

**Air Quality in Anchorage**  
**A Summary of Air Monitoring Data and Trends**  
**1980 – 2008**



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## **Preface**

This report was prepared by the Air Quality Program of the Municipal Department of Health and Human Services. It was originally released in 1994 and periodic updates have been issued since then. Comments and suggestions on this report are encouraged. The Air Quality Program can be contacted at (907) 343-4200 or [morrisss@muni.org](mailto:morrisss@muni.org).

This report is available in the Alaska Collection of the Loussac Library in Anchorage and on the Internet at <http://www.muni.org/iceimages/healthesd/2009%20report%20final.pdf>

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# Air Quality in Anchorage

## A Summary of Air Monitoring Data and Trends

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## Section 1 - Introduction

### Purpose of this Report

The purpose of this report is to summarize air quality monitoring data collected in Anchorage since 1980. It focuses on the six pollutants for which the Environmental Protection Agency (EPA) has established a National Ambient Air Quality Standard (NAAQS). They are carbon monoxide, airborne particulate, airborne lead, sulfur dioxide, ozone and nitrogen dioxide.\* These pollutants are known as criteria pollutants because a health-based air quality standard has been established for them. National standards for other air pollutants have not been established. This report summarizes criteria pollutant monitoring data in Anchorage and describes the trends observed in the data. In addition to the criteria pollutants, the report also discusses volatile organic compound monitoring data collected from monitoring studies completed in 1994, 1996 and 2002.

This summary report was originally released in April 1994 and has been updated periodically since then. This updated report includes air quality data collected through December 2008.

### National Ambient Air Quality Standards

The Clean Air Act, last amended in 1990, requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards has set a NAAQS for each of six principal pollutants, which are called criteria pollutants. They are listed below. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air ( $\text{mg}/\text{m}^3$ ), and micrograms per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ).

At five year intervals, EPA is required to review relevant information and revise standards as necessary.

Anchorage has monitored for benzene and other volatile organic compounds that are known for their harmful health effects. There are no ambient standards for these pollutants. These data are summarized in Section 8 of this report.

EPA ambient air quality standards for the six criteria pollutants are shown in Table 1-1. This table was adapted from <http://epa.gov/air/criteria.html>.

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\* Particulate matter is separated into two size ranges each with a separate NAAQS. Larger sized particles, less than 10 microns in diameter are called  $\text{PM}_{10}$  and smaller sized particles less than 2.5 microns in diameter are called  $\text{PM}_{2.5}$ .

Table 1-1 National Ambient Air Quality Standards				
Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm	8-hour <sup>(1)</sup>	None	
	35 ppm	1-hour <sup>(1)</sup>		
Lead	0.15 µg/m <sup>3</sup> <sup>(2)</sup>	Rolling 3-Month Average	Same as Primary	
	1.5 µg/m <sup>3</sup>	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM <sub>10</sub> )	150 µg/m <sup>3</sup>	24-hour <sup>(3)</sup>	Same as Primary	
Particulate Matter (PM <sub>2.5</sub> )	15.0 µg/m <sup>3</sup>	Annual <sup>(4)</sup> (Arithmetic Mean)	Same as Primary	
	35 µg/m <sup>3</sup>	24-hour <sup>(5)</sup>	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour <sup>(6)</sup>	Same as Primary	
	0.08 ppm (1997 std)	8-hour <sup>(7)</sup>	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm	3-hour <sup>(1)</sup>
	0.14 ppm	24-hour <sup>(1)</sup>		

<sup>(1)</sup> Not to be exceeded more than once per year.

<sup>(2)</sup> Final rule signed October 15, 2008.

<sup>(3)</sup> Not to be exceeded more than once per year on average over 3 years.

<sup>(4)</sup> To attain this standard, the 3-year average of the weighted annual mean PM<sub>2.5</sub> concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m<sup>3</sup>.

<sup>(5)</sup> To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m<sup>3</sup> (effective December 17, 2006).

<sup>(6)</sup> 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 0.075 ppm. (effective May 27, 2008)

<sup>(7)</sup> (a) 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.

(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.

## Summary of Anchorage Air Quality Attainment Status and Trends

### Carbon Monoxide

In June 2004, the EPA reclassified Anchorage from a serious carbon monoxide (CO) nonattainment area to a maintenance area. As a maintenance area, Anchorage is now considered in compliance with the CO NAAQS. Anchorage has not violated the CO standard since 1996 and CO concentrations have dropped by approximately 60% from peak levels experienced in the early and mid-1980's. Moreover, the Municipal Department of Health and Human Services (DHHS) prepared a CO maintenance plan that demonstrates that Anchorage should remain in compliance through at least 2023. In February 2004, on behalf of DHHS, the Alaska Department of Environmental Conservation submitted this plan to EPA as part of a request for reclassification from a nonattainment to maintenance area. EPA approved the plan and shortly thereafter reclassified Anchorage as a maintenance area. Anchorage had been classified as nonattainment for more than 25 years.

