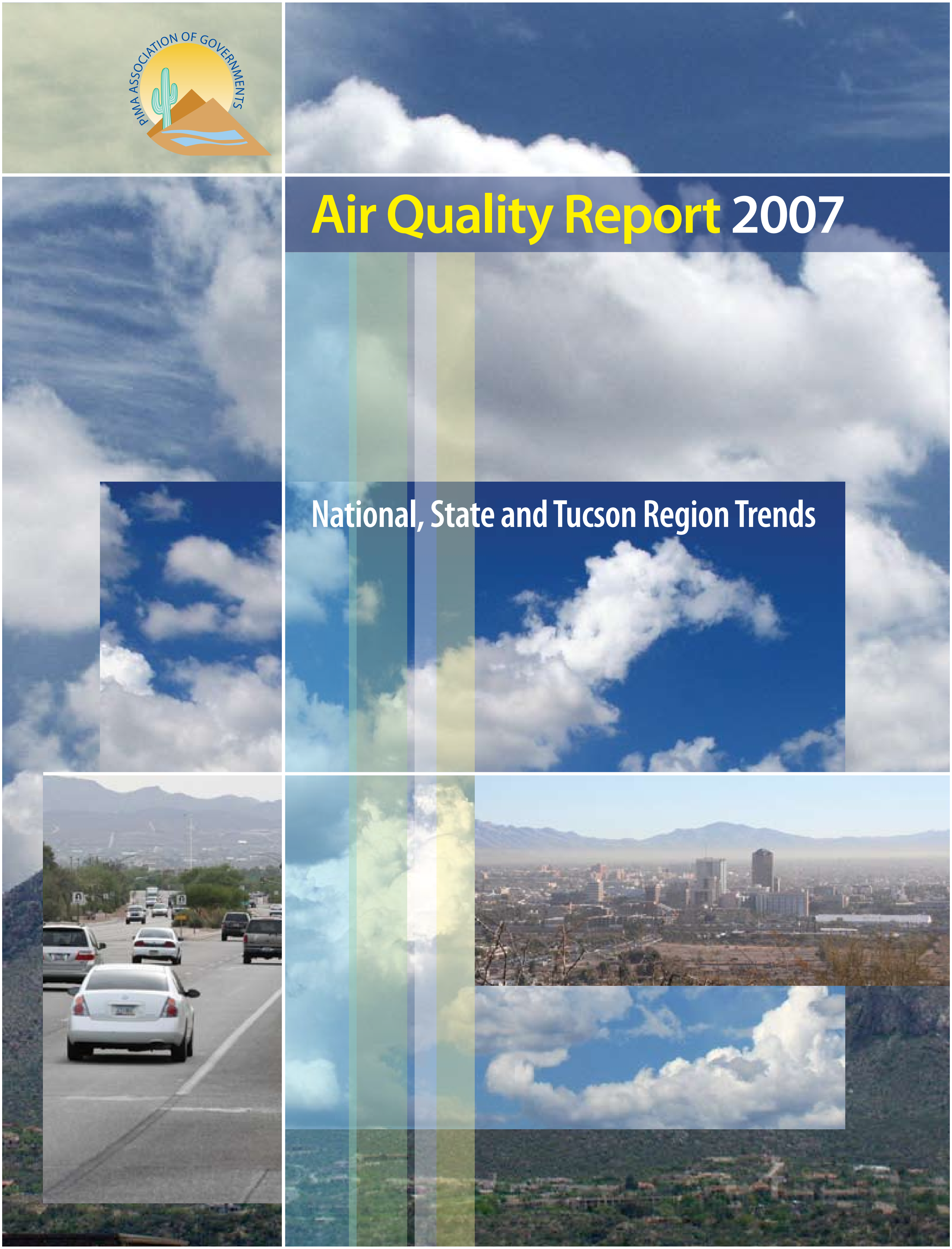

Air Quality Report 2007

National, State and Tucson Region Trends

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Dennis Dickerson

Air Quality Planning Staff:

Air Quality Planning Manager	Research Associate
Lee Comrie	Susanne Cotty

June 2007

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ACKNOWLEDGEMENTS

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Pima Association of Governments:

Lee Comrie
Susanne Cotty
Dennis Dickerson
Philip Cyr
Paul Casertano
Tom Cooney
Rich Corbett
Colleen Crowninshield
Rita Hildebrand
Gayle Johnson
Manny Rosas
Teresa Ruiz
Sheila Storm

Pima County Department of Environmental Quality

Wayne Byrd
Beth Gorman
Karen Wilhelmsen

City of Tucson

Tom Fisher
SunTran
Michele Joseph

EXECUTIVE SUMMARY

The Air Quality Planning program of Pima Association of Governments (PAG) addresses regional air quality issues and provides information to its jurisdictions. PAG strives to understand the primary causes of air pollution. This report provides information on air quality trends in Pima County and compares those with national and state trends. This report represents an expansion of the annual Carbon Monoxide (CO) Progress Report, which is required by the CO Limited Maintenance Plan.

The U.S. Clean Air Act has resulted in major improvements in air quality across the nation. Over the past 35 years, there has been a steady decline in emissions of the six criteria pollutants at the national, state and county levels. These declines occurred despite the fact that population has increased and more miles are being driven each year. Most of these improvements can be attributed to the implementation of stationary source controls, regulation of motor vehicle tailpipe emissions and cleaner burning fuels.

In general, ambient air pollutant concentrations also have decreased nationwide and many Americans are able to breathe healthier air. In Arizona and Pima County, concentrations are generally below the U.S. Environmental Protection Agency (EPA) health standards; however, three criteria pollutants remain a concern in the Tucson region: carbon monoxide, ozone and particulate matter. While carbon monoxide levels no longer exceed the EPA health standard, the region remains under a Limited Maintenance Plan for this pollutant, with specific control measures in place. Ozone levels are currently near 90 percent of the health standard, and this standard is currently under review by EPA. With respect to particulate matter, the region experienced a violation of the health standard in 1999, and a Natural Events Action Plan is in place.

This report highlights three pollutants (carbon monoxide, ozone and particulate matter), detailing emissions, trends and pollutant levels. Additionally, the related air quality issues of regional haze and greenhouse gases are discussed. Mobile sources of air pollutants are the primary focus of this report since they are the major contributor to air pollution in the Tucson region. Stationary sources, such as power plants and mining operations, also contribute to total emissions and are regulated by federal, state and local agencies. The report concludes with a section on mobile source emissions reductions, an analysis of select control measures, and details on other local control strategies currently are in use.

1. BACKGROUND

Pima Association of Governments (PAG) is the designated air quality planning agency for eastern Pima County and addresses regional air quality issues in keeping with federal, state and local requirements. Part of the Air Quality Planning Program's role is to improve our understanding of pollutant emissions in the Tucson region. PAG partners with Pima Department of Environmental Quality (PDEQ) to address this regional role. Separately, PDEQ implements the air quality monitoring program and is the regulatory agency responsible for permitting pollutant sources in Pima County.

In the1970s and early 1980s, the Tucson area frequently violated the carbon monoxide health standard. This resulted in the Environmental Protection Agency (EPA) designating the area as nonattainment. Largely due to stricter tailpipe emission standards, carbon monoxide levels decreased significantly. In 2000, EPA redesignated the Tucson region as an attainment area for carbon monoxide and approved a Limited Maintenance Plan to control that pollutant. Continuation of attainment status relies on PDEQ air monitoring data and PAG air quality modeling analyses to determine if and when emissions control measures should be added or removed.

As part of the Limited Maintenance Plan, PAG is required to produce an annual progress report to document monitoring and analysis of control strategies being undertaken to reduce carbon monoxide levels. Historically, this report has focused only on carbon monoxide and its major source, vehicle tailpipe emissions. However, this year, the report is expanded to include information on ozone and particulate matter. In addition to these criteria pollutants, data are presented on regional haze and greenhouse gases at the national, state and local level. The Tucson area's rapid increase in population, accompanied by increased vehicular traffic, also contributes to greenhouse gas emissions and visibility impairment.

This report includes national and statewide air quality trends, but emphasizes Pima County and local data where possible. The inclusion of multiple pollutants in this report is intended to present a comprehensive overview of emerging trends in the Tucson region. As in previous progress reports, the emphasis continues to be on mobile sources, as they are responsible for the majority of air pollution in the Tucson region. The last chapter contains mobile source emission reduction strategies, an analysis of select measures for the Tucson region, and details on other local measures in place.

2. STANDARDS AND REGIONAL MONITORING INFORMATION

Pursuant to the federal Clean Air Act (CAA), the EPA has established standards for six common air pollutants: CO, lead (Pb), nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), and particulate matter (PM_{10} and $PM_{2.5}$). National Ambient Air Quality Standards (NAAQS) establish limits to protect public health and welfare. Primary standards are established to protect public health, including sensitive populations (children, elderly, and asthmatics). Secondary standards provide protection for public welfare, including protection against visibility impairment, damage to animals, vegetation, and buildings. The CAA requires periodic review of the standards and the most recent modification occurred in 2006. Table 2.1 reflects the current regulatory levels for the various pollutants.

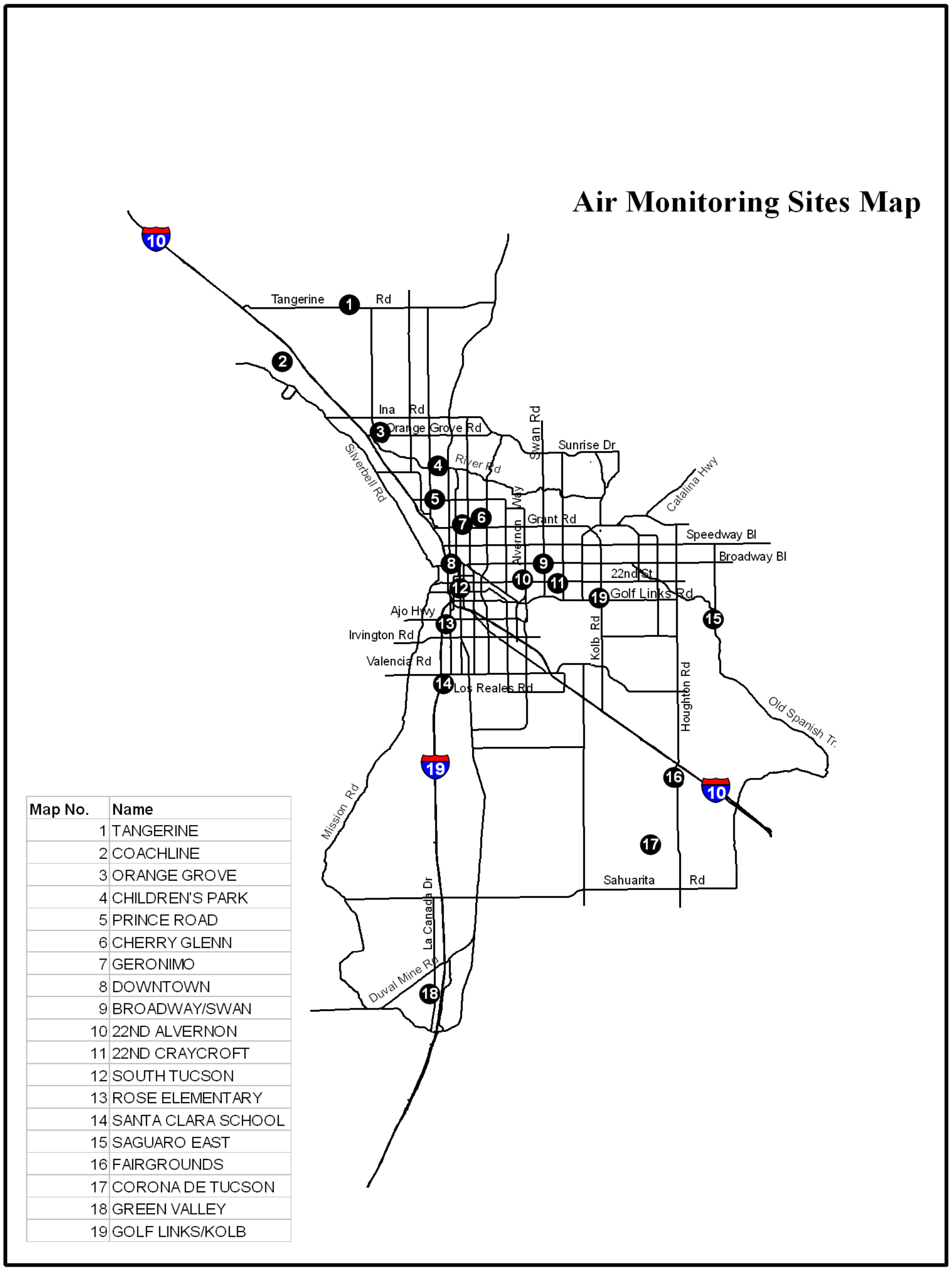
Table 2.1. EPA's National Ambient Air Quality Standards (NAAQS)

Pollutant	Primary Standards	Averaging Times	Secondary Standards
Carbon Monoxide	9 ppm	8-hour (1)	None
	35 ppm	1-hour(1)	None
Lead	105 $\mu g/m^3$	Quarterly Average	Same as Primary
Nitrogen Dioxide	0.053 ppm	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	Revoked (2)	Annual (2) (Arith. Mean)	
	150 $\mu g/m^3$	24-hour(3)	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (4) (Arith. Mean)	Same as Primary
	35 $\mu g/m^3$	24-hour (5)	
Ozone	0.08 ppm	8-hour (6)	Same as Primary
	0.12 ppm	1-hour (7) (Applies only in limited areas)	Same as Primary
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)	-----
	0.14 ppm	24-hour (1)	-----
		3-hour (1)	0.5 ppm

Source: National Ambient Air Quality Standards (Dec. 2006)

(1) Not to be exceeded more than once per year.
(2) Due to lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM_{10} standard in 2006 (effective Dec. 7, 2006).
(3) Not to be exceeded more than once per year on average over three years.
(4) To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentration from a single or multiple community-oriented monitors must not exceed 15.0 $\mu g/m^3$.
(5) To attain this standard, the 3-year average of the 98th percentile of the 24-hour concentrations at each population-orientated monitor within an area must not exceed 35 $\mu g/m^3$ (effective Dec. 17, 2006).
(6) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(7) (a)The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$ 1.
(b) As of June 15, 2005, EPA revoked the 1-hour ozone standard in all areas except fourteen 1-hour ozone nonattainment areas.

To insure that federal limits are not exceeded, ADEQ and PDEQ place air quality monitors around the state and county, respectively, to monitor the levels of the various pollutants. ADEQ has monitors throughout the state and in Mexico while PDEQ has 19 monitors in the metropolitan Tucson area (Figure 2.1). Various pollutants are monitored at each location. For specific monitoring data: www.airinfonow.com/monsites/map_site.asp



Map No.	Name
1	TANGERINE
2	COACHLINE
3	ORANGE GROVE
4	CHILDREN'S PARK
5	PRINCE ROAD
6	CHERRY GLENN
7	GERONIMO
8	DOWNTOWN
9	BROADWAY/SWAN
10	22ND ALVERNON
11	22ND CRAYCROFT
12	SOUTH TUCSON
13	ROSE ELEMENTARY
14	SANTA CLARA SCHOOL
15	SAGUARO EAST
16	FAIRGROUNDS
17	CORONA DE TUCSON
18	GREEN VALLEY
19	GOLF LINKS/KOLB

Figure 2.1. PDEQ Air Quality Monitors in the Tucson Air Planning Area

Source: PAG, 2006

3. POPULATION PROJECTIONS AND POLLUTANT EMISSIONS

Increasing population and decreasing pollutant emissions are evident at the national, state and county levels. These emission reductions can be attributed to federal regulatory controls on vehicle emissions, and utility and industrial source reductions.

National

The U.S. population grew at an average rate of 1 percent per year from 1990-2005. According to the U.S. census data, the nation's population is projected to grow by 46 percent from 1990-2030. Recent trends in air pollutant emissions, however, show a 35 percent decline (Figure 3.1) (USEPA, 2006a).

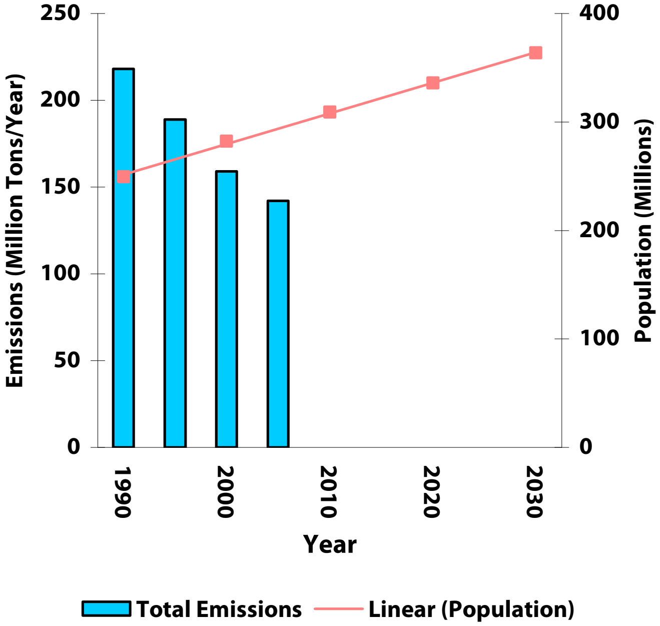


Figure 3.1. Actual and Estimated U.S. Population and Total Criteria Pollutant Emissions: 1990-2030

Source: Population: U.S. Census Bureau 2000, 2004; Emissions: USEPA, 2006a

State and Tucson Region

Arizona is currently one of the fastest growing states in the nation. Arizona's population has increased by an average rate of 3.3 percent per year over the past 15 years (ADES, 2006) and from 1990-2030, is projected to grow to over 10 million. In spite of this trend, state criteria pollutant emissions have declined, showing a 28 percent decrease from 1990-2001 (USEPA, 2005).

Pima County's population also has grown over the past 15 years, averaging over a 2.4 percent growth per year (ADES, 2006). Projections indicate a doubling of the population from 1990-2030 to 1.4 million people (ADES, 2006). Recent trends, from 1990-2001, indicate a 17 percent drop in air pollutant emissions (Figure 3.2) (USEPA, 2005).

