Average $PM_{2.5}$ Compliance (in $\mu g/m^3$)

The three-year average is rounded to the nearest 1 $\mu g/m^3$ for comparison to the standard.

County and City or Site	98th Percentile Observations			Three-Year Average
	1997	1998	1999	
Apache				
St. Johns – Mesa Parada	7	8	10.7 [a]	Sampling discontinued May 1999
St. Johns – Carrizo Draw	7	8	10.3 [a]	
Cochise				
Douglas – High School and Red Cross	11	12	17.0	13.3
Coconino				
Flagstaff Middle School	15	8.1	9.7	11

County and City or Site	98th Percentile Observations			Three-Year Average
	1997	1998	1999	
Gila				
Hayden – Old Jail, ADEQ	17	21.0	20.1	19
Miami – Golf Course	14	10.2	10.6	12
Miami – Ridgeline	8	7.7	8.4	8
Payson	51	34.1	25.5	37
Maricopa				
Estrella	21	18.5	19.3	20
Higley	23	18.1	21.3	21
Palo Verde	11	10.4	10.5	11
Phoenix – Greenwood, ADEQ	33.0	47.1	29.8	37
Phoenix – JLG Super Site	32	28.2	25.4	29
Phoenix – ASU West	20	21.8	16.1	19
Tempe Community Center	26	23.3	24.0	24
Mohave				
Bullhead City (began 11/97)	N/A	14.1	7.2	N/A
Pima				
Organ Pipe National Monument	13	6.8	6.5	9
Rillito – ADEQ (partisol in 1998)	27	N/A	14.7	N/A
Tucson – Orange Grove	21	14.3	23.6	20
Tucson – Craycroft	12	12.3	12.6	12
Tucson – U of A Central	17	15.4	11.8	15
Santa Cruz				
Nogales Post Office	43	34.4	**67.4**	48
Yavapai				
Clarkdale – SE of CTI Flyash Silo (#1)	25	11.3	9.0	15
Clarkdale – School	9	6.8	7.5	8

County and City or Site	98th Percentile Observations			Three-Year Average
	1997	1998	1999	
Clarkdale – NW of Cement Plant (#2)	14	11.3	10.6	12
Hillside	10	5.6	6.9	8
Nelson	15	7.1	8.0	10
Yuma				
Yuma Juvenile Center	16	15.5	15.3	16

[a] *Annual average based on less than 75 percent data recovery per quarter.*
N/A – Data not available or annual average not able to be calculated due to insufficient data.

Section C – Visibility Data

Visibility monitoring consists of three types: aerosol, optical and scene. Aerosol measurements are described elsewhere in this report; however, those measurements are used differently in characterizing visibility impairment. The chemical species that comprise a particulate sample have different extinction efficiencies. Extinction efficiency is the extent to which a particle will either scatter or absorb light, thus blocking its path to one's eye. The overall impact of particles can be estimated by summing the effect of all the component species. This method is the primary approach used in the draft national regional haze rule for estimating present visibility and charting trends for future plan reviews.

Optical measurements can be taken in several ways whose differences are related to characterizing different optical phenomena. For example, the nephelometer, an instrument used considerably by ADEQ, measures light scattering by particles. On the other hand, the aetholometer characterizes how much light is absorbed by particles in the atmosphere. Finally, a transmissometer measures the composite of these optical processes. Data collected by each of these instruments can be represented by several different measurement units, including the deciview, inverse megameters, and visual range. The deciview is similar to the decibel and represents in a linear fashion how the perception of visibility changes. The inverse megameter is a representation of the ratio between how much light is not received by a sensor compared to the amount of light that leaves a source. Finally, visual range, the most familiar representation, quantifies how far one can see. One of the longest records of visibility conditions is human observation of visual range at airports.

Scene information comes primarily from pictures, which provide insight into the structure and extent of haze in the atmosphere. Photography is also used to establish a baseline clean scene and estimate how much the view is obscured in other pictures. Please refer to Chapter 1 of this report for more information on visibility monitoring.