### PM<sub>10</sub>

Eagle River, a community of about 30,000 located approximately 10 miles north of downtown Anchorage, is currently designated as a nonattainment area for airborne particulate, or PM<sub>10</sub>. This designation is the result of air quality violations recorded between 1985 and 1987. A PM<sub>10</sub> control plan was developed to address the PM<sub>10</sub> problem in Eagle River. Because most of the PM<sub>10</sub> in Eagle River was emitted from unpaved roads, this plan focused on paving or surfacing gravel roads in the area. This strategy has been successful. No violations have been measured since October 1987. A maintenance plan has yet to be prepared for Eagle River, however. Until this is completed, Eagle River will remain classified as nonattainment for PM<sub>10</sub>.

The Anchorage bowl is currently considered an attainment area for PM<sub>10</sub>. However, Anchorage has experienced exceedances of the NAAQS related to natural events such as volcanic eruptions and wind storms. Experience has shown that the effects of a volcanic eruption can linger for years following the event. Following the eruption of the Mt. Spurr volcano in August 1992, the NAAQS for PM<sub>10</sub> was exceeded 18 times between 1993 and 1995. Intense wind storms in March 2001 and March 2003 created blowing dust conditions that contributed to a number of exceedances of the NAAQS. Because these exceedances were the largely the result of natural events, EPA has not considered them when evaluating Anchorage attainment status with respect to PM<sub>10</sub>.

Although natural events have contributed to some exceedances, most PM<sub>10</sub> in Anchorage is believed to have manmade origins. PM<sub>10</sub> can be generated from vehicle traffic on unswept roads loaded with winter traction sand or from unpaved roads and parking lots. Anchorage sometimes nearly exceeds the NAAQS during spring break-up especially near heavily traveled roads where traffic stirs up a winter's worth of accumulated road sand.

The Municipality of Anchorage and State of Alaska have modified road maintenance practices in an effort to reduce PM<sub>10</sub> emissions from roadways. In 1996 they began using a coarser, cleaner traction sand to reduce the amount of fines (silt particles less than 75 microns in diameter) being applied to the roadway network. In recent years the Municipality of Anchorage has used magnesium chloride brine, a chemical dust suppressant to reduce PM<sub>10</sub> emissions during the spring break-up when PM<sub>10</sub> concentrations tend to be highest.

### PM<sub>2.5</sub>

Monitoring data collected between 1999 and 2008 indicate that Anchorage is in compliance with the NAAQS for PM<sub>2.5</sub>. Concentrations measured have been well under the NAAQS. No clear upward or downward trend is evident.

### **Lead, Sulfur Dioxide, Ozone, and Nitrogen Dioxide**

Airborne lead concentrations in Anchorage dropped dramatically in the 1980's as lead was phased out of the gasoline supply. By 1987, Anchorage was well below the NAAQS for lead. EPA established a much more stringent the air quality standard in 2008, however. Because monitoring for lead has not been performed in recent years, is not known whether Anchorage meets this new standard.

Although monitoring data for sulfur dioxide (SO<sub>2</sub>), ground level ozone (O<sub>3</sub>) and nitrogen dioxide (NO<sub>2</sub>) are limited, the data suggest that Anchorage is likely well under the NAAQS for these three criteria pollutants.

### **Volatile Organic Compounds/Benzene**

No ambient air quality standard has been set for these pollutants. Anchorage data suggest that some volatile organic compounds (e.g. benzene) are highly correlated with ambient CO measurements. The decline observed in ambient CO concentrations suggests that ambient levels of benzene and some volatile organic compounds have also declined.

Anchorage's air quality status with regard to criteria pollutants is summarized in Table 1-2.

<b>Pollutant</b>	<b>Current Status</b>
CO	In June 2004 the EPA reclassified Anchorage as a maintenance area after being classified as nonattainment or serious nonattainment for over 25 years. Anchorage has not violated the CO NAAQS since 1996.
PM <sub>10</sub>	Eagle River is currently considered nonattainment but may be redesignated as a maintenance area. The Anchorage bowl has exceeded the NAAQS during windstorms and after ash fall from volcanic eruptions but these exceedances are considered "natural events" and Anchorage remains classified as an attainment area.
PM <sub>2.5</sub>	Attainment
Lead	Status with regard to the new air quality standard for lead has not been determined.
SO <sub>2</sub>	Attainment
O <sub>3</sub>	Attainment
NO <sub>2</sub>	Attainment