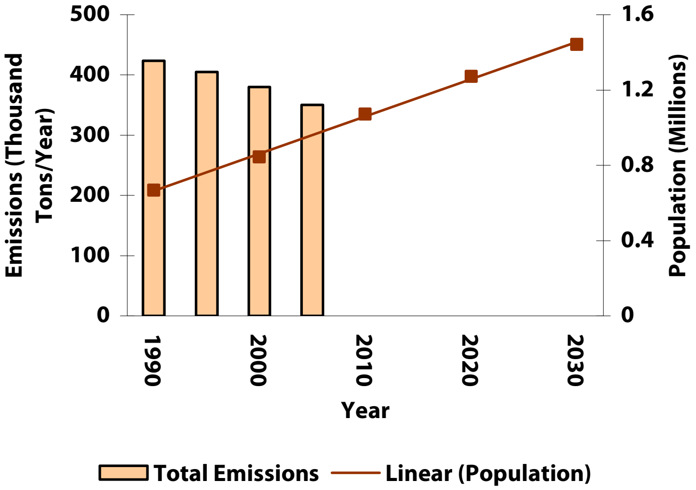


Figure 3.2. Actual and Estimated Pima County Population and Total Criteria Pollutant Emissions: 1990-2030

Source: Population: U.S. Census. 2000; AZDES, 2006; Emissions: USEPA, 2005

4. MAJOR POLLUTANTS IN EASTERN PIMA COUNTY

Mobile sources remain the largest emission source in the Tucson region. Locally we are driving more miles, yet air pollutant levels remain generally healthful. Carbon monoxide levels remain low largely due to cleaner vehicles and fuels. Levels of coarse and fine particles (PM_{10} and $PM_{2.5}$) have increased slightly from last year, but remain below the health standard. Ozone levels continue to be measured at close to 90 percent of the EPA health standard – as they have for the last decade.

The following chapter presents information on the major pollutants of concern: carbon monoxide, ozone and particulate matter. Details on trends for both pollutant emission sources and concentrations are provided at the national, state and local levels.

CARBON MONOXIDE

Carbon monoxide (CO) is an odorless, poisonous gas that results from the incomplete combustion of fossil fuels. This occurs when carbon or substances that contain carbon, such as gasoline, wood, or coal are not burned completely.

CO replaces oxygen in the blood and can affect the cardiovascular and nervous systems. It enters the blood via the lungs and permanently binds to hemoglobin (the iron-containing protein in red blood cells). CO prevents hemoglobin from carrying oxygen needed to sustain life. Lower concentrations of CO have been shown to affect people with heart disease, can cause dizziness, headaches and fatigue, and in high concentrations, even death.

Emissions primarily occur from on-road and nonroad vehicle exhausts (automobiles, buses, trucks, airplane, trains, construction equipment, lawn machinery) and some industrial processes. CO is normally found in its highest concentrations along the roadside, especially where there is heavy traffic. Other areas where high CO levels can occur include parking garages and poorly ventilated tunnels.

National

Nationwide, there has been a substantial reduction in CO emissions (Figure 4.1). This decline can be attributed to tougher restrictions on vehicle emissions, including stricter tailpipe emissions, increased use of new technology, vehicle testing, use of oxygenated fuels, and stricter regulation of industrial facilities.

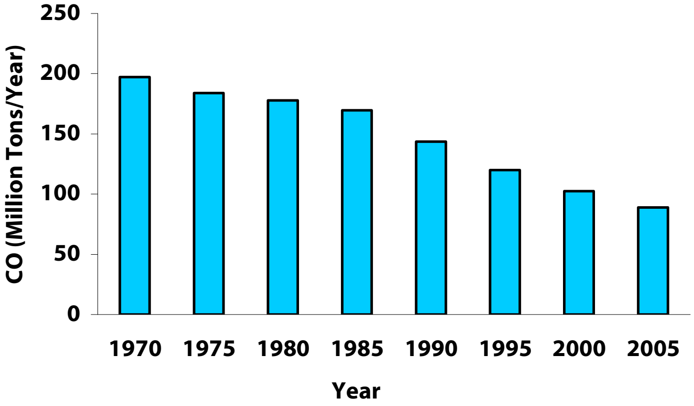


Figure 4.1. U.S. Emissions of Carbon Monoxide: 1970-2005

Source: USEPA, 2006a

EPA has developed ambient air quality trends for CO using a nationwide network of monitoring sites. From 1980-2006 the national average of CO concentrations dropped 74 percent (Figure 4.2).

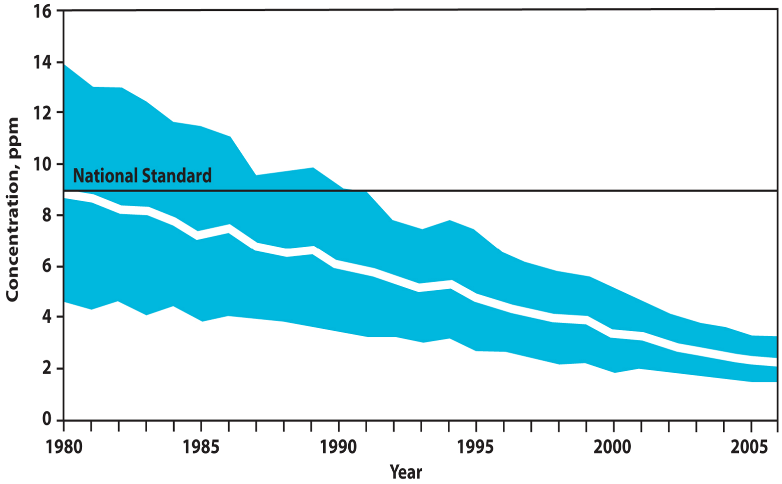


Figure 4.2. U.S. Carbon Monoxide Concentrations: 1980-2006
Based on annual 2nd maximum 8-hour average; data from 144 sites nationwide

Source: Adapted from USEPA, 2007b

State

National vehicle emission standards, use of oxygenated fuels, and the vehicle inspection program all have contributed to the state's declining CO emissions. From 1990-2001, Arizona's CO emissions decreased by 33 percent (USEPA, 2005). However, the state's major source of CO emissions continues to be motor vehicle emissions. In the metropolitan areas of the state, approximately 51 percent of CO emissions result from on-road motor vehicles; 45 percent originate from nonroad sources, off-road vehicles, construction, lawn and garden equipment and the remaining 4 percent from point and area sources (ADEQ, 2006).

Similar to national trends, the state's CO concentrations have declined dramatically since the mid 1970s. From 1981-1986, the Phoenix area exceeded national standards over 100 times each year, with the last exeedance in 1999. As is the case nationally, this improvement is largely due to new vehicle emission standards, the vehicle inspection and maintenance program and the use of oxygenated fuels during the winter months. Over the 2004-2005 time period, there were no violations of the CO standards in Maricopa, Pima, and Pinal counties (ADEQ, 2006).

Tucson Region

The declining CO emissions evident nationally and in Arizona are also apparent in Pima County. From 1990-2001, county CO emissions decreased by 20 percent (USEPA, 2005). As in the state, on-road vehicle emissions generate most of the CO emissions (56 percent). Nonroad vehicle emissions contribute 40 percent; area and point sources contribute 4 percent (Figure 4.3) (adapted from Causley, et al, 2001).

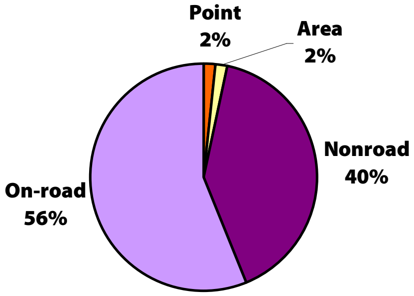


Figure 4.3. Sources of Carbon Monoxide Emissions in eastern Pima County, 2005

Source: Adapted from Causley, et al, 2001

Over the past 33 years, CO concentrations in Pima County have followed the downward trend evident in the U.S. and statewide (Figure 4.4). Although the CO standards were violated frequently in the region during the 1970s, there have been no violations of the CO standard since 1984. CO levels are currently around 25 percent of the EPA health standard. Therefore, CO is not considered a health threat in our region. Once again, technological advances leading to implementation of lower tailpipe emission standards for new cars, state vehicle inspection and maintenance programs, and use of oxygenated fuels during the winter months are responsible for these declines. Local programs which promote alternate travel modes, such as the RideShare Program, Travel Reduction Program, and the Pima County Clean Air Program, aid in reducing congestion and thus CO levels.

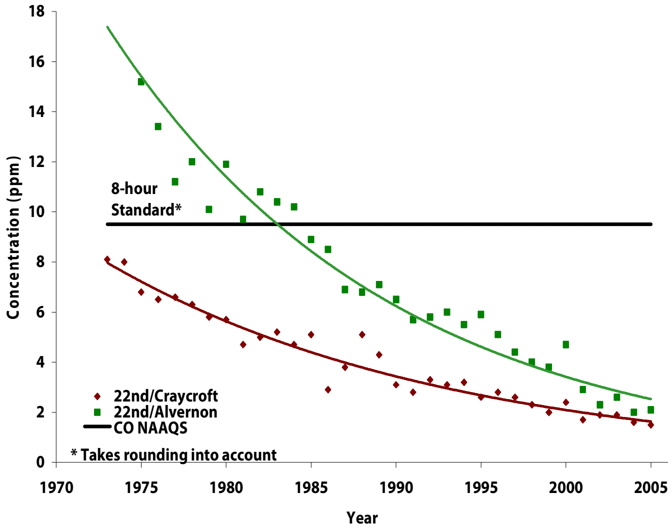


Figure 4.4. Eastern Pima County Carbon Monoxide Concentrations: 1973-2005
2nd maximum 8-hour average CO concentration

Source: PDEQ, 2006a, 2006b

CO concentrations tend to be highest in winter, when temperatures are cool, wind speeds are low, and a temperature inversion is present. This occurs when a stable atmospheric layer restricts the mixing of pollutants.

There is a strong correlation between peak traffic patterns and high CO concentrations. Figure 4.5 Illustrates hourly traffic patterns and CO levels over a 24-hour period near 22nd and Alvernon during a winter day in 2006. CO levels increase with rush hour traffic and congestion, and decrease with increased mixing of air during the day. Elevated CO concentrations are seen in the evening hours with less mixing, a more stable air mass and the possible onset of a temperature inversion.

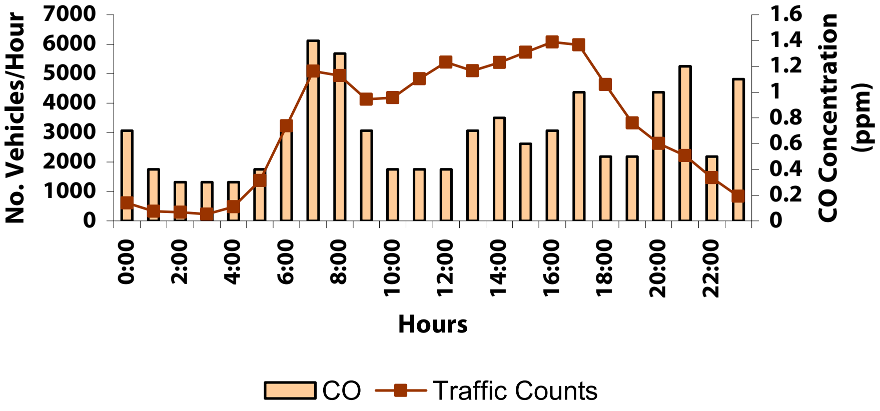


Figure 4.5. Average Vehicle Traffic and Average Carbon Monoxide Concentrations near 22nd and Alvernon Intersection - March 28, 2006

Source: CO Concentrations: PDEQ Air Info Now, 2006. Traffic Data: PAG, 2006

Pima County CO Monitoring Activities

A. Microscale Monitoring:

Two permanent microscale[1] monitors are located in the Tucson region. The first microscale monitor is located at 22nd Street/Alvernon and monitoring began in 1975. Data from this monitor provide a historical record and show how the Tucson region has reduced its CO levels over time. For the 2006-2007 CO season this site recorded lower CO readings than the previous year.

The second microscale monitor is sited at the southeast corner of Golf Links/Kolb and monitoring began in September 2002 to fulfill the CO LMP monitoring requirements. This microscale monitor continues to operate from October through April of each year.

B. Mobile Monitoring for the Limited Maintenance Plan:

PDEQ performed mobile monitoring at hot-spot intersections in the Tucson area. The monitoring was done with a mobile CO monitor at three different locations with monitoring sites selected by identifying intersections with the highest volume and worst congestion.

Highlights from the 2005 PDEQ CO Monitoring Report regarding mobile monitoring results are extracted here (PDEQ, 2007):

C. Microscale and Mobile Monitoring Comparisons:

Eight-hour rolling averages were determined for the mobile units during their respective sampling periods and the concurrent periods at the 22nd Street/Alvernon and Golf Links/Kolb, as well as for each of the sites monitored by the mobile units. The results are displayed in Table 4.1. This allows for a closer comparison between the hot-spot mobile sites and the PDEQ historical microscale CO sites. The highest reading recorded at Golf Links/Kolb was less than one-fifth of the standard (the NAAQS level for an 8-hour average is 9 ppm). These low readings strongly indicate that Tucson is not likely to exceed the CO standard in the future.

Speedway/Swan vs. 22nd/Alvernon
Monitoring data from this intersection tracked the current 22nd Street/Alvernon site very closely. The spikes which were higher than the 22nd Street/Alvernon site could indicate a higher level of congestion developing at the Speedway/Swan site.

Broadway/Kolb vs. 22nd/Alvernon
Data analysis recovered from the monitor indicates that concentrations at the Broadway/Kolb site tracked CO measurements at the 22nd Street/Alvernon site very closely. This indicates that the traffic patterns are very similar across the larger Tucson metro area.

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[1] *Air quality measurements used to represent distributions near major roadways, in particular for carbon monoxide.*

Table 4.1. 8-Hour Carbon Monoxide PDEQ Monitored Concentrations (ppm) for Hot-Spot Intersections 2006-2007 CO Season

Site	8-hour max	8-hour 2nd high	Concurrent readings at 22nd St/Alvernon 8-hour max	Concurrent readings at Golf Links/Kolb 8-hour max
Speedway/Swan	1.6	1.3	2.1	1.3
Orange Grove/ Oracle	1.0	0.9	1.1	1.3
Broadway/Kolb	1.6	1.4	2.0	1.7
22nd St./Alvernon for entire sampling period	2.1	2.0		
Golf Links/Kolb for entire sampling period	1.7	1.7		

Source: PDEQ, 2007

Orange Grove/Oracle vs. 22nd/Alvernon
The analysis of the monitoring data indicated that the levels at Orange Grove/Oracle tracked 22ndStreet/Alvernon very well, showing very similar traffic patterns.

D. Modeling of Carbon Monoxide Hot-Spot Intersections

PAG conducts microscale CO modeling analyses as required by the LMP, using CAL3QHC Version 2. This model is used as a screening tool to highlight the levels of ambient CO concentrations that could be produced in those areas most susceptible to CO violations. Intersections are chosen based on their average daily traffic (ADT) and level of service (LOS), as well as for comparison with the intersections where microscale monitoring data are collected. Details of model parameters can be found in Appendix B.

Intersection Analyses
PAG Technical Services staff prepared a list of the intersections with the highest ADT and the worst LOS for 2006 based on traffic counts and travel demand modeling analyses. PAG Air Quality Planning staff selected the three highest ADT and the three worst LOS intersections as candidates for CAL3QHC microscale modeling. The intersections that qualified for hot-spot modeling are shown in Table 4.2

Table 4.2. Highest ADT and Worst LOS Intersections, 2006

Rank	Highest ADT	Worst LOS
#1	Ina/Oracle	Ina/Oracle
#2	Broadway/Kolb	Tanque Verde/Grant/Kolb
#3	Speedway/Campbell	Valencia/Kolb

Source: PAG Regional Planning, 2006

From the intersections selected for turning movement counts, the highest ADT and the worst LOS occurred at the Ina/Oracle intersection. The ADT was 104,832 vehicles and highest average delay per vehicle was 123 seconds (LOS 'F') during afternoon peak hour traffic (4:30 p.m. to 5:30 p.m.).

In addition, 22nd Street/Alvernon and Golf Links/Kolb were modeled. Both intersections have a CO microscale monitor and are modeled for historical purposes and for comparison to monitored values. Table 4.3 shows the modeling results for the 8-hour CO concentrations for the worst LOS, the highest ADT intersections, and the permanent microscale locations.

Table 4.3. Modeled 8-Hour Carbon Monoxide Concentrations (ppm) for Hot-Spot Intersections, 2006

Intersections	**8-Hour Average Concentration (ppm)** (background of 0.50 ppm, persistence factor of 0.56)
Tanque Verde/Grant/Kolb	3.2
Speedway/Swan	3.1
Golf Links/Kolb*	2.8
Broadway/Kolb	2.7
Ina/Oracle	2.6
22nd/Alvernon*	2.5
Orange Grove/Oracle	2.3
Valencia/Kolb	2.2

* PDEQ Microscale Monitors

Source: PAG modeling, 2006

PARTICULATE MATTER

Particulate matter (PM) is composed of small solid particles or liquid droplets from smoke, dust, fly ash and condensing vapors and can be suspended in the air for long periods of time. Particles can be directly emitted (primary), or can be formed when emissions of oxides of nitrogen (NO_x), sulfur oxides (SO_x), ammonia, organic compounds, and other gases react in the atmosphere (secondary).

Particulate matter is classified into two groups depending on particle size. PM coarse (PM_{10}) contains particles less than or equal to 10 micrometers in diameter while PM fine ($PM_{2.5}$) consists of particles measuring less than or equal to 2.5 micrometers in diameter. Generally, coarse PM is composed largely of primary particles and fine PM is composed mostly of secondary particles.

These microscopic particles can affect breathing and respiration, cause lung damage and possibly cause premature death with children, the elderly, and people suffering from heart or lung disease at greater risk. The larger particles, PM coarse, are mostly deposited in the nasal passages, while the very small particles can penetrate and be deposited deep in the lung sacs and membranes. Particulate matter can alter the body’s defense systems and cause cancer. In addition to health concerns, particulate matter can damage paint, enhance metal corrosion, and soil buildings and clothing. Suspended particulates also reduce visibility (see regional haze section).

Fine particulate matter or $PM_{2.5}$ travels deeper into the lungs and can be more harmful than PM_{10}. It also can contain toxic substances such as metals and organic compounds. Many health studies have correlated increased exposure to $PM_{2.5}$ with increases in premature death as well as a range of serious respiratory and cardiovascular effects. Fine PM also can contain toxic substances such as metals and organic compounds. Many health studies have correlated increased exposure to $PM_{2.5}$ with increases in premature death as well as a range of serious respiratory and cardiovascular effects.