Class I and Wilderness Areas

In anticipation of the regional haze rule, ADEQ undertook development of a visibility monitoring program directed at Class I areas in partnership with Arizona's federal land managers. The aim is to collect data at all of Arizona's Class I Areas. Based on the regional haze rule, five years of data will be needed. Since the IMPROVE program consists only of aerosol sampling, ADEQ will jointly operate sites by installing nephelometers that measure light scattering. Since IMPROVE aerosol samplers will only operate every three days and represent 24-hour averages, making continuous measurements provides insight into variation in visibility impairment with time, along with advancing the understanding of the relationship between particles and light scattering.

Table I.19 summarizes the 1998 and 1999 nephelometer data from locations in or near Arizona Class I Areas. The data are summarized into three categories for all hours: the average visibility of the dirtiest 20 percent, the mean visibility, and the average visibility of the cleanest 20 percent.

Table I-19. Visibility in Class I Areas (Nephelometer Data in Mm^{-1})

Site	Year	All Hours		
		Dirtiest 20%	Mean	Cleanest 20%
Humboldt Mountain	1998	24	9	0
	1999	25	11	2
Mount Ord	1998	29	12	2
	1999	22	11	3
McFadden Peak	1998	25	10	2
	1999	18	7	0
Muleshoe Ranch	1998	24	11	4
	1999	19	10	4
Rucker Canyon	1998	32	13	3
	1999	19	9	3
Sycamore Canyon	1998	N/A	N/A	N/A
	1999	27	13	4
Tucson Mountain	1998	29	12	2
	1999	24	14	6

N/A - Averages not available

Urban Haze

In addition to the 24-hour PM_{10} samples collected for regulatory purposes that can also be used in the assessment of urban haze (shown earlier), ADEQ also has collected six hour samples of PM_{10} and $PM_{2.5}$. The six-hour samples were for the morning hours (5 a.m. to 11 a.m.) and were collected in the Phoenix and Tucson metropolitan areas. The 1999 morning hours' PM_{10} and $PM_{2.5}$ observations are summarized in Tables I.20 and I.21.

Along with the PM sampling, ADEQ also operated transmissometers and nephelometers in Phoenix and Tucson. Data from these instruments for 1998 and 1999 are presented in Table I.22. The data are separated into categories for all hours and six hours. Each category is further summarized into the average visibility for the dirtiest 20 percent of the sampled hours, the mean visibility of all hours, and the cleanest 20 percent of the sampled hours.

Site	1999 Annual Average		Maximum		2nd Highest		Number of Samples
	Total	Fine	Total	Fine	Total	Fine	
Estrella Park	39.3	11.1	84	24.7	77	20.9	58
Higley	77.1	12.0	176	25.4	169	25.4	59
Phoenix JLG Supersite	37.4	12.8	89	34.3	73	29.6	58
Tempe	38.9	11.1	116	30.4	77	27.3	58
ASU West	35.2	11.3	81	38.5	76	24.2	57

Table I.21. Tucson Metropolitan Area Six-Hour (5 a.m.-11 a.m.) PM_{10} (total) and $PM_{2.5}$ (fine) in $\mu g/m^3$

Site	1999 Annual Average		Maximum		2nd Highest		Number of Samples
	Total	Fine	Total	Fine	Total	Fine	
Tucson Central	38.0	11.9	99	29.5	97	25.6	59
Craycroft	28.5	9.7	73	36.3	70	19.8	59
Orange Grove	41.2	11.3	170	22.9	123	20.1	54

Table I.22. Phoenix and Tucson Urban Haze Data 1998-1999 in Mm^{-1}

Site	Year	All Hours			5 a..m - 11 a..m		
		Dirtiest 20%	Mean	Cleanest 20%	Dirtiest 20%	Mean	Cleanest 20%
Phoenix Transmissometer	1998	135	79	46	138	85	51
	1999	125	71	38	124	75	42
Phoenix Nephelometer	1998	91	35	10	75	34	13
	1999	88	36	11	74	36	14
Tucson Transmissometer	1998	N/A	N/A	N/A	N/A	N/A	N/A
	1999	97	60	36	111	67	39
Tucson Nephelometer	1998	44	20	4	47	23	6
	1999	43	23	10	42	24	11

N/A – Averages not available