## Section 2 - Carbon Monoxide

### Health Effects of Carbon Monoxide

Carbon monoxide is a colorless, odorless and poisonous gas produced by incomplete burning of carbon in fuel. The health threat from CO is most serious for those who suffer from cardiovascular disease. A number of studies have suggested that exposure to elevated levels of CO in the ambient air can lead to earlier onset of exercise-induced angina (chest pain) among patients with ischemic heart disease. Other possible risk groups include fetuses, young infants and the elderly and those with pre-existing diseases that decrease the availability of oxygen to critical tissues. The NAAQS for CO is set at 35 ppm (parts per million by volume) for a one-hour average and 9 ppm for an eight-hour average, not to be exceeded more than once per year. This health-based standard is intended to protect those most sensitive to the effects of CO exposure. The eight-hour standard is the more restrictive limit.

Extremely high concentrations (above 1,200 ppm) of CO can develop in indoor environments as the result of faulty home heating systems or because of exhaust leaks in motor vehicles and are considered immediately dangerous to life and health.<sup>†</sup> At these concentrations, exposure to CO can cause unconsciousness and even death unless the victim is removed from the source and provided with immediate medical care. These high exposures occur only in indoor or enclosed spaces, however. Outdoor exposures above 20 ppm are rare in Anchorage, and health effects at these concentrations are subtle even among the susceptible population.

### Sources of CO in Anchorage

According to the latest inventory compiled for the Anchorage bowl area for the year 2007, an estimated 66.5% of winter season CO emissions in Anchorage were from motor vehicles. Motor vehicle emissions occur during the start up or warm-up idling and later during the on-road travel portion of a trip. Local research suggests that cold starts and warm-up idling are very important components of vehicle emissions. In the winter, many Anchorage drivers engage in extended warm-ups, particularly prior to a morning commute. A study conducted in Anchorage during the winter of 1998-99 indicated that the average warm-up period for morning commuters was 12 minutes. Area-wide, warm-up idling accounts for 16% of total CO emissions and more than a fifth of all vehicle emissions. In some neighborhood residential areas, warm-up idling accounts for almost half the CO emitted by all sources in the area. Cold winter temperatures significantly increase these cold start emissions. Other significant sources of CO in Anchorage include airport operations and residential wood burning. Estimated CO emissions for a typical winter weekday are summarized by source for the year 2007 in Table 2-1.<sup>‡</sup>

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<sup>†</sup> National Institute for Occupational Safety and Health (NIOSH) has established the IDHL (immediately dangerous to life and health) for carbon monoxide = 1,200 ppm.

<sup>‡</sup> A comprehensive CO inventory was prepared as part of a draft revised Anchorage CO Maintenance Plan prepared in 2008. Vehicle emissions were estimated using the EPA MOBILE6 emission factor model in conjunction with vehicle travel estimates from the Anchorage Transportation Model. Vehicle start estimates from the transportation model were used along with data from local emission testing to estimate emissions during vehicle starts. The FAA EDMS model was used to estimate emissions from Ted Stevens Anchorage International Airport and the EPA NONROAD model was used to estimate emissions from most other source categories.

<b>Table 2-1</b> <b>Sources of CO Emissions in 2007</b> <b>Typical Winter Weekday</b>		
<b>Source Category</b>	<b>CO Emitted (tons per day)</b>	<b>% of total</b>
Motor vehicle – on-road travel	50.9	50.5%
Motor vehicle – warm-up idle	16.1	16.0%
Ted Stevens Anchorage International Airport Operations	12.4	12.3%
Merrill Field Airport Operations	0.7	0.7%
Wood burning – fireplaces and wood stoves	6.2	6.2%
Space heating – natural gas	3.8	3.8%
Miscellaneous (railroad, marine, snowmobiles, snow removal, portable electrical generators, welding, etc.)	9.3	9.2%
Point sources (power generation, sewage sludge incineration)	1.3	1.3%
<b>TOTAL</b>	<b>100.7</b>	<b>100%</b>

### **CO Maintenance Area Designation and Boundary**

Anchorage was first identified as experiencing high levels of ambient carbon monoxide (CO) concentrations in the early 1970's. Since that time, extensive monitoring programs demonstrated elevated levels of CO throughout the community. Anchorage violated the CO NAAQS every year from 1972 through 1994 and again in 1996. In 1998 the EPA declared Anchorage as a serious nonattainment area for CO. However, beginning in 1997, Anchorage began to compile a continuous string of years in compliance with the NAAQS. In February 2004, on behalf of the Municipality of Anchorage, the State of Alaska requested that the EPA redesignate Anchorage from a nonattainment area to an area that has attained the standard. This request was accompanied by a maintenance plan that showed that Anchorage should continue to maintain compliance with the NAAQS through 2023. The EPA approved this plan on June 23, 2004. Anchorage is now considered a CO maintenance area, an area that has attained compliance with the NAAQS. The boundary of the maintenance area is shown in Figure 2-1. The locations of Anchorage CO monitoring stations, both current and discontinued are also shown.