PM COARSE (PM_{10})

Coarse particulate matter (PM_{10}) can be generated from sources such as paved and unpaved road travel, woodsmoke, burning fuels, fugitive dust from earth moving, mining, construction, and agricultural activities and from vacant lots.

National

Over the past 35 years, there has been an 84 percent reduction in national PM_{10} emissions (Figure 4.6). Contributing to this trend is increased regulation of vehicle emissions and stricter controls on utility and industrial operations (USEPA, 2006a).

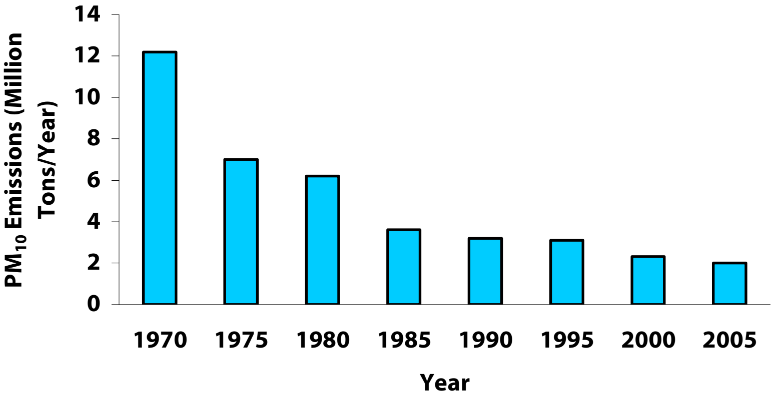


Figure 4.6. U.S. PM_{10} Emissions: 1970-2005

Source: USEPA, 2006a

Before 1988, particulate matter was measured as total suspended particulates. In 1987, there was a revision in the federal health standard for particulates, and the emphasis was changed to PM_{10}.

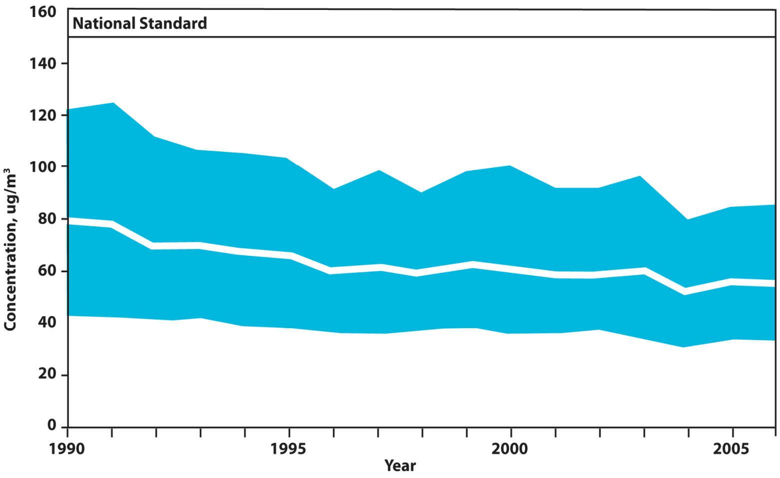


Figure 4.7. U.S. PM_{10} Concentration Trends: 1990-2006
Values based on seasonally weighted average; trend based on 391 sites

Source: USEPA, 2007b

Nationally, PM_{10} concentrations have been well below the NAAQS standards for the past 16 years and show a 30 percent reduction over this period (Figure 4.7) (USEPA, 2007b).

State

Declining Arizona PM_{10} emissions follow the national trend. From 1990-2001, state PM_{10} emissions have decreased by 13 percent (USEPA, 2005). Coarse particulate concentrations also have decreased in both urban and rural settings but standards are periodically violated, and can result from high wind events, and combinations of agricultural and earthmoving activities, road construction and vehicular traffic. ADEQ monitors PM_{10} in all

15 Arizona counties and Mexico. From 2003-2005, Maricopa County had 12 violations of the 24-hour standard; Cochise had one, Pinal had two, and one in Santa Cruz County.

Currently, 10 areas in Arizona have violated one or both of the PM_{10} standards frequently enough to be designated nonattainment areas by EPA. Depending on the location, the sources of the particulate matter in these nonattainment areas include: unpaved roads, mine tailings, agricultural activities, industrial processing and construction practices. The responsible air quality agency in these nonattainment areas has submitted documents to EPA detailing procedures to reduce PM_{10} emissions, including fugitive dust.

Tucson Region

In Pima County, on-road, area, point and nonroad source all contribute to PM_{10} emissions. From 1990-2001, there was a 20 percent decline in PM_{10} emissions (USEPA, 2005). Estimates using a 2000 emissions inventory indicate that on-road sources, including vehicle emissions, and dust from paved and unpaved roads, contributed 38 percent to total PM_{10} emissions. Area sources, such as residential fireplaces and woodstoves, produced 31 percent of emissions. Point sources, such as mining operations, concrete and asphalt production, contributed 21 percent, while nonroad sources (construction and mining equipment, and lawn and garden equipment) produced 10 percent (adapted from Causley, et al, 2001) (Figure 4.8).

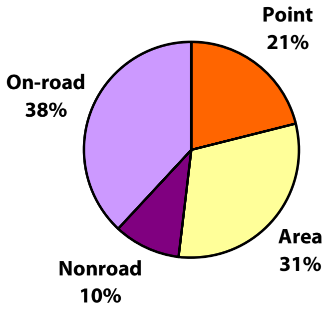


Figure 4.8. Sources of PM_{10} Emissions in eastern Pima County, 2005

Source: Adapted from Causley, et al, 2001

Elevated levels can occur during periods of high winds as well as under stable conditions when temperature inversions are present. Pima County is usually in compliance with the PM_{10} health standards but violated the 24-hour PM_{10} standard in 1999 with six recorded exceedances (Figure 4.9). High winds and unusually long dry periods were considered factors contributing to the high particulate readings for that year. In response, PDEQ developed a Natural Events Action Plan (NEAP) and submitted it to EPA on June 23, 2001. The plan was developed to protect public health and welfare from airborne fine dust particles during future high wind dust events. Since the submission of the NEAP, the Tucson region has experienced three exceedances of the 24-hour PM_{10} standard. In 2003, an exceedance of the 24-hour standard occurred (considered a natural event due to the forest fires in the Catalina Mountains). No exceedances occurred during 2004 or 2005. PDEQ is currently engaging in outreach, education and increased enforcement activities to ensure compliance with the local regulations required under the NEAP.

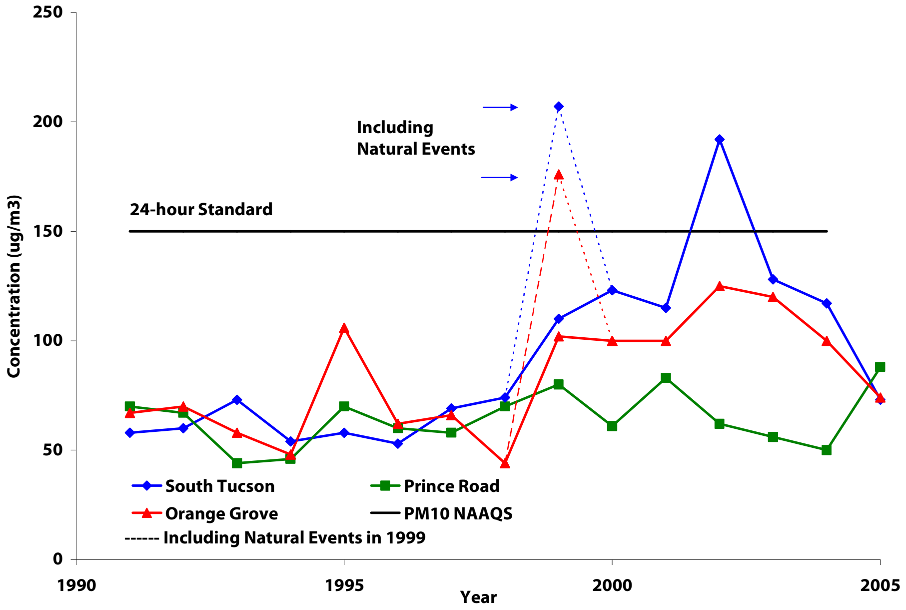


Figure 4.9. Eastern Pima County PM_{10} Concentrations: 1991-2005
2nd Maximum 24-hour PM_{10} Concentration

Source: PDEQ, 2006a, 2006b

Between the NEAP's implementation in fiscal year 2003-2004 and fiscal year 2005-2006, PDEQ's compliance staff conducted over 5,000 dust inspections, issuing 307 Notices of Opportunity to Correct, and 84 Notices of Violation. With an average of 108 inspections per month, the compliance staff continues to respond to airborne dust complaints, and provide surveillance throughout Pima County for fugitive dust activity (Wilhelmsen, 2006).

During this same timeframe, PDEQ's fugitive dust outreach and education staff conducted 155 public presentations and displays, and contacted nearly 11,000 people via letters, e-mails and phone calls regarding airborne dust issues. In total, outreach staff reached over 28,000 people between the program's inception in 2003 and June 2005. PDEQ continues to extend outreach efforts to contractors, haulers, street cleaners, landscapers, horse affiliations, private landowners, religious institutions, neighborhood organizations, businesses, schools, government agencies and the general public.

To aid PDEQ in gathering information on PM sources and to assist its jurisdictions, PAG has coordinated traffic counts on selected dirt roads since 2001. The goal of these counts is to protect public health. Roads are selected based upon their proximity to high population areas and input from local jurisdictions. Results from the 2006 roads count show that the highest volume dirt roads were located in the western portion of the Tucson region. Taylor Lane, 2006's busiest dirt road, averaged 1,281 vehicles per day (based on a 48 consecutive hour count). This data provides a tool for jurisdictions to identify potential sources of PM, and to assist them in their planning efforts and prioritizing roads for dust abatement strategies.

PM FINE ($PM_{2.5}$)

Fine particulate matter ($PM_{2.5}$) is a complex mixture of extremely small particles and liquid droplets. Particles discharged directly, or primary emissions, are produced by sources such as diesel engines, wood-burning activities, and industrial and commercial combustion processes. Secondary particles are formed by reactions of atmospheric gases and organic carbon particles, to form particles.

National

EPA began estimating PM2.5 emissions in 1990. Since then, there has been a 13 percent drop in emissions (USEPA, 2006a) (Figure 4.10). Reductions can be attributed primarily to federal regulations reducing vehicle and industrial emissions.

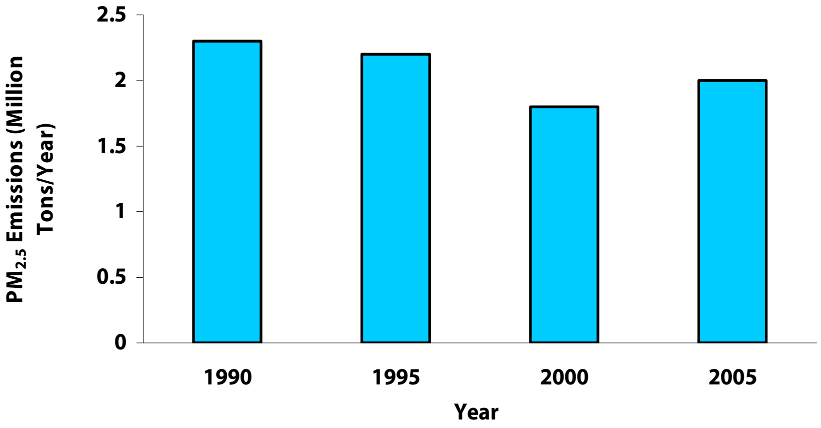


Figure 4.10. U.S. $PM_{2.5}$ Emissions: 1990-2005

Source: USEPA, 2006a

$PM_{2.5}$ standards were not established by EPA until 1997. At that time, a 24-hour and an annual standard were established to protect public health. Additional health studies led to a further strengthening of the 24-hour standard to 35 µg/m^3 in 2006. Nationally, there has been a 15 percent decline in concentrations over the past seven years (Figure 4.11) (USEPA, 2007b).

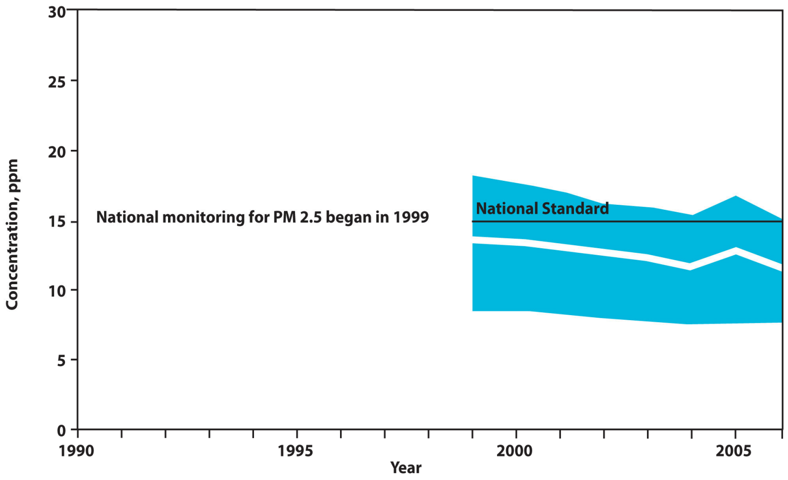


Figure 4.11. U.S. $PM_{2.5}$ Concentrations: 1999-2006
Values based on seasonally weighted annual average; trend based on 750 sites

Source: USEPA, 2007b

State

As in the United States, state $PM_{2.5}$ emissions also have decreased. From 1990-2001, state emissions have declined by 30 percent (USEPA, 2005).

Monitoring of $PM_{2.5}$ in Arizona began in the late 1990s, when EPA established the standards. State $PM_{2.5}$ concentrations continue to be well below the EPA health standards. ADEQ collects monitoring data from seven counties in Arizona and no violations occurred in these counties from 2003-2005 (ADEQ, 2006).

Tucson Region

Tucson, with a relatively small industrial sector, generally has low $PM_{2.5}$ emissions. County $PM_{2.5}$ emission totals have dropped 12 percent from 1990-2001 (USEPA, 2005). In the American Lung Association's 2007 *State of the Air* report, Pima County scored an "A" for fine particle pollution (American Lung Association, 2007).

PDEQ monitors indicate that local $PM_{2.5}$ concentrations are well below the EPA health standards (Figure 4.12).

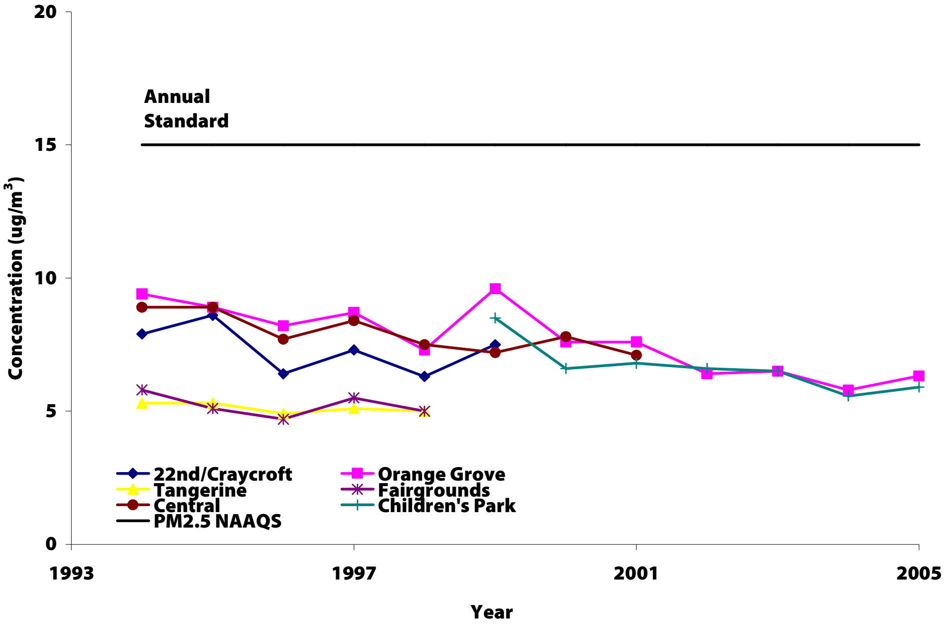


Figure 4.12. Annual Average eastern Pima County $PM_{2.5}$ Concentration: 1994-2005

Source: PDEQ, 2006a, 2006b

OZONE

Ozone (O_3) is an invisible gas which is a form of molecular oxygen (three oxygen atoms linked together). It occurs naturally in the upper atmosphere (about 9 to 13 miles above the earth's surface), and protects life on earth by filtering out harmful ultraviolet radiation from the sun. Ozone at ground levels, however, is a harmful pollutant and a major component of smog.

Ozone is a severe irritant to the respiratory system and can cause shortness of breath, coughing, wheezing and stinging eyes. It can damage lung tissue and make people more susceptible to respiratory infections. Ozone is especially harmful to children, the elderly and those with impaired health. This includes people with respiratory problems such as asthma, emphysema, chronic bronchitis and cardiovascular patients. It also inhibits plant growth and can cause damage to crops and forests.

Ozone is generally not emitted directly, but forms when ozone precursors, oxides of nitrogen (NO_x) and volatile organic compounds (VOCs), react in the presence of sunlight. Typical urban sources of NO_x and VOCs are emissions from on-road mobile sources (cars, buses and trucks), nonroad mobile sources (construction vehicles, planes and trains), power plants and factories. VOCs also are naturally occurring and are emitted by plants and referred to as biogenic emissions.

National

Over the past 35 years, ozone precursor emissions (NO_x and VOC) have decreased 29 percent and 53 percent, respectively (Figure 4.13) (USEPA, 2006a).

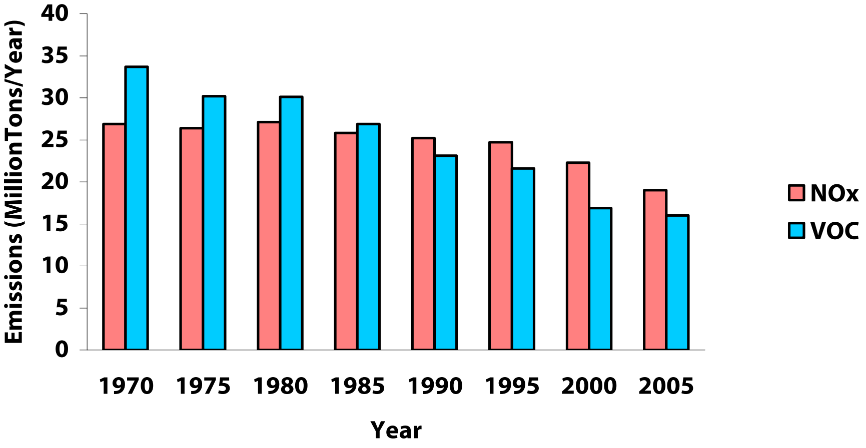


Figure 4.13. U.S. Emissions of the Ozone Precursors (Oxides of Nitrogen and Volatile Organic Compounds): 1970-2005

Source: USEPA, 2006a

According to EPA's 2006 *Air Emission Trends* report, the ambient 8-hour ozone levels have decreased 21 percent over the past 26 years (Figure 4.14). These reductions can be attributed to control programs focused on ozone precursor emission reductions. These programs have targeted electric utilities, chemical manufactures, and mobile source emissions (vehicle emission inspection programs, reformulated gasoline, and strict tailpipe emission standards).