## CO Monitoring in Anchorage

Over the years, CO monitoring has been conducted at ten sampling locations in the Municipality of Anchorage. As monitoring priorities have changed, sites have been added and discontinued. In 2008 monitoring was conducted in downtown Anchorage (8th and L Street), at the Turnagain station in Spenard, the Garden station in east Anchorage and at the Park Gate Building in the Eagle River central business district.

The Municipality of Anchorage Department of Health and Human Services (DHHS) monitors CO 24 hours a day from October 1 through March 31 in conformance with guidelines established in federal regulations. Instruments meet all specifications required by the EPA for ambient CO monitoring and are designated by the EPA as a "reference method" for CO. Calibrations are performed regularly in accordance with EPA guidance and the instrument manufacturer's recommendations. Third party instrument performance audits are conducted by EPA and/or by the ADEC at least once during each CO monitoring season.

Hourly averages of CO levels are provided from each station in the network. These data are uploaded to the DHHS central computer every weekday. Data are submitted to EPA on a quarterly basis to be included in their air quality database known as AirData AQS. This database contains criteria pollutant and hazardous air pollutant data from around the U.S.

**Figure 2-2**

**TECO 48 CO Analyzer with Strip Chart Recorder and Data Acquisition System  
Garden Monitoring Station**



The locations of the stations in the CO monitoring network are described in Table 2-2. Monitoring stations are located in neighborhoods to characterize residential exposures, and have been sited near busy mid-town intersections to characterize CO exposures in areas with heavy traffic. Each monitoring station was selected in accordance with guidelines established by the EPA. Over the past 30 years, several monitoring stations have been discontinued because they have been found redundant while others have been added to meet new monitoring objectives.

<b>Table 2-2</b>	
<b>Description of Anchorage CO Monitoring Sites</b>	
<b>Location</b>	<b>Site Description</b>
Garden	Monitoring began at this neighborhood location at 16th and Garden Street in 1979. Concentrations at this "neighborhood-scale" site have exceeded those measured at micro-scale monitors located near major traffic corridors.
Turnagain	Monitoring began at this neighborhood-scale station in October 1998. It was established as a result of a special saturation monitoring study conducted in the winter of 1997-98. CO concentrations measured here were the highest of the twenty sites monitored during the study. Turnagain exceeded the NAAQS once in 1999 and 2001. Thus far no more than one exceedance per year has been observed here and this site remains in compliance with the NAAQS.
Parkgate	Monitoring began at this middle-scale station in downtown Eagle River in December 2005.
8 <sup>th</sup> & L Street	Monitoring began at this middle-scale station in downtown Anchorage in October 2007.

Bowman (discontinued)	Monitoring began at this neighborhood-scale station at Bowman Elementary in south Anchorage in December 2005 and was discontinued in March 2007.
7th & C Street (discontinued)	This station was located mid-block between 6 <sup>th</sup> and 7th Avenue on C Street. Monitoring began here in 1973 and was discontinued in 1995.
Benson (discontinued)	Monitoring began at this micro-scale site on the southwest corner of Spenard Road and Benson Blvd in 1978 and was decommissioned in December 2001.
Sand Lake (discontinued)	Monitoring began at this neighborhood-scale site in 1980 and was discontinued in March 1998. This station was located on Raspberry Road approximately 0.3 miles east of Jewel Lake Road in west Anchorage.
Seward Highway (discontinued)	Monitoring began at this micro-scale site, located on the southwest corner of the intersection of Benson Blvd. and Seward Highway, in October of 1987. Over the past 15 years, this station has recorded the most exceedances of the NAAQS. This site last violated the NAAQS in calendar year 1996 when three exceedances were measured. Monitoring here was discontinued December 2004.
Jewel Lake (discontinued)	Monitoring began here in October 2002 and was terminated in March 2004.

### **CO Data Summary and Trends**

In 1983, CO levels in Anchorage exceeded the NAAQS at one or more monitoring stations on 53 days. CO concentrations have fallen dramatically over the past twenty years, however. No violations have been measured since 1996. Single exceedances of the NAAQS were measured in 1998, 1999 and 2001 but these were not considered violations because the NAAQS allows up to one exceedance per calendar year. No exceedances were measured in 1995, 1997, 2000, or during the years 2002 through 2008.

The highest and second highest 8-hour averages for five Anchorage monitoring stations are tabulated by year, 1980 – 2008, in Table 2-3. The number of days exceeding the NAAQS at each station is also tabulated. The table shows that dramatic reductions in CO concentrations have occurred in Anchorage over the past 29 years.

The trend in the second highest 8-hour average concentration or second maximum measured in each calendar year is often used to measure improvements in CO air quality and progress toward

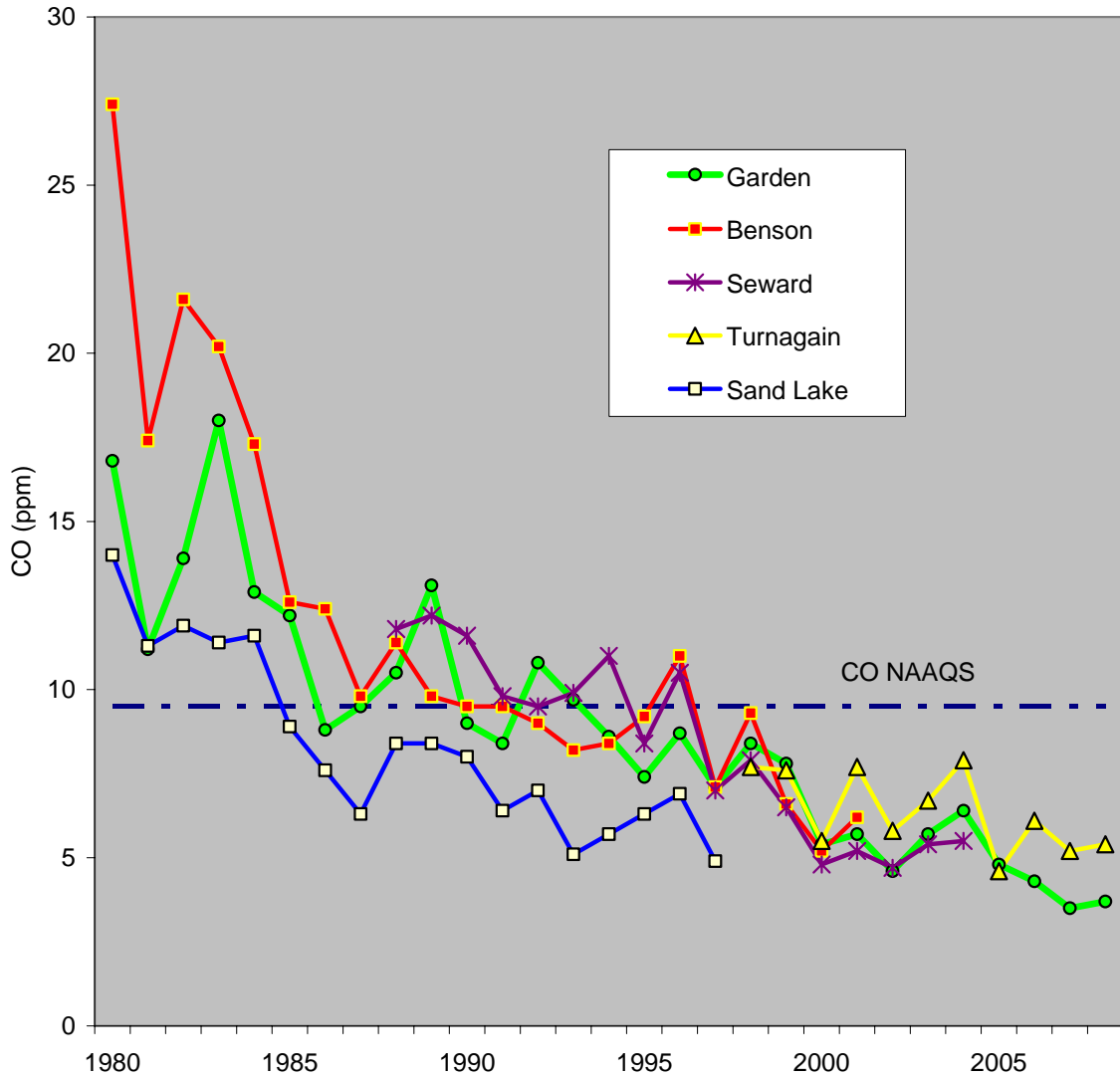
attainment of the NAAQS. The second maximum is statistically more robust (i.e., less prone to year-to-year fluctuation) than the first maximum, making it easier to discern long-term air quality trends. The second maximum is also a direct measure of compliance with the NAAQS. A community is considered to be in compliance if the second maximum at all monitoring stations is below 9.5 ppm.