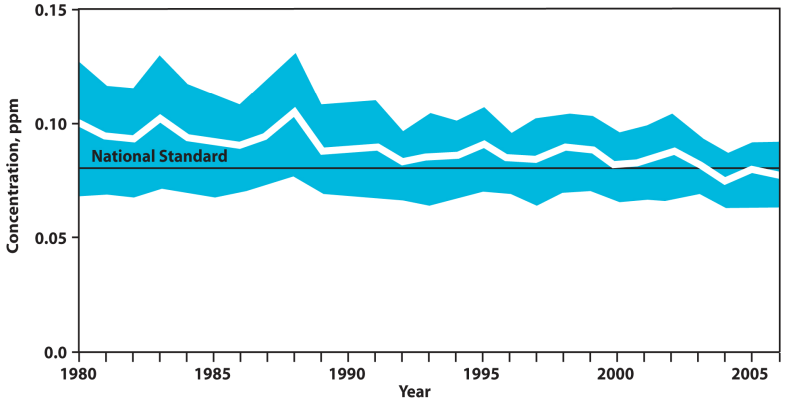


Figure 4.14. U.S. Ozone Concentrations: 1980-2006
Values based on annual 4th maximum 8-hour average; trend based on 275 sites

Source: USEPA, 2007b

State

Similar to the national trends, Arizona has experienced similar reductions in precursor emissions. From 1990-2001, ozone precursor emissions of VOC and NO_x have decreased 25 percent and 3 percent, respectively, (USEPA, 2005).

In 1990, a portion of Maricopa County was classified as a moderate one-hour ozone nonattainment area due to repeated violations of the ozone health standard. The area failed to come into compliance by the mandated deadline, and consequently, EPA reclassified the area as a serious nonattainment area in 1997. In 2000, ADEQ submitted plans to EPA designating detailed control measures to reduce ozone levels. No violations of the one-hour standard have been recorded since 1996. Maricopa Association of Governments (MAG) submitted a maintenance plan to reclassify the area to attainment and provided assurances that ambient ozone levels would continue to meet the one-hour standard. EPA approved the maintenance plan and redesignated the area as attainment for the one-hour standard.

In 2004, EPA designated Maricopa County and the Apache Junction portion of Pinal County nonattainment for the 8-hour ozone standard, due to repeated violations of eight-hour standard from 1995-2004. ADEQ is required to submit an air quality plan detailing control measures to EPA in 2007.

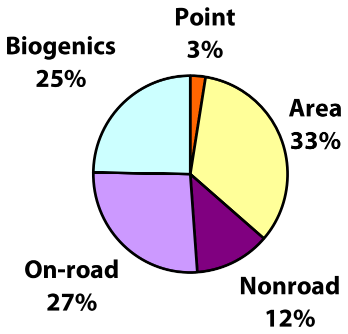
ADEQ monitors ozone levels from nine counties in Arizona. These include counties where national parks and monuments occur since ozone is a major component of smog and its precursors can impair visibility. No violations of the eight-hour standard occurred in these nine counties from 2003-2005 (ADEQ, 2006).

Tucson Region

From 1990-2001, county VOC emissions dropped 15 percent, while NO_x emissions increased by 7 percent (USEPA, 2005). Area sources such as residential fireplaces, architectural surface coating and gas stations are a significant source of VOCs (33 percent), but contribute less to total NO_x emissions. On-road sources and naturally occurring plant-generated VOCs (biogenics) also contribute significantly to local VOC emissions (Figure 4.15).

On-road sources represent a major contributor to NO_x emissions. Point sources, such as airports, natural gas facilities and power plants, also generate significant amounts of NO_x (adapted from Causley, et al, 2001).

VOCs



NO_x

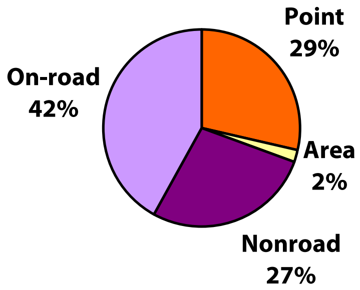


Figure 4.15. Sources of Ozone Precursors (VOCs and NO_x) in eastern Pima County, 2005

Source: Adapted from Causley, et al, 2001

Since PDEQ initiated ozone monitoring in 1973, levels have remained fairly uniform throughout the Tucson metropolitan area (Figure 4.16). Pima County scored a 'B' for ozone pollution in the most recent American Lung Association's *State of the Air* report (American Lung Association, 2007).

Recent local data indicate that the Tucson region experiences ozone levels at about 90 percent of the 8-hour standard set by the EPA. Currently, these standards are under review by the EPA and a more stringent standard has been recommended by the EPA Science Advisory Committee.

Higher ozone levels tend to be recorded in areas outside the central urban area and during summer afternoons. The scavenging of ozone by NO_x in the urban core accounts for the lower ozone levels in the metropolitan area and higher levels near the edges of the urban area.

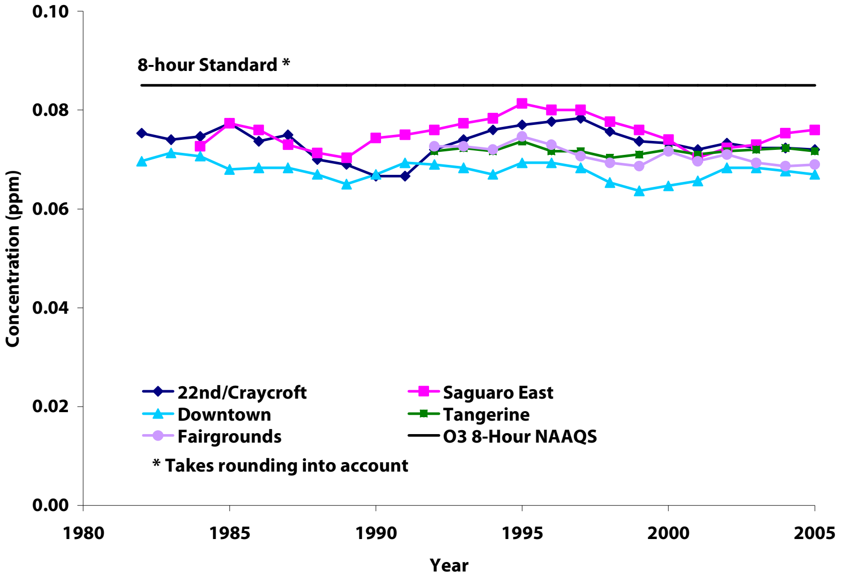


Figure 4.16. Eastern Pima County Ozone Concentrations: 1982-2005
3-year average of the 4th highest 8-hour ozone concentration

Source: PDEQ, 2006a, 2006b

Summer afternoons with intense sunlight, moderate heat and stable air conditions promote the formation and duration of elevated ozone levels. Ozone levels also are affected by mountain-valley air circulation. Typically, a daily reversal in wind direction with down-slope winds (from the southeast) occurs during the early morning with up-slope winds (from the northwest) occurring in the afternoon. The down-slope winds transport pollution westward/northward during the late evening and early morning. The up-slope winds transport pollution eastward during the afternoon and early evening, toward Saguaro National Park East which generally records higher ozone concentrations during the ozone season. In this manner, both ozone precursors and ozone itself are transported across the region (Diem, 2001).

One of the most effective control measures for ozone has been the Federal Motor Vehicle Control Program. This has reduced NO_x and VOC emissions by placing stringent emissions regulations on vehicle manufacturers. These regulations require manufacturers to develop systems capable of capturing excess gasoline vapors and cleansing tailpipe emissions. However, these systems don't always perform as designed and can deteriorate. In addition, poorly tuned vehicles and tampered vehicles can increase emissions. Promotion of alternate travel mode programs such as RideShare, the Travel Reduction Program, and Pima County's Clean Air Program, also help to reduce ozone levels.

PAG Ozone Studies

Several studies have been conducted by PAG in recent years in order to gain a better understanding of ozone concentrations, formation and transport in the Tucson region. A brief description of each study follows.

A. Evaluation of the Cost of Ozone Nonattainment and Ozone Control Measures in Pima County, 1999

Environmental Sciences Inc. was contracted by PAG and PDEQ to investigate ozone pollution in Pima County. The project had two major goals: evaluate the likely costs if Pima County violates the federal ozone standard, and determine possible steps that could be taken to delay or prevent a violation.

The principal findings of the ozone study were:

- The 8-hour standard could be exceeded, but it is not likely within the next few years (assuming no change in the existing standard).
- Annual costs of ozone nonattainment could exceed $50 million.
- Relationships between ozone and its precursors are complex and difficult to predict.
- More detailed information is needed on the sources of ozone precursors and the quantities of emissions before control measures can be prioritized.
- Vehicle emissions account for about 2/3 of all "man-made" emissions in Pima County.
- Natural sources of certain precursors also may be significant.
- Projected emissions from on-road vehicles indicate a downward trend in the medium to long term, primarily due to increasingly stringent emission standards for new vehicles.
- Increases or decreases in precursor emissions may not produce proportional changes in ozone levels.

As a result of these findings, further studies were conducted to gain greater insight into the annual emissions of ozone precursor compounds, as well as other criteria pollutants.

B. Emissions Inventories for the Tucson Air Planning Area (TAPA), 2000

The goal of the 2000 Tucson Region Emissions Inventory study was to develop an emissions inventory (EI) for stationary point and area sources, as well as nonroad mobile sources within the TAPA. Ozone precursors, VOCs and NO_x, were the focus of the study, while secondary emphasis was given to CO, oxides of sulfur, and PM.

Base year emissions were estimated for the year 2000 and emissions projections were developed for 2005 and 2010. In addition, three day-specific emissions inventories were developed in an attempt to support future modeling work and to provide a better understanding of how emissions vary from day to day. The inventory data were developed to be suitable for input into a photochemical model.

C. Volatile Organic Compound Data Collection and Validation, 2001

In conjunction with the EI study, VOC samples were collected in Tucson during 2000 and 2001 to aid in understanding the types of VOCs contributing to ozone formation. The study's ultimate goal was to link these VOCs to possible emission sources and to assess possible emission controls to minimize ozone formation.

Sonoma Technology, Inc. (STI) was contracted by PAG to perform validation and select analyses of the VOC data collected for the Tucson region. STI recommended the use of the Measurement-based Analysis of Preferences in Planned Emission Reductions (MAPPER) model to assess the region's ozone chemistry.

The University of Arizona and Georgia State University researchers used the MAPPER model and VOC/NO_x ratios to evaluate the Tucson region's air chemistry from April through September from 1995 to 1998. Since both precursors are necessary for ozone formation, it is important to determine which reactant is limiting for ozone production and during which portion of the ozone season. In areas that are VOC-sensitive, the amount of ozone produced is limited by the amount of VOC available. In areas that are NO_x-sensitive, the amount of ozone produced is limited by the amount of NO_x available. Knowing when and which precursor is limiting can aid in the selection of control measures. Results indicated variable sensitivity depending on the time of year, as shown in Table 4.4.

Table 4.4. Monthly Ozone Sensitivities using MAPPER[2]

Method	April	May	June	July	August	September
MAPPER	NO_x-sensitive to transitional except for downtown (VOC-sensitive)	Transitioning to VOC-sensitive	By end of June, most of metro area is VOC-sensitive	Transitional to NO_x-sensitive	Transitional to NO_x-sensitive	VOC - sensitive

PAG staff conducted an additional analysis with MAPPER using April through September 2000-2001 data to verify these findings. Results showed that the Tucson region exhibits a

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[2] *The MAPPER program uses measurements of ozone, nitric oxide (NO), and either NO_x ($NO + NO_2$) or NO_x (the sum of all oxidized nitrogen species) to compute the extent of reaction (ratio of instantaneous to maximum smog production) from the G. Johnson algorithm.*

great deal of transitional sensitivity (ozone is about equally sensitive to VOCs and NO_x) and that it also fluctuates between being VOC-sensitive and NO_x-sensitive throughout the year, depending on the season. Therefore, these analyses show that ozone concentrations will not substantially change without the implementation of control measures for both VOCs and NO_x (Diem, 2001).

D. System for Management, Observation, and GIS Modeling of Air Pollution (SMOGMAP), 2001

SMOGMAP, a multi-year project conducted by University of Arizona researchers, was completed in 2001 under a PAG contract. The goal of SMOGMAP was to integrate air quality-related data within a geographic information system (GIS) allowing for visualization-driven insight and analysis of those data.

The SMOGMAP project was comprised of two components: development of gridded, multi-temporal, atmospheric pollutant emission inventories and the mapping of ground-level, atmospheric pollution levels.

EIs were developed for ozone precursors, as well as several other pollutants, from stationary point and areas sources, biogenic VOCs, as well as nonroad and on-road mobile sources. The emission estimates included both annual and month-specific daily emissions for both typical weekdays and weekends during the mid-to late 1990s.

The results of the inventory show annual anthropogenic NO_x and VOC emissions for the Tucson Region (Figures 4.18 and 4.19). These maps illustrate graphically the location and relative concentrations of VOCs and NO_x in the Tucson region. As expected, the highest concentrations of both precursors are associated with vehicle emissions and occur along the major arterials and freeways. These emissions estimates were then used in statistical models to estimate ambient pollution concentrations across the Tucson region.

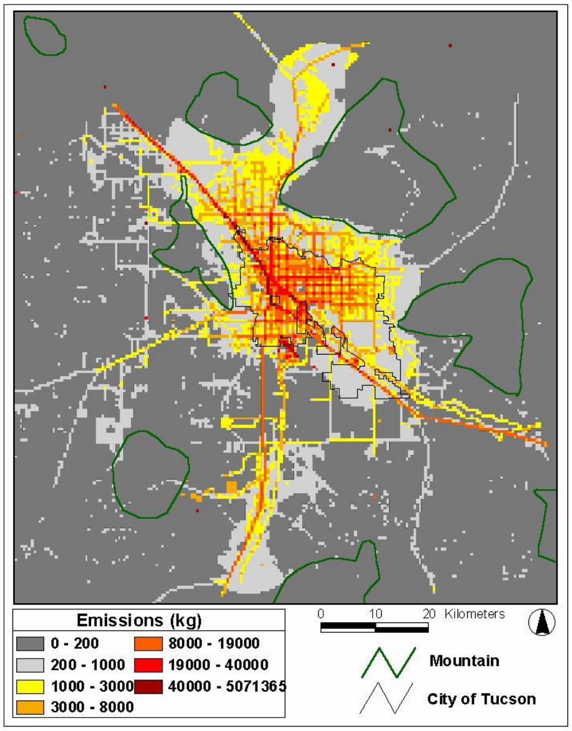
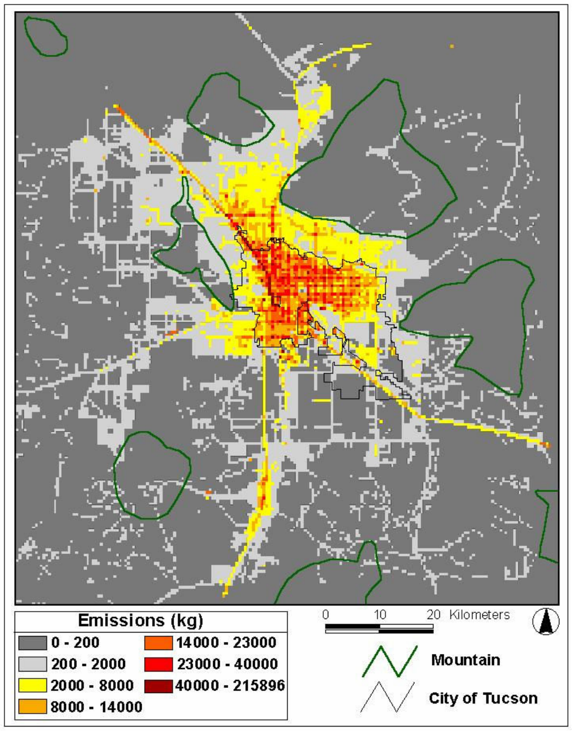


Figure 4.17. Map of Annual Anthropogenic NO_x Emissions for the Tucson Region

Source: SMOGMAP, 2001

Figure 4.18. Map of Annual Anthropogenic VOC Emissions for the Tucson Region

Source: SMOGMAP, 2001



5. REGIONAL HAZE

Visibility impairment results from the scattering and absorption of light by particles and gases in the atmosphere. Particles linked to serious health effects (sulfates, nitrates, organic carbon, soot, and soil dust) can also significantly reduce visibility. Two types of particles are responsible for reduced visibility: primary particles, emitted directly into the air, and secondary particles, formed from chemical reactions of emitted gases. Primary particles include coarse and fine soils, elemental carbon (soot) and organic carbon. Secondary particles include ammonium sulfate (formed from gaseous sulfur dioxide), ammonium nitrate (formed from gaseous NO_x), and organic carbon particles (formed from volatile organic carbon gases). Unlike the NAAQS for criteria pollutants, there are no established federal or state standards for acceptable levels of haze.

Visibility-reducing particles can be natural or anthropogenic (human-caused). Some natural sources include wildfire emissions, volcanic activity, and wind-blown coarse and fine soils. Anthropogenic emissions originate from point sources, (utility and industrial boilers, smelters, and refineries) and mobile sources (cars, trucks, and nonroad equipment).

Particle type and relative humidity have significant effects on the degree of reduced visibility. Some particles, such as elemental carbon, scatter and absorb light at high rates compared with soil particles while other particles, such as ammonium salts, are more efficient at scattering light and creating haze under high humidity conditions (Regional Haze State Implementation Plan for the State of Arizona, 2003). It is important to determine the composition of the particles and climatic conditions to characterize their impact on visibility and to establish appropriate control measures.