Year	Benson (microscale) 2902 Spenard Road			Garden (neighborhood) 3000 E 16 <sup>th</sup> Street			Sand Lake (neighborhood) 3426 Raspberry Road			Seward (microscale) 3002 New Seward Highway			Turnagain (neighborhood) 3201 Turnagain Street		
	max	2 <sup>nd</sup> max	# days ≥9.5	max	2 <sup>nd</sup> max	# days ≥9.5	max	2 <sup>nd</sup> max	# days ≥9.5	Max	2 <sup>nd</sup> max	# days ≥9.5	max	2 <sup>nd</sup> max	# days ≥9.5
1980	27.4	26.3	39	17.1	16.8	21	14.0	14.0	6	--	--	--	--	--	--
1981	17.4	16.2	33	12.6	11.2	7	12.6	11.3	5	--	--	--	--	--	--
1982	21.6	18.1	30	15.6	13.9	14	16.6	11.9	3	--	--	--	--	--	--
1983	20.2	16.0	48	19.6	18.0	24	11.5	11.4	7	--	--	--	--	--	--
1984	17.3	17.1	27	13.0	12.9	6	12.6	11.6	5	--	--	--	--	--	--
1985	12.6	12.4	9	12.7	12.2	4	9.2	8.9	0	--	--	--	--	--	--
1986	12.4	11.7	5	10.5	8.8	1	8.1	7.6	0	--	--	--	--	--	--
1987	9.8	8.6	1	10.7	9.5	1	8.1	6.3	0	--	--	--	--	--	--
1988	11.4	10.4	3	11.8	10.5	2	8.5	8.4	0	12.3	11.8	9	--	--	--
1989	9.8	9.6	2	14.0	13.1	2	10.0	8.4	1	14.0	12.2	5	--	--	--
1990	9.5	9.4	1	9.8	9.0	1	8.8	8.0	0	13.0	11.6	11	--	--	--
1991	9.5	8.1	0	8.9	8.4	0	6.7	6.4	0	11.5	9.8	3	--	--	--
1992	9.0	8.8	0	10.9	10.8	2	7.1	7.0	0	10.4	9.5	2	--	--	--
1993	8.2	7.6	0	10.0	9.7	2	8.8	5.1	0	10.4	9.9	2	--	--	--
1994	8.4	8.3	0	9.4	8.6	0	5.8	5.7	0	11.3	11.0	2	--	--	--
1995	9.2	7.6	0	8.4	7.4	0	6.7	6.3	0	9.0	8.4	0	--	--	--
1996	11.0	9.6	3	8.9	8.7	0	7.7	6.9	0	10.8	10.5	3	--	--	--
1997	7.1	6.8	0	7.3	7.1	0	5.9	4.9	0	7.3	7.0	0	--	--	--
1998	9.3	8.2	0	9.5	8.4	1	--	--	--	9.4	7.9	0	8.1*	7.7*	0*
1999	6.6	5.9	0	8.2	7.8	0	--	--	--	7.5	6.5	0	10.1	7.6	1
2000	5.2	4.7	0	5.8	5.4	0	--	--	--	5.2	4.8	0	7.2	5.5	0
2001	6.2	5.7	0	6.1	5.7	0	--	--	--	5.4	5.2	0	9.8	7.7	1
2002	--	--	--	4.7	4.6	0	--	--	--	5.4	4.7	0	6.4	5.8	0
2003	--	--	--	6.1	5.7	0	--	--	--	6.2	5.4	0	8.3	6.7	0
2004	--	--	--	6.8	6.4	0	--	--	--	5.8	5.5	0	8.1	7.9	0
2005	--	--	--	4.8	4.8	0	--	--	--	--	--	--	5.7	4.6	0
2006	--	--	--	5.1	4.3	0	--	--	--	--	--	--	6.5	6.1	0
2007	--	--	--	4.0	3.5	0	--	--	--	--	--	--	5.5	5.3	0
2008	--	--	--	4.0	3.7	0	--	--	--	--	--	--	6.3	5.4	0

\* Incomplete year of data. Turnagain station began operations in mid-October 1998.

Annual second maximum concentrations recorded at the five sites with the longest continuous data records (Benson, Garden, Sand Lake, Seward Highway, and Turnagain) are plotted in Figure 2-3. Available data from each site during the 29 year period 1980 -2008 are plotted. During this period, the annual second maximum CO concentration declined by 76% at Garden. Similar downward trends are observed at other sites.

**Figure 2-3**  
**Trend in 2nd Maximum 8-hour CO Concentration at Anchorage CO Monitoring Stations**  
**1980 - 2008**



## Diurnal Pattern in CO Concentrations

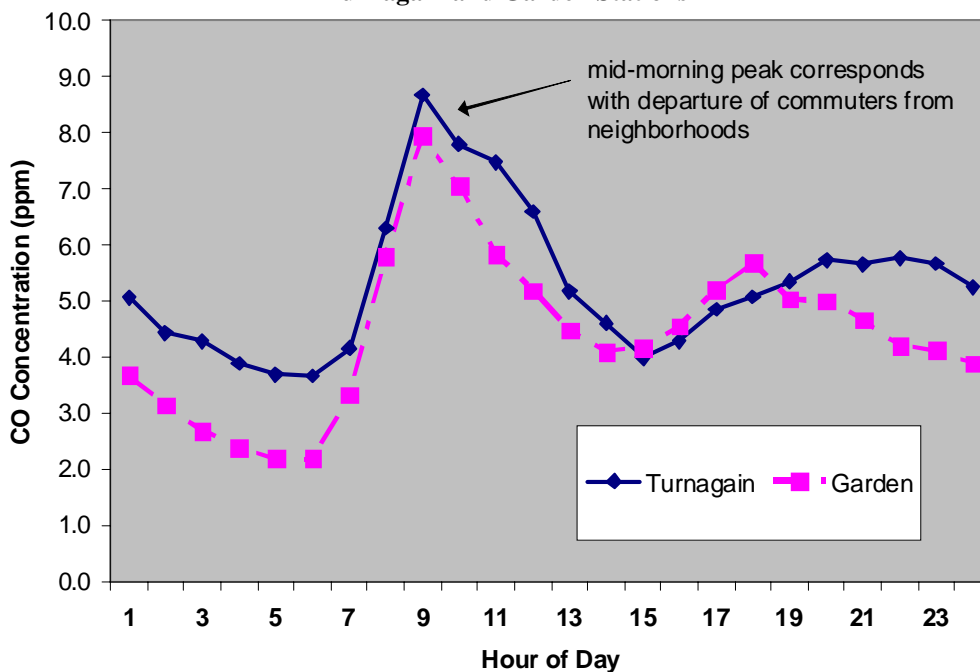
There is a distinct diurnal pattern in ambient CO concentration that corresponds to driving patterns in the vicinity of a monitoring site. Residential neighborhood sites like Turnagain and Garden typically experience their highest CO concentrations in the mid-morning following the morning commute and accompanying vehicle warm-up idle. Sites located near major traffic thoroughfares like the Seward Highway site typically exhibit their highest concentrations during the evening rush hour.

The diurnal variation in CO concentrations at the Turnagain, Garden and Seward Highway stations are illustrated in Figures 2-4(a-b). The hourly averages shown are composites of the 99<sup>th</sup> percentile of hourly averages measured between 2000 and 2007 at the Turnagain and Garden station and between 2000 and 2004 at the Seward Highway station. §

At the Garden and Turnagain stations, both of which are located in residential areas, CO concentrations rise quickly in the early morning hours as commuters start their cars and leave for work. Figure 2-4(a) shows concentrations peak at about 10 a.m. and drop off substantially during the late morning and early afternoon. Concentrations build again somewhat in the evening hours but the evening peak is substantially lower than the morning peak.

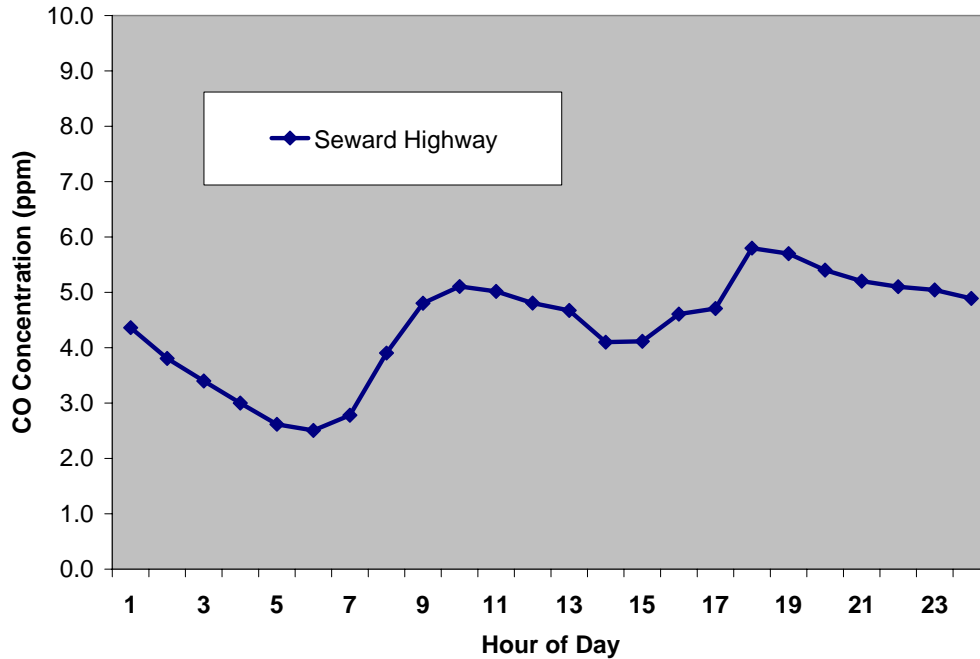
The diurnal pattern in CO concentrations near major traffic arterials is different than residential areas. Figure 2-4(b) shows the diurnal pattern at the Seward Highway station, located at the busy intersection of the Seward Highway and Benson Boulevard. Although a morning peak is present, the highest concentrations in the day correspond with the evening commute. Concentrations peak between 5 and 6 p.m. and decline slowly thereafter. Cold start emissions from evening commuters leaving from downtown and mid-town employment centers likely contribute to this evening peak.