National

The Regional Haze Rule (RHR) was a milestone in EPA's efforts to improve visibility nationwide. It requires states to set periodic goals for improving visibility in 156 natural areas. Each state must develop a plan that contains enforceable measures and strategies for reducing visibility-impairing pollution. In June, 2005, the EPA amended the 1999 Regional Haze Rule by requiring emission controls known as best available retrofit technology, or BART, for industrial facilities. The goal of the regional haze program is for Class I[3] wilderness areas to attain the visibility level experienced with only natural sources affecting visibility. To comply with the RHR, each state must submit a plan addressing regional haze issues in their Class I areas.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program is a national cooperative visibility monitoring network involving EPA, federal land management agencies, and state air agencies. IMPROVE's objective is to establish current visibility and aerosol conditions in Class I areas. Among their goals are to identify

[3] *Class I area designations were based on an evaluation required by Congress in the 1977 federal CAA amendments. The evaluation reviewed areas of parks and national forests which were confirmed as wilderness before 1977, were at least 6,000 acres, and have visual air quality as an important resource.*

chemical species and emission sources responsible for visibility impairments, document long-term trends, assess progress toward the national visibility goal, and to provide regional haze monitoring in all protected Class I federal areas (ADEQ, 2006).
IMPROVE began monitoring natural areas in 1988 and has continually expanded its monitoring program since 1999, when EPA finalized the Regional Haze Rule (RHR). More information on the program is available at: http://vista.cira.colostate.edu/improve/

Results of IMPROVE's monitoring data indicate that natural visual range is approximately 45-90 miles in the eastern U.S. and 120-180 miles in the West. In the East, air quality data collected in 1999 showed the mean visual range for the worst days was 14.4 miles compared to a visual range of 50.4 miles on good days. In the West, visibility on the worst days has remained constant, ranging between 80-86 miles from 1990-1999 (USEPA, 2002).

In addition to differences in visibility between the eastern and western U.S., the composition of the pollutants vary (Table 5.1). Although sulfates are the major contributor in both regions, they constitute a greater percentage of the Eastern total (USEPA, 2002).

Table 5.1. Composition of Pollutants Impacting Visibility in the Eastern and Western U.S.

Pollutant	Percent Contribution	
	East	**West**
Sulfates	60-80	25-50
Organic Carbon	10-18	25-40
Nitrates	7-16	5-15
Elemental Carbon (soot)	5-8	5-15
Crustal Material (soil dust)	5-15	5-25

Source: USEPA, 2002

Several federal programs have reduced pollutants contributing to regional haze including: EPA's Acid Rain Program (reducing SO_2 and NO_x emissions), EPA's NAAQS; mobile source controls, and other strategies that reduce particulate emissions.

Western Region

Visibility-impairing pollutants travel across state and international borders moving far from the pollution source. Thus, visibility is not a localized phenomenon, but can involve large geographic areas. To that end, the Western Regional Air Partnership (WRAP) was formed in 1997 as a collaborative effort among tribal and state government representatives from 13 states (Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming) and several federal agencies (U.S. Department of the Interior, EPA, and the Forest Service). The goal of the partnership is to develop technology and policy tools to comply with the EPA's Regional Haze Rule (RHR) to improve visibility in the Western U.S.

State and Tucson Region

To develop more detailed information about state visibility issues, Arizona has been participating in the IMPROVE program. The Arizona Class I network consists of a visibility monitoring sites established by ADEQ and by the IMPROVE committee. Monitoring is conducted for these 12 mandatory Class I federal areas in Arizona: Grand Canyon National Park, Petrified Forest National Park, Sycamore Canyon Wilderness, Mount Baldy Wilderness, Pine Mountain Wilderness, Mazatzal Wilderness, Sierra Ancha Wilderness, Superstition Wilderness, Saguaro Wilderness, Galiuro Wilderness, Chiricahua Wilderness, and Chiricahua National Monument Wilderness. As required by the RHR, ADEQ must develop a plan for each Class I area. Only the first four listed areas have been addressed in ADEQ's 2003 Regional Haze Plan; the other eight area plans must be submitted for EPA review by December 2007.

Since the early 1990s ADEQ has continuously taken optical measurements of visibility in the metropolitan areas of Tucson and Phoenix to characterize the extent of urban haze. Light extinction, the degree that light is reduced by its interaction with atmospheric particles and gases, is measured with a transmissometer. The units of measurement are inverse megameters (Mm^{-1}); the higher the light extinction value in Mm^{-1}, the greater the reduction in visibility. Figures 5.1 and 5.2 illustrate visibility trends for the urban areas of Phoenix and Tucson, respectively (ADEQ, 2006).

Overall, visibility in Phoenix has improved over the past 10 years. Visibility is expected to improve as controls are implemented to control ozone precursors and particulate matter. Significantly, the Tucson region has experienced a far greater improvement over this same 10-year period. However, a recent upward swing during 2003-2005 highlights the need to continue monitoring these trends (ADEQ, 2006).

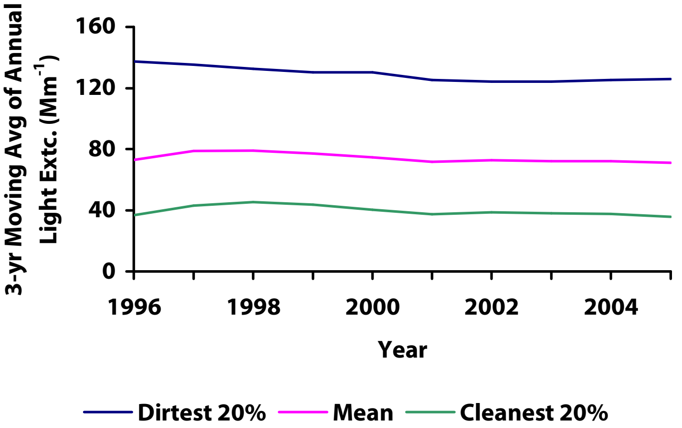


Figure 5.1. Light Extinction Trends for Phoenix: 1996-2005
Shown as three-year moving averages for all hours

Source: ADEQ, 2006

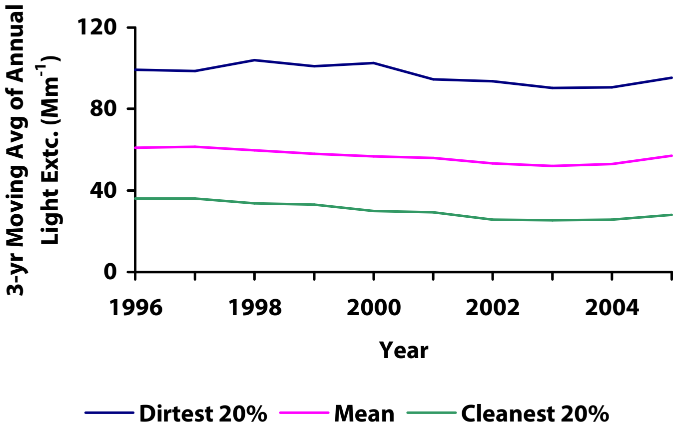


Figure 5.2. Light Extinction Trends for Tucson: 1996-2005
Shown as three-year moving averages for all hours

Source: ADEQ, 2006

6. GREENHOUSE GASES

Many chemicals in the atmosphere act as greenhouse gases (GHG) because they absorb infrared radiation and trap heat in the atmosphere. Some are naturally occurring such as water vapor, carbon dioxide (CO2), methane, nitrous oxide (N2O), and ozone. Human activities, such as burning fossil fuels, deforestation, farming and livestock practices, landfill emissions, and use of fluorinated gases add to the levels of these naturally occurring gases.

The various greenhouse gases do not have equal heat trapping potential. The Intergovernmental Panel on Climate Change (IPCC) developed a ranking system, the Global Warming Potential (GWP), to evaluate the warming potential of individual GHG relative to the same mass of carbon dioxide. Using the GWP values, based on a 100-year time frame, methane has a 20 times greater warming potential than CO_2, and nitrous oxide has over 300 times greater potential, with the fluorinated gases ranging from 140-24,000 times greater heating potential than CO_2 (USEPA, 2006c). A brief discussion of natural and anthropogenic sources of GHG follows.

Water Vapor
Water vapor is the most abundant greenhouse gas, varying from 0 percent to 2 percent in the atmosphere (EPA, 2006c). It is short-lived and is both naturally occurring and anthropogenic in origin. Anthropogenic emissions of water vapor are not included in national greenhouse gas emission inventories since human activity is considered to have a negligible effect on water vapor concentrations (EIA, 2006).

Carbon Dioxide
By far, CO_2 is the major anthropogenic component of greenhouse gas emissions. It is naturally present in the carbon cycle where billions of tons are removed by oceans and growing plants (sinks) and are emitted back into the atmosphere annually through natural processes. Fossil fuel combustion is the largest contributor of anthropogenic greenhouse gas emissions in the U.S. and in the world.

Methane
Methane is emitted from a variety of natural and human-related sources. Natural sources include wetlands, permafrost, termites, oceans, freshwater bodies, non-wetland soils, and wildfires. Human related activities such as fossil fuel production, landfill emissions, and human and animal waste management all generate methane emissions. Approximately 60 percent of global methane emissions are related to human-related activities (IPCC, 2001).

Nitrous oxide
Nitrous Oxide (N_2O) is generated by both natural and human-related sources. Natural sources include a wide variety of biological processes in soil and water, particularly microbial action in wet tropical forests. Anthropogenic sources of N_2O include agricultural soil management, vehicle emissions, and management of human and animal wastes.

Fluorinated Gases
Fluorinated gases are emitted from a variety of industrial processes (aluminum production, semiconductor manufacturing, electrical power transmission, magnesium production and processing. Since they remain in the atmosphere almost indefinitely, concentrations of these gases will increase as long as emissions continue.

National

Since the industrial revolution in the mid-18th century, global atmospheric concentrations of CO_2 have risen about 35 percent due primarily to the combustion of fossil fuels (IPCC, 2001). Current CO_2 levels are at 377 ppm, up from the pre-industrial level of 280 ppm (USEPA, 2006c). The U.S. contributes about 25 percent to global carbon dioxide emissions from the burning fossil fuels, which produces the majority of anthropogenic greenhouse gas emissions (EIA, 2004). In 2005, human-generated CO_2 made up 83 percent of all U.S. GHG emissions (Figure 6.1). Two major sources of fuel combustion are electric power generation and on-road vehicle emissions (USEPA, 2006c).

Methane contributes almost 9 percent to total GHG emissions (Figure 6.1). In 2004, four major anthropogenic activities accounted for much of U.S. methane emissions: landfills (25 percent), natural gas systems (21 percent), livestock enteric fermentation (20 percent), and coal mining (10 percent) (USEPA, 2006c).

Nitrous oxide is another component of total GHG emissions (Figure 6.1). In 2004, the primary anthropogenic sources of N_2O were agricultural activities: soil and manure management (72 percent); mobile vehicle emissions (11 percent), and nitric acid production (4 percent) (USEPA, 2006c).

Fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) contributed a combined 2.2 percent to the 2005 total (Figure 6.1) (EIA, 2006). The major source of fluorinated gas emissions in 2004 was from their use as a substitute for ozone-depleting gases (72 percent) (USEPA, 2006c). Fluorinated gas emissions are minimal compared to CO_2 but they have a greater potential than CO_2 to trap heat in the atmosphere over a 100-year period (USEPA, 2006c).

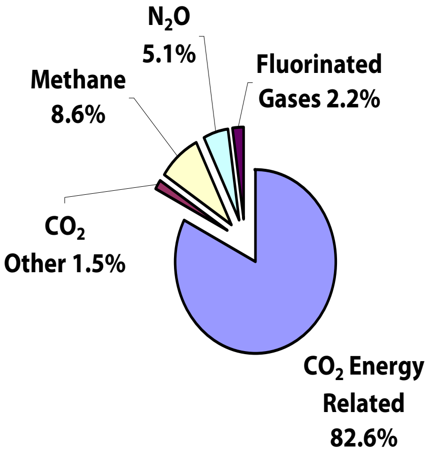


Figure 6.1. Composition of U.S. Greenhouse Gas Emissions, 2005

Source: EIA, 2006

Over the past 15 years, there was a 17 percent increase in total GHG emissions. However, the average 2005 annual rate of growth in total GHG emissions of 1 percent was somewhat lower than the 1.2 percent growth of 1990 (EIA, 2006).

From 1990 to 2005, emissions of CO_2 increased by 20 percent, N_2O increased by 10 percent, fluorinated gases have increased 84 percent, while methane emissions have decreased 13 percent, over this same period (Figure 6.2)(EIA, 2006).

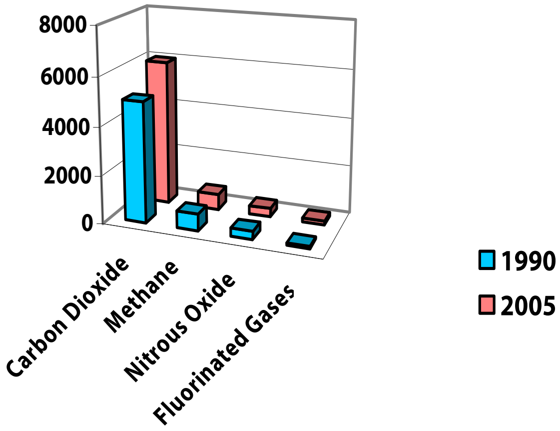


Figure 6.2. U.S. Greenhouse Gas Emissions 1990 vs. 2005
Values are millions of metric tons per year of carbon dioxide equivalent.

Source: EIA, 2006

Currently, the federal government is pursuing several strategies to address global climate change by implementing both domestic and international programs. Wide arrays of voluntary, regulatory and incentive-based programs are administered by the federal government and focus on energy efficiency, agricultural practices, and GHG reductions.

In 2002, the *Global Climate Change Initiative* set a national goal of reducing greenhouse gas intensity by 18 percent between 2002 and 2012 through voluntary measures. To achieve this goal a number of domestic programs were initiated to encourage partnerships among industry and researchers to employ alternate energy use and devise ways to improve current technology in reducing GHG emissions (USEPA, 2006c).

State

Arizona GHG emissions are rising rapidly compared to the United States, driven by the rapid rate of Arizona's population and economic growth. State GHG emissions were up 51 percent from 1990 to 2000, while national emissions rose by 23 percent during this period (Bailie, et al, 2006).

Combustion of fossil fuels in electricity production and in transportation accounted for almost 80 percent of Arizona's GHG emissions during 2000 (Figure 6.3) (Bailie, et al, 2006). Another 11 percent of GHG emissions originated from the remaining uses of fossil fuels – natural gas, oil products, and coal in the residential, commercial, and industrial sectors. Agricultural activities (manure management, fertilizer use, and livestock) resulted in methane and N_2O emissions that accounted for 5 percent of emissions. Although industrial processes contributed about 5 percent to state GHG, their emissions are rising due to increased use of fluorinated gases as substitutes for ozone-depleting chlorofluorocarbons, CO_2 released during cement and lime production, and methane released by natural gas systems and coal mines. Methane and N_2O releases from landfills and wastewater management facilities accounted for 2 percent of total state emissions. Landfill and wastewater facilities have reduced their emissions in recent years by capturing methane gas for energy use.

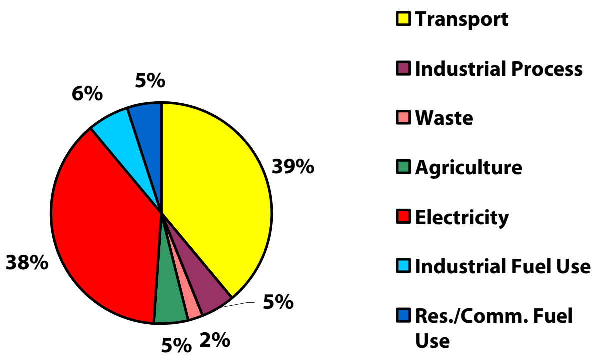


Figure 6.3. Arizona Greenhouse Gas Emissions by Sector, 2000

Source: Bailie, et al, 2006

Future projections of state GHG emissions indicate an increase in emissions from all sectors except agriculture (Figure 6.4). The state's projected rate of emissions growth is 3 percent per year from 2000 onward. Four factors are primarily responsible for the increase in emissions after 2010: electrical demand growth rate faster than population growth; increasing dependence on coal-based electric generation; freight traffic growth faster than population, and increasing hydrofluorocarbons emissions in refrigeration, air conditioning, and other applications (Bailie, et al, 2006).

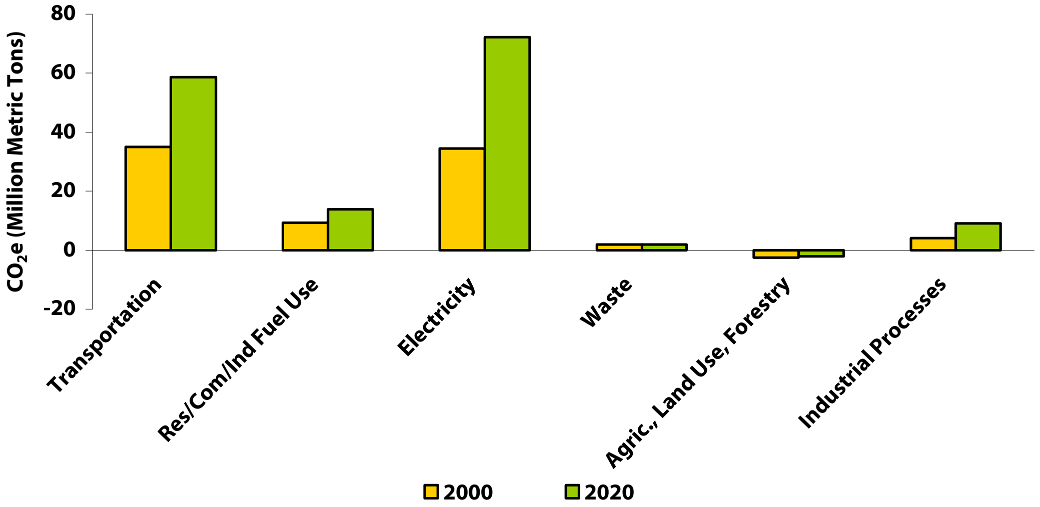


Figure 6.4. Actual and Projected Greenhouse Gas Emissions - Arizona 2000 vs. 2020

Source: Adapted from Bailie, et al, 2006

In 2005, Gov. Janet Napolitano signed an Executive Order establishing the 35-member Climate Change Advisory Group (CCAG). In addition to requiring the aforementioned inventory and forecast, this Executive Order directed the CCAG, in coordination with ADEQ, to develop a Climate Change Action Plan and provide recommendations for reducing Arizona GHG emissions. The CCAG recommended 49 policy recommendations focusing on various sectors of Arizona's economy: residential, commercial, industrial and waste management; energy supply; transportation and land use; and agriculture and forestry.

Based upon the CCAG's policy recommendations, Gov. Napolitano signed an Executive Order in 2006 establishing a statewide goal to reduce Arizona's future GHG emission to 2000 levels by 2020 and to reduce levels by 50 percent of 2000 levels by 2040. Executive Order 2006-13 also created the Climate Change Executive Committee whose task is to implement the recommendations of the CCAG's for reducing state GHG emissions. Additional information about the program is available at: www.azclimatechange.us

In February 2007, Gov. Napolitano joined with California, New Mexico, Oregon, and Washington, in signing the Western Regional Climate Action Initiative. By joining this partnership, these five states are committed to developing a collective regional target for reducing GHG by August 2007. They then have 18 months to devise a program to reach the target.

Tucson Region

In 1997, the City of Tucson contracted with Venture Catalyst to conduct a citywide greenhouse gas emissions inventory. This report pinpointed two major sources of greenhouse emissions: electricity use and generation and the burning of fossil fuels (gasoline, diesel, natural gas, jet fuel/propane, and coal) (Venture Catalyst, 1997). Total carbon dioxide production was estimated and allotted to five sectors depending on their use of electricity and/or fuels (Figure 6.5). Similar to other air pollutants, a considerable amount of CO_2 was generated by mobile sources. The industrial sector, which includes manufacturing, mining, and utilities, also contributed a significant amount to total CO_2 emissions.

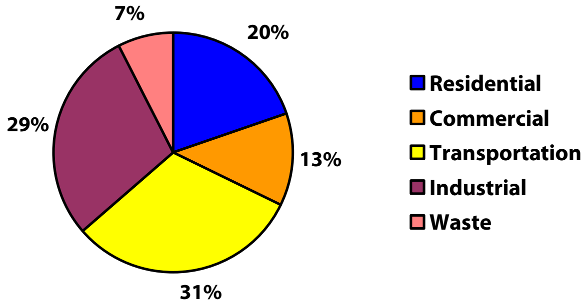


Figure 6.5. Tucson Greenhouse Gas Emissions by Sector, 1995

Source: Venture Catalyst, 1997

Pima County coordinates several programs addressing greenhouse gas reduction. Several of these programs focus on reducing energy use, thereby lowering demand on electric generating plants that are major sources of air pollutants. In 2006, Pima County proposed a Green Building Program which would offer incentives such as credits toward permitting fees, faster permit-processing time, and issuance of green building certificates to promote green building activities. Green or sustainable buildings use construction practices that enhance energy and water efficiency, improve waste management and air emissions. The program focuses on using local building materials and reusing and recycling existing structures and materials.

Tucson Electric Power (TEP) initiated a voluntary new home program in 1997 that guarantees heating and cooling costs for three years. The program addresses energy use on a square footage basis. Participants automatically receive a minimum of a 12 percent reduction in electric rates. Guarantee Program homes represented 56 percent of the regional new construction market in 2006. In an additional program to reduce GHG, TEP captures landfill gas and converts it to usable energy.

TEP, in partnership with the Tucson Clean and Beautiful organization's *Trees for Tucson,* offers residents up to two, five gallon-size trees at a nominal cost when planted on the west, east, or south side of their homes. The program has distributed more than 50,000 trees since its inception in 1993. The City of Tucson estimates that at maturity, each tree will save about 300kWh of electricity annually by providing shade and reducing cooling costs.

Pima County, the City of Tucson, and the Town of Marana each have developed a Habitat Conservation Plan (HCP) to promote wise use and conservation of the desert environment. By designating how and where development occurs, these plans will preserve natural areas and benefit air quality by limiting urban sprawl and associated pollutants.

In addition to their Habitat Conservation Plan, Tucson is engaged in activities that foster the goals of the Climate Protection Agreement such as the City's General Plan, the Houghton Area Master Plan, the Tucson Sustainability Standard for new construction, and, and greater energy efficiency standards for city facilities and fleets.

In September 2006, Mayor Walkup endorsed the U.S. Mayor's Climate Protection Agreement, which sets GHG reduction targets, adopts and enforces land use policies to reduce sprawl, preserves open space, creates alternatives to private vehicle travel, and promotes use of clean alternative energy sources. In May 2007, Pima County adopted a resolution setting a broad set of goals relating to sustainability.

7. MOBILE SOURCE EMISSIONS REDUCTIONS

Mobile sources produce air pollution and include both on-road vehicles (cars, trucks, buses) and nonroad vehicles (airplanes, trains, marine vessels, recreational vehicles, lawn equipment). Through combustion and evaporation, mobile sources produce four major air pollutants: CO, hydrocarbons, NO_x, and PM. Toxics and GHG emissions also are produced, but are not covered in this section.

National

Although vehicle emissions are not the only source of air pollution, on-road mobile sources nationally account for 55 percent of CO emissions, 35 percent of NO_x, 27 percent of VOC, and 1 percent of PM_{10} emissions (FHWA, 2004). Even though a projected 29 percent increase in population and an 85 percent increase in VMT is anticipated from 2000-2030, pollutant levels are expected to decrease due to increased regulation of vehicle emissions (U.S. Census Bureau, 2004; FHWA, 2002, USEPA, 2006d).

National Strategies

Gasoline Engines

Starting in 1963 with the Clean Air Act, EPA has mandated standards for all new cars and trucks sold in the United States. Vehicle emissions also have been reduced by the provisions of the 1990 Clean Air Act Amendments. Restrictive Tier 1 emissions standards became effective in 1994, specifying exhaust emissions for VOCs and NO_x for all gasoline and diesel-powered on-road motor vehicles.

In 2004, stricter EPA tailpipe emission standards (Tier 2) for all new passenger vehicles went into effect. These standards regulate emissions from light-duty vehicles and trucks (including sport-utility vehicles and passenger vans). Tier 2 standards, phased in over 2004-2009, limit NO_x emissions to 0.07 grams per mile (gpm), an 86 percent reduction from pre-2004 vehicles. In addition, these regulations require refiners and importers to produce and handle gasoline averaging 30 ppm sulfur.

Since 2004, manufacturers of commercial vehicles (over 8,500 lbs.) are required to comply with heavy duty engine standards. These standards require the engines to emit approximately 50 percent lower NO_x levels compared to the 1998-2003 models. Additionally, these requirements reduce particulate matter emissions significantly and restrict the maximum sulfur content of diesel to 15 ppm (ultra low sulfur diesel).

Diesel Engines

Engines manufactured from 2004 onward are required to produce a 50 percent reduction in NO_x emissions compared to previous models. Beginning with the 2007 models, heavy duty trucks and buses will run on low sulfur diesel fuel, reducing pollution by over 90 percent by 2030. EPA states that lowering the sulfur content from 500 ppm to the 15 ppm level will reduce NO_x emissions by 2.6 million tons per year, particulate matter emissions will be reduced by 110,000 tons/year, and acute respiratory incidents, hospital and emergency visits per year are estimated to be drastically lower (USEPA, 2006b).

National Tier 3 standards, phased in over 2006-2008, require more stringent control of NO_x, hydrocarbon, and PM emissions for new nonroad diesel engines (50 horsepower and greater). These standards will reduce NO_x emission by 60 percent and PM emissions by 40 percent from the Tier 1 emission levels (USEPA, 2003).

In 2004, EPA promulgated the Clean Air Nonroad Diesel Rule (Tier 4), phased in over 2008-2015, to reduce nonroad diesel engine emissions. By integrating engine modifications with fuel controls, the rule provides greater emission reductions. Beginning in 2007, engine manufacturers started producing engines with advanced emission control technologies that decrease emissions by more than 90 percent. Additionally, the rule required refiners to start producing low sulfur (15 ppm) diesel fuel by mid- 2006, a 97 percent reduction from previous levels (USEPA, 2006b). As part of the 2004 Clean Air Nonroad Diesel rule, EPA finalized new requirements for the diesel fuel rule that will decrease levels of sulfur in fuel used in marine vessels by 99 percent, beginning in 2007 (USEPA, 2007a).

In March 2007, EPA proposed a new control program that would dramatically reduce emissions from all types of marine engines (including those used on recreational and small fishing boats, yachts, tugs, and ocean going vessels). The proposal aims to cut PM emissions from these engines by 90 percent and NO_x emissions by 80 percent (USEPA, 2007a).

State

Over the next 20 years, state VMT and population increases are expected to drastically increase. A projected 71 percent population increase and a 105 percent increase in daily VMT are expected from 2000-2025 (Cambridge Systematics Inc., 2004; U.S. Census, 2000). In the Phoenix and Tucson metropolitan areas, on-road vehicle emissions account for about half of the CO and NO_x emissions, and one-third of the VOC emissions (ADEQ, 2006). In response to the current and future population and VMT increases, several programs are in place to reduce on-road vehicle emissions.

State Strategies

The Arizona Vehicle Emission Inspection Program (VEIP) began in 1977, and includes the metropolitan areas of Phoenix (Area A) and Tucson (Area B). As of January 2002, an on-board diagnostics (OBD) test was incorporated into the VEIP. This test, performed on 1996 and newer cars and light duty trucks, accesses engine operating data and identifies problems before they lead to engine damage and emissions system failure.

In the metro Phoenix area, an enhanced test is required biennially for most gasoline-powered vehicles manufactured between 1981 and 1995. During this test (known as I/M 147) the vehicle is driven on rollers at varying speeds to simulate an urban driving cycle while the exhaust is continuously measured for VOCs, CO, CO_2, and NO_x.

In addition to a stricter VEI program, the Phoenix region uses Arizona cleaner burning gas (CBG) throughout the year. CBG is formulated to reduce the amount of smog-forming emissions due to its reduced sulfur and benzene content, lower vapor pressure, and the addition of ethanol. Differences between the programs are due to the Tucson region's designation as a maintenance area for CO, while the Phoenix region's designation is maintenance for CO and nonattainment for ozone and PM_{10}.

In April 2005, a proposed revision to the VEIP was initiated when Gov. Napolitano signed House Bill 2357, exempting motorcycles and collectible vehicles from emissions testing in the Tucson area, and collectible vehicles in the Phoenix area. The final rule was published in the Federal Register in March 2007.

Tucson Region

The Tucson region continues to experience growth in population and vehicle miles of travel (VMT). From 2000 to 2030, the Pima County population is projected to increase by 48 percent while VMT is estimated to increase by approximately 152 percent (PAG, 2004, 2006b) (Table 7.1).

Since Pima County has few large industrial complexes, on-road mobile sources produce the majority of air pollution in the Tucson region. During 2001, on-road vehicles were responsible for 49 percent of total emissions, 57 percent of the CO, 50 percent of the NO_x and 36 percent of the VOC emissions (USEPA, 2005). In 2004, PAG staff completed the *2000 On-Road Mobile Emissions Inventory* to better understand air pollution, both spatially and temporally, in the TAPA.

At the request of the Environmental Planning Advisory Committee to support the planned Regional Transportation Authority's projects, PAG staff completed the gridded on-road emissions mapping project for the 2030 transportation network in 2006. Although VMT is expected to more than double from 2000 to 2030, it is estimated that total pollution from motor vehicles will decrease significantly (Table 7.1). This is largely due to stricter federal tailpipe emission standards and cleaner fuels required for new cars and trucks, as well as fleet turnover.

Table 7.1. Actual & Estimated VMT and On-Road Mobile Emissions in eastern Pima County

	Population	VMT (mi/day)	Emissions (tons/year)			
			CO	VOC	NO_x	Total
2000	848,385	17,684,396	164,021.7	16,108.6	15,842.9	195,973.2
2030	1,442,420	47,689,799	77,655.5	4,478.5	2,889.9	85,023.9

Source: 2000 VMT: PAG, 2004. Estimated VMT: PAG, 2006b. Emissions: PAG MOBILE6.2 Model, 2006.

In Figures 7.2 and 7.3 the gridded annual total pollutant emission map for 2000 and the projected emissions map for 2030 are shown using the same color scale for comparison. The 2030 emissions across the region are significantly less than those for 2000. On-road emissions of CO, VOCs and NO_x follow the same pattern, with the highest levels emitted along the freeways and major arterial streets. Many of the large, heavily congested intersections also stand out as hotspots because of the high volume of traffic and slower speeds. It is anticipated that, in the future, cleaner cars and fuel will assist the region in maintaining pollutant levels below the federal health standards. PAG continues to follow trends to ensure that regional growth and subsequent expansion of the transportation network and travel along the outskirts do not overwhelm the benefits of cleaner cars and fuel.

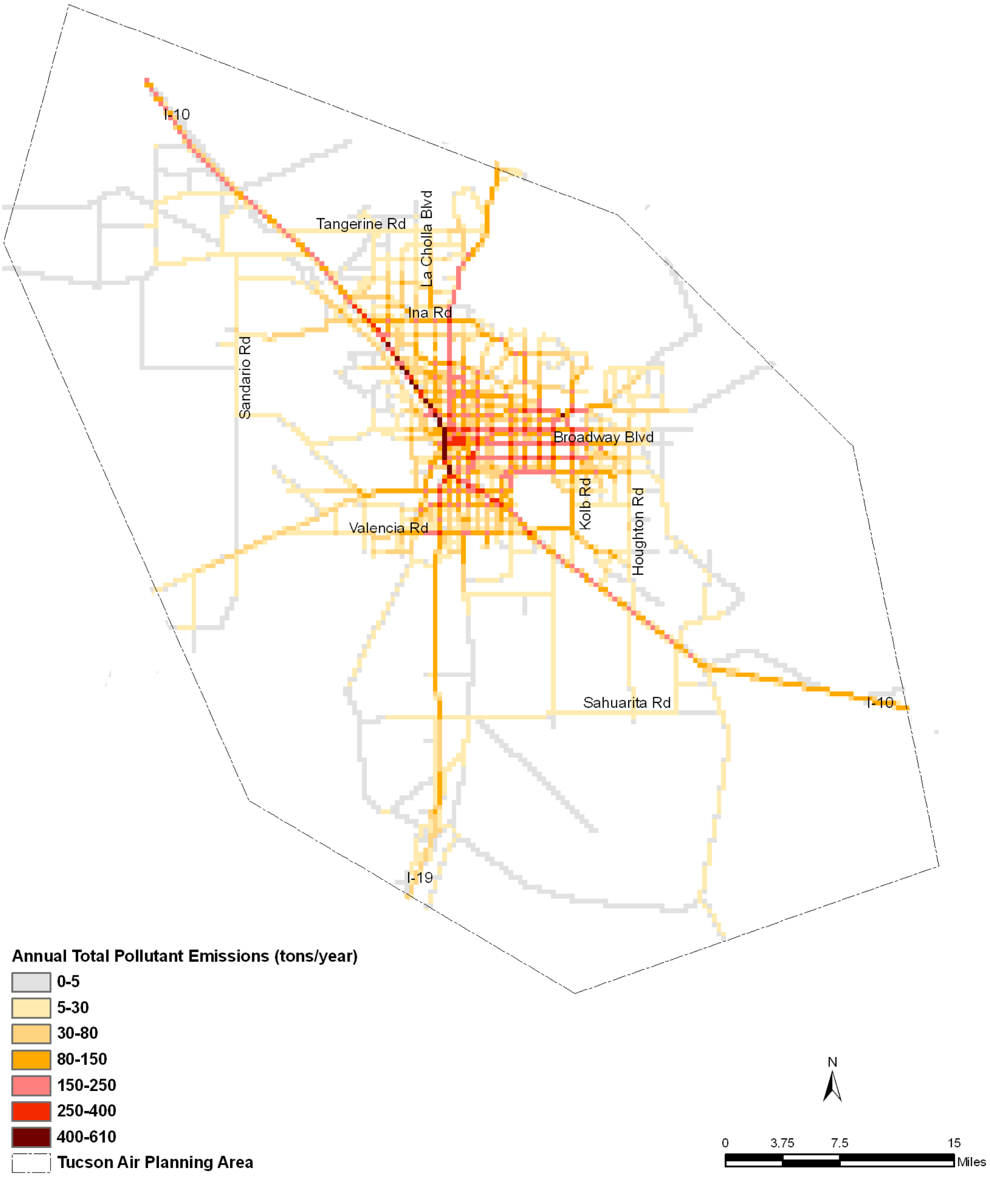


Figure 7.1. Annual Total Pollutant Emission Map for eastern Pima County, 2000 (tons/year)
Source: PAG 2000 On-Road Mobile Source Emissions Inventory, 2004

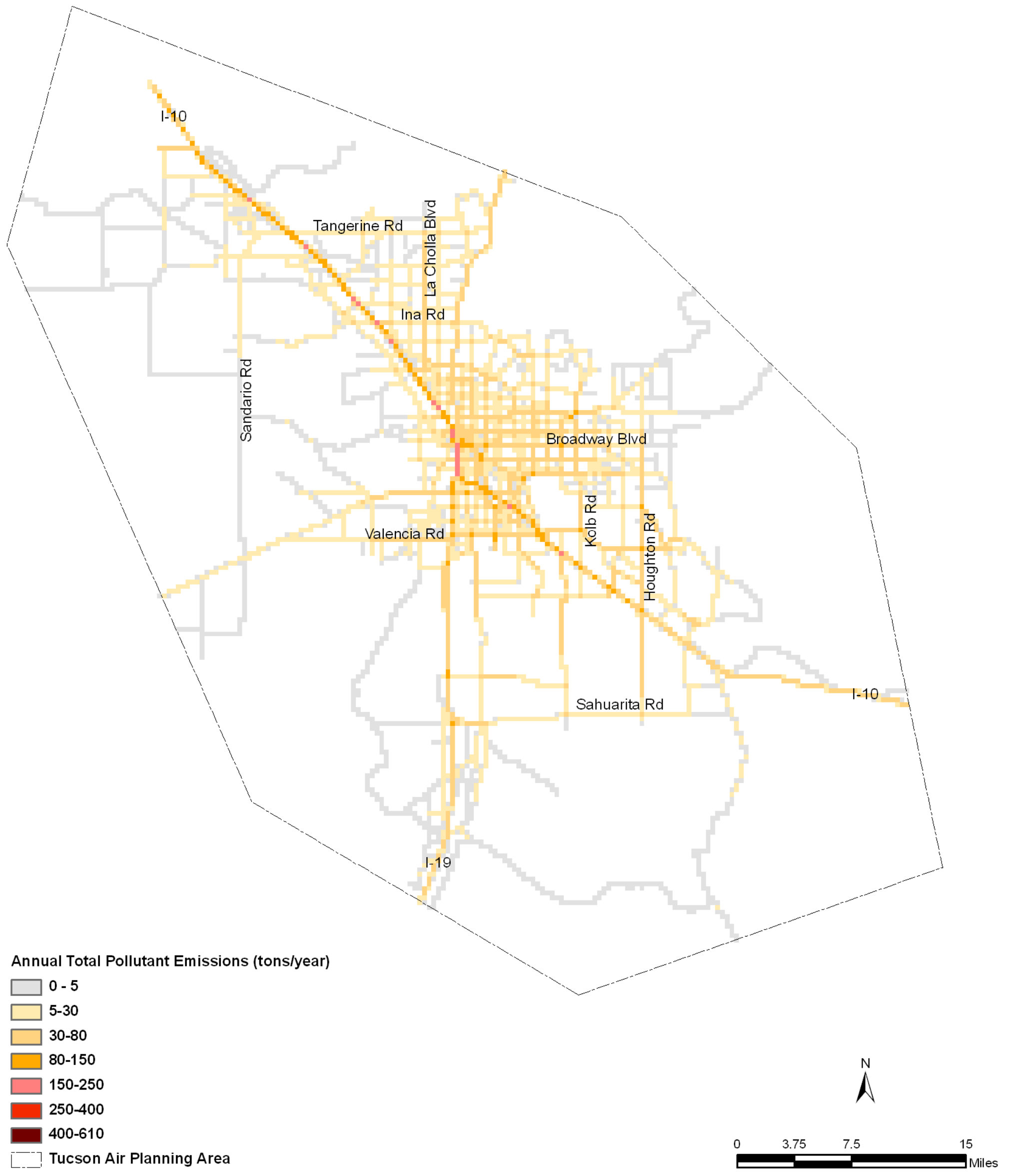


Figure 7.2. Projected Annual Total Pollutant Emission Map for eastern Pima County, 2030 (tons/year)

Source: PAG, 2006

County Strategies

Emissions Analysis - Vehicle Emissions Inspection Program (VEIP) and Oxyfuel Program

The VEIP and Oxyfuel Program are required elements of the Carbon Monoxide Limited Maintenance Plan. The state-operated VEIP began in 1977. This annual program uses the Basic Inspection Maintenance program to check whether the emissions control system on a vehicle is operating correctly. Testing is done for post-1967 vehicles. The On-Board Diagnostics test is required in the Tucson region for vehicles five years and older. The Oxyfuel Program was initiated in 1990. This program decreases CO tailpipe emissions in the winter months by adding ethanol and/or methyl tertiary butyl ether (MTBE) to all grades of motor fuel. Ethanol has been the predominant additive for the last nine years. The current oxygen content of winter motor fuels is 1.8 percent by weight. In 1996, the Arizona State Legislature approved a contingency plan for Pima County to raise the minimum oxygen content to 2.1 percent by weight in the event of a confirmed CO violation. A.R.S. 41-2125 gives PAG, with concurrence of the ADEQ director, the ability to increase the oxyfuel increment by not less than 0.3 percent by weight of oxygen and not more than the maximum allowed by EPA under specified conditions.

To evaluate these programs, PAG Air Quality Planning staff produced pollutant emission factor estimates for 2007 and 2011. The evaluation compares the emission reduction benefits with and without the VEIP and Oxyfuel Program in place. The evaluation also compares the emission reduction benefit derived from the current program (1.8 percent by weight oxygen) and a possible future scenario (in the event of a CO violation) if the oxygen content were raised by 0.3 percent to 2.1 percent by weight.

The EPA MOBILE6.2 model was used with the vehicle mix for Pima County (provided by ADOT) and an average area-wide vehicle speed of 29.5 mph with year specific traffic data. The "All Vehicle" category from the MOBILE6.2 model was used. MOBILE6.2 emissions modeling results reflect the averaging of the high and low altitude scenarios and the averaging of summer and winter values in the calculation of emission factors.

Table 7.2 illustrates the pollutant emissions benefits, in grams/mile traveled, for the combined total of CO, NOx, VOC, and PM_{10}, with and without the VEIP and the winter Oxyfuel Program, and including anti-tampering provisions (ATP). Detailed pollutant-specific emission factors can be found in Appendix A.

Table 7.2. Total Pollutant Annual Average Emission Factors (Combined CO, NO_x, VOC, and PM_{10}) (grams/mile)

Year	Case 1: No VEIP, no oxyfuel	Case 2: No VEIP, with winter 1.8% oxyfuel	Case 3: With VEIP, no oxyfuel	Case 4: With VEIP, with winter 1.8% oxyfuel*	Case 5: With VEIP, with winter 2.1% oxyfuel
2007	17.54	16.92	15.00	14.56	14.49
2011	13.44	13.08	11.11	10.84	10.80

* Case 4 describes the current programs in Tucson

The emission control measures adopted by the region are 1.8 percent by weight oxyfuel during the CO season (Oct. 1 - March 31), and an annual VEIP for vehicles five years and older. Table 7.3 reflects the combined emission savings resulting from the VEIP and Oxyfuel programs in tons/day for 2007.

Table 7.3. Modeled CO, NO_x, VOC, and PM_{10} Savings per Day due to State Vehicle Emissions Inspection and Oxyfuel Programs (tons/day)

Year	VEIP (No Oxyfuels)	VEIP and 1.8% Oxyfuel	VEIP and 2.1% Oxyfuel
2007	66.09	77.54	79.36

Source: PAG MOBILE6.2 modeling, 2007

In Pima County the emissions benefit of the VEIP in 2007 is estimated to be 66.09 tons/day total of CO, NO_x, VOC, and PM_{10} (PAG modeling, 2007). Pollutant emissions saved from the Oxyfuels Program are estimated to be 11.45 tons/day. The benefit of increasing the oxyfuel content to 2.1 percent from 1.8 percent by weight of oxygen is estimated to be 1.82 tons/day.

The benefits of the VEIP and Oxyfuel Program diminish over time due to projected fleet turnover, as older vehicles are retired from the Pima County fleet mix. One of the contributing factors is that most new cars are fitted with electronic fuel injection systems that automatically compensate for the proper air-to-fuel mixture to reduce emissions.

Other Programs

Reid Vapor Pressure

Reid Vapor Pressure (RVP) is a measurement of the stabilized pressure exerted by a volume of liquid at 100° F and therefore is considered a measure of gasoline volatility. Higher RVP and the warmer temperatures experienced in Tucson during winter can result in more gasoline vapors being generated, therefore producing uncontrolled exhaust emissions or enrichment. Lowering the RVP of gasoline can reduce the uncontrolled enrichment, thus decreasing CO exhaust emissions.

A.R.S. 41-2122 contains a contingency measure that allows for the establishment of a lower RVP (down to 9 psi) under certain circumstances, specifically if the CO NAAQS is violated. This only applies if the oxyfuels are already at their maximum level and a cost-benefit analysis of all other reasonable CO emission reduction measures that could be implemented in lieu of reducing RVP has been done. The lower RVP would then take effect beginning the winter following the CO NAAQS violation, and each winter thereafter. Following another violation of the NAAQS, the one psi waiver must be removed by ADEQ.

Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) use real-time, travel-related information to integrate all components of a traditional transportation system (roads, transit, traffic control devices, vehicles and drivers) into an interconnected network. ITS use advanced technologies in electronics, information processing, and communications to gather, process and distribute information necessary to maintain and increase the efficiency and safety of the functioning system.

The City of Tucson currently monitors and controls over 450 traffic signals from the City of Tucson Transportation Control Center. The City of Tucson, Arizona Department of Transportation, Pima County, Marana, Oro Valley, Sahuarita and the City of South Tucson are in partnership to provide a "seamless" traffic signal operation across jurisdictional boundaries. This has resulted in the interconnection of traffic signals, in and adjacent to the City of Tucson, into a centrally coordinated operation. This type of signal coordination improvement provides for improved traffic flow and is most effective in locally congested areas, where progressive flows can reduce stops and signal delay. The increase in flow rate and decrease in stops and idle time can lead to a significant reduction in vehicle emissions.

As part of a Federal Highway Administration (FHWA) case study, Tucson was analyzed for potential benefits related to planned ITS and operational improvements. FHWA modeling software was used along with data from the Tucson region travel forecast model to show the impacts of planned ITS and operational improvement through 2025. Study results showed an average reduction of 25 percent in travel time per day, and fuel use reduction of over 11 percent (nearly 60 gallons per Tucson resident) and a CO, hydrocarbon, and NO_x emission reduction of approximately 10, 12, and 16 percent, respectively (FHWA, 2005)

Clean Cities Program

The Clean Cities program is a national effort sponsored by the U.S. Department of Energy (DOE), to increase clean fuel vehicle usage, reduce the country's dependence on foreign petroleum sources, and improve air quality.

The local 71 member coalition consists of representatives from major utilities and other fuel providers, private companies, vehicle dealers, fleet owners and a variety of government agencies.

The program maintains a fuel-neutral position with respect to the promotion and use of all clean fuels. Currently, regional emphasis is placed on the use of biodiesel (B20 primarily used locally - 20 percent soybean oil, 80 percent diesel) E85 (85 percent ethanol, 15 percent gasoline), compressed natural gas (CNG), propane, hybrid electric, and truck and school bus idle reduction. The Coalition is working closely with school districts to implement clean fuel driver training programs, use of clean fuel vehicles, and an outreach program educating young drivers on alternatives to petroleum fuel.

The Coalition worked with the University of Arizona to implement an extensive E85 program in their FlexFuel Vehicles (FFVs). The University recently added a 4,000 gallon E85 tank to their facility at the motor pool site. The City of Tucson has also entered into an intergovernmental agreement with the University of Arizona to use E85 in their existing FFVs until other arrangements can be made. In December 2006, the City of Tucson modified all their diesel vehicles to run on B20.

Nationally, the number of clean fuel vehicles has grown, assisted by the Energy Policy Act of 1992; the act mandates federal and state governments to add a percentage of clean fuel vehicles to their fleets annually. Clean fuel vehicles are gaining acceptance and popularity as the public becomes more aware of their benefits. As reported by Coalition members, the number of local clean fuel vehicles continues to grow (Figure 7.3). In 2006, approximately 4.2 million gallons of gasoline were displaced with the implementation of Clean Cities strategies, which focus on the use of alternative fuels.

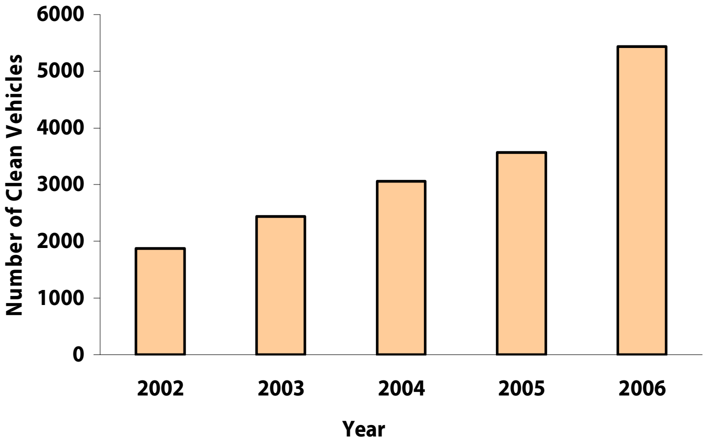


Figure 7.3. Number of Clean Fuel Vehicles in Pima County: 2002-2006

Source: PAG, 2006a; Crowninshield, 2007

A major obstacle to the proliferation of clean vehicles is the scarcity of adequate clean fueling infrastructure. Currently, the electric vehicle infrastructure is sufficient with five electric recharging stations throughout the Tucson area and one in Casa Grande. Propane refueling stations are available throughout the region. There is only one public-access CNG refueling station at the Tucson International Airport; a second CNG station is planned for the downtown area. There are 11 restricted-access (business/government) CNG stations throughout the county. Three public-access biodiesel outlets are available in the Tucson region. The state's first retail ethanol E85 station opened in December 2004, and since then, four more have opened in Tucson, one in Sierra Vista, and several are planned for Maricopa County. A map of alternative fueling sites in Pima County can be found at: http://www.pagnet.org/CleanCities/AFVSites.htm

Voluntary Vehicle Repair and Retrofit Program

The purpose of PDEQ's Voluntary Vehicle Repair and Retrofit (V2R2) Program is to reduce vehicle-related emissions by providing a financial incentive to repair older vehicles in order to pass the state emissions test. Established through state legislation in 1998, the V2R2 program began repairing vehicles in Pima County in 1999. On average, emissions are reduced by 81 percent per vehicle. At the end of 2005-06 fiscal year, over 3,360 vehicles have been repaired with a reduction of approximately 1,120 tons of emissions per year for the life of the repairs.

Gas Cap Replacement Program

PDEQ implemented the Gas Cap Replacement (GCR) Program in 2004-2005 with funding through ADEQ and a subsequent grant from the Gila River Indian Community. The program's goal is to reduce volatile organic compounds (VOCs) from mobile sources in southern Arizona. The objective of the GCR program is to provide replacement gas cap vouchers for leaky vehicle gas caps and locate vehicles with faulty gas caps that are exempt from the annual state emissions test. To date, 9,157 gas caps have been tested with 315 failures, a 3.4 percent failure rate. Based upon research from existing programs around the U.S., the potential reduction of air pollution per leaky gas cap replaced is estimated at 11.2 pounds of VOCs and four pounds of benzene per year. Based on the number of vouchers distributed through this program, it is estimated that up to 4,788 pounds of air pollution have been eliminated per year. Additionally, with the potential for as much as 30 gallons of gasoline evaporating per leaky gas cap, up to 9,450 gallons of gasoline will be saved per year through this program (PAG, 2006a) By replacing a leaking gas cap, a consumer could save approximately $76.00 per year (based on an average price of $2.52 /gallon of regular gasoline).

These values may underestimate gas cap leakage and subsequent program benefits under Arizona conditions. With our high temperatures and low humidity, we could realize greater reductions in VOC and benzene emissions per year.

PAG RideShare Program

The RideShare Program was established in 1974 and is administered by PAG. It offers a free computer-matching service for people interested in carpooling to work or college. In 2003, PAG conducted a database user's survey indicating that 29 percent of the RideShare applicants were actively carpooling. At the beginning of 2004, RideShare instituted an Internet-based application system for commuters seeking a carpool matching list. Since its inception, more than 500 commuters have registered for carpool matching through the PAG Web page.

In 2005, RideShare averaged over 2,200 carpool lists sent to commuters each month. At the close of 2006, in preparation for joining a statewide online carpool matching system, the RideShare carpool database was purged to approximately 2,000 current registrants representing over 500 employment locations.

At present, RideShare is working with Valley Metro in Phoenix and the Arizona Department of Transportation to develop a statewide interactive online carpool matching system. This system will benefit commuters traveling between counties and looking for carpool partners.

In 2002, RideShare launched the first regional guaranteed RideHome program for carpoolers. RideHome provides a safety net to the carpooler by offering four taxi rides per year for emergency purposes. In 2005, the RideHome was expanded to include Sun Tran bus riders from the more than 250 employers in the Travel Reduction Program. In 2006, over 300 vouchers were distributed for use by commuters, with four used for emergency rides.

Data from the 2003 American Community Survey, released in March 2005, indicate that carpool use in Tucson is significantly higher than the national average (Tucson, 12.2 percent and United States, 10.4 percent).

PAG Travel Reduction Program

The Travel Reduction Program (TRP) was created in 1988 when Pima County, Tucson, South Tucson, Marana and Oro Valley each passed Travel Reduction Ordinances (TROs). The town of Sahuarita passed its ordinance and joined the program in 1996. The ordinances are reviewed every three years, with the next review in 2008. The goals of the ordinances are to reduce traffic congestion and improve air quality. The TRP is implemented through PAG, working with major employers, those with 100 or more full-time equivalent employees at a single or contiguous site; an employer with less than 100 employees can voluntarily participate in the TRP.

Employers in the TRP encourage their employees to reduce the vehicle miles traveled through the use of alternate travel modes (carpooling, vanpooling, use of public transportation, bicycling, walking), compressed workweeks or teleworking. Employees participating in the TRP represent 29 percent of the total regional workforce in Pima County. Table 7.4 shows a comparison of the regional results from 1989 (base year) with the results of 2001 through 2005.

Table 7.4. Annual TRP Survey Results

Year	Average AMU (%)	Average VMT	Number of Job Sites	Total Employees	Average Survey Response Rate (%)
1989*	17.6	47.3	148	77,230	68.5
2001	31.0	56.2	269	111,086	87.7
2002	29.2	58.6	269	112,518	84.9
2003	28.6	58.1	271	108,705	86.0
2004	29.2	57.1	279	112,588	86.6
2005	30.4	57.4	283	113,242	86.4

* 1989 is the base year for the TRP

Source: PAG, 2006a

The TRP is evaluated annually based on two factors: reduction in the average weekly one-way motor vehicle miles traveled (VMT) and employee alternate mode usage (AMU). While the average VMT has increased over the past 16 years, a greater percentage of workers are using alternate modes of transportation (Table 7.4).

Data indicate that TRP respondents have been residing farther from their work site since 1989; however, the average weekly commute (one-way miles) has essentially held steady at approximately 57 miles from 2003-2005 (Figure 7.4).

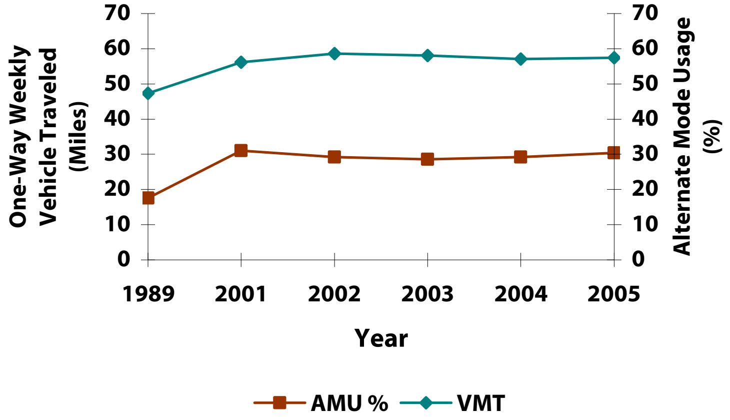


Figure 7.4. Annual Percentage of Alternate Mode Usage and One-Way Weekly Vehicle Miles Traveled: 1989-2005

Increasing alternate mode usage is directly associated with decreased gasoline use. Mileage and gasoline use also are reduced due to compressed workweeks, trips avoided by field workers, and less driving days due to teleworking. In calculating 2005 savings, an average fuel efficiency value of 20 miles per gallon and a driving cost of $0.405 per mile were used (U.S. Internal Revenue Service standard mileage rate for 2005). Therefore, each mile "not driven" saved $0.405. Pollution savings are calculated based on an average emission rate of one pound of pollution for every 23 miles driven (PAG Air Quality MOBILE6.2 model). The 2005 TRP savings based on the vehicle miles saved from alternate mode usage are shown in Table 7.5.

Table 7.5. 2005 TRP Savings from Alternate Mode Usage

Vehicle Miles Not Traveled	89.6 million miles
Gasoline Not Consumed	4.5 million gallons
Driving Costs Saved	36.3 million dollars
Pollution Prevented	3.9 million pounds

Source: PAG, 2006a

The TRP continues to be supported by the six jurisdictions, the Pascua Yaqui Tribe and Tohono O'odham Nation. PAG continued to support the USEPA and USDOT Best Workplaces for Commuters program. Forty employers in 2006 were awarded the designation of a Best Workplaces for Commuters based on meeting the program's national standard of excellence to provide commuting benefits to their employees.

Vanpool Incentive Program

The TRP staff continues to promote and implement the Vanpool Incentive Program (VIP) developed in 2002 with a "Contributor Agreement" with Enterprise Rent-A-Car Inc. The program administers a $400 monthly subsidy, provided by PAG, per van to qualified TRP employees. The VIP has 17 vans on the road with growing interest among other TRP employees regarding vanpools. The current participants are: Raytheon Missile Systems (two vans), Federal Correctional Institution (five vans), Indian Health Services – Sells (eight vans), Town of Marana (one van), and Ventana Medical Systems (one van). Annual savings from these vans are: 938,040 miles, 46,452 gallons of gasoline, 413,423 dollars, 40,393 pounds of pollution, 153 less parking spaces, and 34,578 dollars saved in parking costs.

PDEQ Clean Air Program

The goals of the PDEQ's national award-winning program are to increase awareness of air quality issues and encourage actions to reduce air pollution. PDEQ's Clean Air Program (referred to as the Voluntary No-Drive Day Program in the SIP) is a state-mandated program that began in 1988 to address CO violations in Pima County. This Program employs several methods to achieve its goals including: Community Outreach, School and Youth Programs, and Annual Public Events.

During the 2005/2006 fiscal year:

- approximately 3,336 individuals attended Clean Air Program presentations,
- 106,700 participated in community events,
- 14 educators received air quality curricula or training,
- 78,950 mailings delivered program materials,
- 311,350 requests for information were made to the PDEQ Web site,
- 618,000 requests for information were made to the Air Info Now Web site,
- 1,450 calls were processed for the Smoking Vehicle Hotline,
- 148,500 educational brochures or items were distributed to the public.

Mass Transit

Sun Tran provides fixed-route transit service within the City of Tucson, and into Pima County, South Tucson, Marana, Oro Valley, and the Pascua Yaqui Tribe. The system's 37 fixed routes cover a 226-square-mile area.

Ridership on Sun Tran has grown for a fourth consecutive year. The system experienced an 8.4 percent increase in ridership during FY 2005-2006 compared to the previous fiscal year. Sun Tran set an annual ridership record, carrying more than 17.1 million riders in FY 05-06.

Currently, approximately 90 percent of Sun Tran's fleet is powered by clean-burning fuel technologies (CNG, B20, and dual-fueled (CNG/diesel)). In 2005, Sun Tran added 38 new replacement buses to its fleet that are fueled with B20. Like compressed natural gas, B20 emits significantly fewer particulates than traditional diesel-fueled vehicles. Another 136 buses are either dedicated CNG or dual-fueled buses. Sun Tran expects to take delivery of 12 additional biodiesel replacement buses in 2007.

For added convenience to transit users, Sun Tran serves 20 free park and ride lots across the region. Each bus is equipped with bike racks and folding bicycles are accommodated on board. Rental bike lockers are available at a nominal charge at five of the park and ride lots and other select bus stop locations.

Through Sun Tran's commuter pass program, *Get on Board*, most governmental employers in Tucson offer reduced-cost bus passes as an employee benefit. A partnership with PAG enables Sun Tran to offer *Guaranteed RideHome*, which provides a free taxi ride home in an emergency. In addition to Travel Reduction Program companies, *Get on Board* members are qualified to join the program and are eligible for up to four free taxi vouchers a year.

Bicycling

The City of Tucson has had designated bicycle facilities since 1971 and Pima County has developed bikeways since the mid-1970s. The first comprehensive plan for bicycling was developed by PAG in 1974, and is updated every five years. The consistent addition of bikeways, including bike routes, bike lanes, roadway shoulders, and shared-use paths (classed as pedestrian facilities) has helped in maintaining constant bike usage.

In 1993, the City of Tucson first received designation as a Bicycle Friendly City by the League of American Bicyclists. In 2004, the League categorized Tucson as a Silver-level Bicycle Friendly Community, making it one of only four communities in the nation, and one of 12 communities to be ranked as a Bicycle Friendly City. In 2004, an effort was organized to achieve a regional Platinum Bicycle Friendly Community rating in 2006. This effort resulted in the PAG region receiving the League's first regional award, and a designation at the "Gold" level.

Bikeways in the metropolitan area are currently estimated at more than 650 miles. The adopted 2000 PAG Regional Plan for Bicycling calls for 800 miles of bikeways by 2010 and 1,200 miles of bikeways by 2020. In addition, it is local government policy to include bike lanes on all new street construction and reconstruction projects.

The 2000 PAG Tucson Household Travel Survey indicated, approximately 2 percent of the region’s residents used bicycle travel for their home-to-work commute, and it is estimated that slightly more than 3 percent of all travel is by bicycle (PAG, 2005).

Walking

Pedestrian travel has become an increasingly important issue in the Tucson region. Approximately 5 percent of all regional trips are by walking. Investment in pedestrian facilities is now a major component of the transportation planning process in every jurisdiction for a variety of health, safety and mobility benefits.

In 2000, PAG completed the first Regional Pedestrian Plan, which is used to develop and improve pedestrian facilities throughout the Tucson region. The plan has a special focus on improving pedestrian safety, accessibility and connectivity along the existing roadway network and river park system.

It includes specific recommendations on the following issues:

- Design standards for sidewalks, ramps, crosswalks and traffic signals
- Compliance with the Americans Disability Act (ADA) accessibility guidelines
- Inclusion of pedestrian facilities in local land use development policy
- Pedestrian safety education and enforcement
- Sidewalk inventory and mapping
- Promotional activities for pedestrian travel, and
- Inclusion of pedestrian planning in all transportation planning processes.

In late 2003, PAG completed an inventory and map of existing sidewalks along all collectors and arterials within the Tucson region. The map identifies missing sidewalk gaps and wheelchair ramps that need to be constructed in compliance with federal ADA requirements. During the second phase of this project, a sidewalk project ranking system was developed by PAG with the guidance of local pedestrian planners, advocates and representatives from the disabled community.

The sidewalk inventory and ranking system was the basis for the development of a pedestrian element within the 20-year Regional Transportation Authority (RTA) plan, approved by voters in May 2006. The plan includes over $60 million for new sidewalks, paths, wheelchair ramps, signalized pedestrian crossings, and funding for the Safe Routes to Schools Program. This investment will greatly enhance pedestrian travel in the region.

8. CONCLUSIONS

Favorable air quality is essential to the economic viability of metropolitan Tucson, the physical health of its residents and the preservation of its desert ecosystem. We are fortunate that Tucson area residents generally breathe healthy air.

Carbon monoxide results from the incomplete combustion of fossils fuels. Nationally, carbon monoxide emissions and concentrations have decreased dramatically from 1970-2005. These reductions can be attributed to tougher federal restrictions on vehicle emissions, including stricter tailpipe emission standards, increased use of new technology, and to a lesser degree, stricter regulation of industrial facilities. Locally, more than 95 percent of carbon monoxide emissions are attributed to mobile sources, with almost 60 percent from on-road motor vehicle exhaust. The region last violated the EPA health standard in 1984.

Dust from paved and unpaved roads, wood smoke, earth moving, mining, and agricultural activities are all sources of particulate matter. Overall, particulate emissions and concentrations have been declining since the 1970s at the national, state and county levels. Contributing to this decline are control measures aimed at vehicle emissions, industrial regulations, and dust abatement practices. Locally, particulate matter concentrations tend to be below the EPA health standards. While vehicle tailpipe emissions of coarse particulates are minimal, fugitive dust from vacant lands, paved and unpaved roads contribute to elevated levels in the region, particularly in conjunction with dry and windy conditions.

Ground level ozone forms when its precursors, volatile organic compounds and oxides of nitrogen, react in sunlight. Ozone precursors are generated by motorized vehicles, power plants, and industrial facilities. Over the past 35 years, national ozone precursor emissions and concentrations have declined. While state precursor emissions have decreased, ozone concentrations in the Phoenix area have routinely exceeded the national health standard. In Pima County, on-road motor vehicles contribute over one third of the ozone precursor emissions. These precursor emissions have declined somewhat over the last decade, but ozone concentrations remain around 90 percent of the EPA health standard. The region has not experienced any violations of the ozone health standard.

Pollutants contributing to regional haze impair visibility in both urban and natural areas. However, stricter vehicle and fuel regulations and increased management of coal-fired power plants and closure of smelters have reduced sulfate and nitrogen oxide emissions that contribute to visibility impairment. Citizens in the western U.S. are generally able to enjoy a high degree of visibility. In the urban areas of Phoenix and Tucson, visibility on the worst days has increased over the last decade, with the Tucson area showing greater improvement during this period. On occasion, thermal inversions or high winds together with air pollutant emissions can lead to periods of impaired visibility.

The major source of anthropogenic U.S. greenhouse gas (GHG) emissions is the burning of fossil fuels. The Global Climate Change Initiative of 2002 sets national goals for reducing

GHG emissions through a variety of voluntary programs that encourage the use of alternate energy sources, establish cooperative agreements with industry, and promote smart growth. In Arizona, based on the results of a recent state inventory, GHG emissions have increased 56 percent from 1990 to 2005. Arizona's Gov. Napolitano has taken a leadership role by establishing a Climate Change Executive Committee, in cooperation with state industry representatives, to work on implementing recommendations to reduce state GHG emissions to mandated target levels. Arizona also has partnered with several western states to develop regional GHG reduction targets. Locally, utility companies, builders, and local officials are initiating policies and programs that promote more efficient energy use, increase use of alternative modes of transportation and alternate fuels, and reduce urban sprawl.

Mobile sources are responsible for the majority of air pollution in the Tucson region. Federal programs have successfully reduced mobile source emissions primarily by targeting vehicle manufacturers and fuel suppliers. State and county programs such as the vehicle inspection programs, use of oxygenated fuels, reformulated gas (Phoenix) and travel reduction have also reduced state and local mobile source emissions. In the Tucson region, the emissions reduction from the vehicle emissions inspection program and use of oxygenated fuels in winter was modeled and resulted in a pollution savings of 76 tons/day for 2007.

Currently, the Tucson area meets all federal health standards. Should EPA adopt more stringent standards, particularly for ozone, the region could exceed regulatory limits and require implementation of local measures to improve air quality. These could include cleaner burning fuels or a more stringent vehicle inspection program. However, with the increasing availability of cleaner fuels and vehicles along with stricter regulation of vehicle tailpipe emissions, it is expected that air quality will continue to improve nationally and in the Tucson region.

9. LIST OF ACRONYMS

A.R.S. - Arizona Revised Statutes

ADA - American Disability Act

ADEQ - Arizona Department of Environmental Quality

ADOT - Arizona Department of Transportation

AFV - Alternative Fuel Vehicles

ADT - Average Daily Traffic

AMU - Alternate Mode Usage

ATP - Anti-Tampering Provisions

B20 - Biodiesel containing 20 percent vegetable oil and 80 percent diesel

BART - Best Available Retrofit Technology

CAA - Clean Air Act

CBG - Cleaner Burning Gas

CCAG - Climate Change Advisory Group

CFR - Code of Federal Regulations

CNG - Compressed Natural Gas

CO - Carbon Monoxide

CO_2 - Carbon Dioxide

DOE - U.S. Department of Energy

E85 – Fuel Blend of 85 percent Ethanol and 15 percent Gasoline

EI - Emissions Inventory

EPA - U.S. Environmental Protection Agency

GPM - Grams per Mile

GHG - Greenhouse Gases

GWP - Global Warming Potential

HB - House Bill

HCP - Habitat Conservation Plan

IPCC - Intergovernmental Panel on Climate Change

ITS - Intelligent Transportation System

LMP - Limited Maintenance Plan

MAG - Maricopa Association of Governments
MPH - Miles per Hour
MTBE - Methyl Tertiary Butyl Ether
NAAQS - National Ambient Air Quality Standards
NEAP - Natural Events Action Plan
NO_x - Oxides of Nitrogen
NO_2 - Nitrogen Dioxide
N_2O - Nitrous Oxide
O_3 - Ozone
OBD - On-Board Diagnostics
PAG - Pima Association of Governments
PDEQ - Pima County Department of Environmental Quality
PM - Particulate Matter
PPM - Parts per Million
RHR - Regional Haze Rule
RTA - Regional Transportation Authority
RTP - Regional Transportation Plan
RVP - Reid Vapor Pressure
SIP - State Implementation Plan
SO_2 - Sulfur Dioxide
SO_x - Sulfur Oxides
TAPA - Tucson Air Planning Area
TCM -Transportation Control Measure
TIP -Transportation Improvement Program
TRO - Travel Reduction Ordinance
TRP - Travel Reduction Program
V2R2 - Voluntary Vehicle Repair and Retrofit
VEIP - Vehicle Emissions Inspection Program
VIP - Vanpool Incentive Program
VMT - Vehicle Miles Traveled
VOC - Volatile Organic Compounds
WRAP - Western Regional Air Partnership

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APPENDIX A: Emission Analysis

CASE 1: No VEIP, No Winter Oxyfuel

Emission Factors (g/mi) 2007

	Winter	Summer	Average
VOC	1.63	1.53	1.58
CO	16.03	12.15	14.09
NO_x	1.89	1.74	1.82
PM_{10}	0.05	0.05	0.05
Total	**19.60**	**15.47**	**17.54**

Emission Factors (g/mi) 2011

	Winter	Summer	Average
VOC	1.23	1.16	1.20
CO	12.85	9.12	10.99
NO_x	1.32	1.12	1.22
PM_{10}	0.04	0.04	0.04
Total	**15.44**	**11.44**	**13.44**

CASE 2: No VEIP, 1.8% Winter Oxyfuel

Emission Factors (g/mi) 2007

	Winter	Summer	Average
VOC	1.58	1.53	1.56
CO	14.85	12.15	13.50
NO_x	1.89	1.74	1.82
PM_{10}	0.05	0.05	0.05
Total	**18.37**	**15.47**	**16.92**

Emission Factors (g/mi) 2011

	Winter	Summer	Average
VOC	1.19	1.16	1.18
CO	12.09	9.12	10.61
NO_x	1.32	1.20	1.26
PM_{10}	0.04	0.04	0.04
Total	**14.64**	**11.5165**	**13.08**

CASE 3: With VEIP, No Winter Oxyfuel

Emission Factors (g/mi) 2007

	Winter	Summer	Average
VOC	1.46	1.38	1.42
CO	13.40	10.21	11.81
NO_x	1.80	1.66	1.73
PM_{10}	0.05	0.05	0.05
Total	**16.71**	**13.3**	**15.00**

Emission Factors (g/mi) 2011

	Winter	Summer	Average
VOC	1.08	1.03	1.06
CO	10.39	7.33	8.86
NO_x	1.21	1.09	1.15
PM_{10}	0.04	0.04	0.04
Total	**12.72**	**9.49**	**11.11**

CASE 4: With VEIP, 1.8 % Winter Oxyfuel

Emission Factors (g/mi) 2007

	Winter	Summer	Average
VOC	1.42	1.38	1.40
CO	12.55	10.21	11.38
NO_x	1.80	1.66	1.73
PM_{10}	0.05	0.05	0.05
Total	**15.82**	**13.3**	**14.56**

With VEIP, 1.8 % Winter Oxyfuel

Emission Factors (g/mi) 2011

	Winter	Summer	Average
VOC	1.05	1.03	1.04
CO	9.91	7.30	8.61
NO_x	1.21	1.09	1.15
PM_{10}	0.04	0.04	0.04
Total	**12.21**	**9.46**	**10.84**

CASE 5: With VEIP, 2.1 % Winter Oxyfuel

Emission Factors (g/mi) 2007

	Winter	Summer	Average
VOC	1.41	1.38	1.40
CO	12.41	10.21	11.31
NO_x	1.8	1.66	1.73
PM_{10}	0.05	0.05	0.05
Total	**15.67**	**13.3**	**14.49**

With VEIP, 2.1 % Winter Oxyfuel

Emission Factors (g/mi) 2011

	Winter	Summer	Average
VOC	1.05	1.03	1.04
CO	9.83	7.30	8.57
NO_x	1.21	1.09	1.15
PM_{10}	0.04	0.04	0.04
Total	**12.13**	**9.47**	**10.80**

APPENDIX B: CAL3QHC Modeling Details

Model Settings for MOBILE6.2 Runs:

- Free flow link speeds were set at 35 miles per hour (mph) for each link.

- Emission factors were derived using the MOBILE6.2 model, averaging high and low altitude scenarios for 2006, with the current Tucson region Vehicle Emissions Inspection Program (VEIP), Reid Vapor Pressure (RVP) of 10.12 pounds per square inch (psi) (actual 2005-2006 winter average), and oxyfuels at 1.8 percent by weight (100 percent ethanol blend).

- The idle emission factor was obtained by multiplying the 2.5 mph emission factor by 2.5 (standard methodology).

- The mixing height was set at 1,000 meters, with a stability class of 4 (D).

- Wind speed was set at 1 meter per second. Concentrations were calculated for multiple wind directions at 10° intervals for 360°. This allowed for the calculation of the highest CO concentration at the receptor using all wind directions (at 10° intervals).

- The receptor height was set at 1.8 meters. The background concentration used was 0.50 ppm. This concentration reflects the average 1-hour concentration at the 22nd Street/Craycroft monitor for the months of November through January of the last two CO seasons (2004-2005 and 2005-2006).

- The persistence factor to convert the 1-hour CO concentration derived from the model to reflect an 8-hour average was calculated to be 0.56. This was obtained from the 10 highest non-overlapping 8-hour averages at the 22nd Street/Alvernon monitor, using the ratio of the 8-hour average to the maximum 1-hour average concentration for that 8-hour period. Concentrations were calculated for the 2006 modeling scenario.

- The background concentration calculated for this modeling effort is lower than last year's, and the persistence factor is slightly higher than the 2005 value.