**Figure 2-4 (a) Diurnal Variation in Hourly CO Concentration in Residential Areas Turnagain and Garden Stations**



§ The Seward Highway Station was decommissioned on December 30, 2004. This discussion and Figure 2-4(b) therefore are limited to data collected from 2000-2004.

**Figure 2-4 (b) Diurnal Variation in Hourly CO Concentration in Commercial Area Seward Highway Station**



### **Influence of Meteorology on Ambient CO Concentrations**

In Anchorage, CO concentrations are highest during the months of November through February. As a high-latitude community, with long winter nights and weak daytime solar energy input, Anchorage frequently experiences strong and persistent temperature inversions that trap CO close to the ground. In mid-winter, due to the short daytime period available for warming and the low sun angle, inversions often persist throughout the day. Inversion strengths as high as +5°F per 100 foot rise in elevation have been measured. When winds are light, there is little vertical or horizontal dispersion of pollutants. Poor dispersion conditions, combined with high emission rates from motor vehicles started in cold temperatures create an environment particularly conducive to developing elevated CO concentrations.

The highest CO concentrations tend to occur on days with low wind speeds, clear or partly cloudy skies, and cold temperatures. Weather conditions during periods when the 8-hour average CO concentrations at the Turnagain site were at or above the 98<sup>th</sup> percentile are summarized in Table 2-4.\*\* The average temperature during these periods was 4°F, with a range from -16°F to +18°F. The average wind speed was 2 miles per hour.

It should be noted that Local Climatological Data from the National Weather Service observatory at Point Campbell on the Ted Stevens Anchorage International Airport were used to prepare Table 2-4. Point Campbell is in the extreme western part of Anchorage, adjacent to Cook Inlet. Temperatures there are often moderated by the surrounding water body. Temperatures in east Anchorage, away from the inlet, can sometimes be 10 to 20°F lower than temperatures in west Anchorage. Wind speeds at Point Campbell can also be higher than areas to the east, particularly under a northerly wind regime. Thus, the wind speed and temperatures recorded at Point Campbell may not always accurately reflect conditions elsewhere in Anchorage.

\*\* CO data from Turnagain for the period October 1998 – December 2008 were analyzed to determine the 98<sup>th</sup> percentile 8-hour average concentration. This was computed to be 5.8 ppm. Table III.B.3-3 provides a summary of weather conditions during 8-hour periods when CO concentrations were equal to or higher than 5.8 ppm.

**Table 2-4  
 Meteorological Conditions during Periods of High CO Concentrations at  
 Turnagain Monitoring Station (8-hour Average  $\geq$  98<sup>th</sup> Percentile)  
 October 1998 – December 2008**

<b>Date</b>	<b>8-hour Average (ppm)</b>	<b>Day of Week</b>	<b>Time of Day</b>	<b>Temp (°F)</b>	<b>Wind Speed (mph)</b>	<b>Sky Cover*</b>
12/16/1998	7.69	Wed	4 PM - 12 AM	2	2	CLR
12/24/1998	8.06	Thu	4 PM - 12 AM	6	0	FEW
01/04/1999	5.90	Mon	4 PM - 12 AM	-1	4	CLR
01/06/1999	10.14	Wed	11 AM - 7 PM	2	2	FEW
02/07/1999	5.80	Sun	10 PM - 6 AM	-9	2	FEW
02/08/1999	7.31	Mon	3 AM - 11 AM	-9	7	SCT
02/11/1999	6.09	Thu	1 AM -9 AM	-16	4	CLR
02/22/1999	6.50	Mon	7 PM - 3 AM	9	3	BKN
02/23/1999	7.61	Tues	4 AM - 12 PM	11	0	OVC
11/10/1999	5.93	Wed	4 AM - 12 PM	10	4	CLR
11/27/1999	7.16	Sat	5 PM - 1 AM	10	1	CLR
12/06/1999	7.24	Mon	6 AM - 2 PM	9	5	CLR
01/15/2000	7.21	Sat	7 PM - 3 AM	2	3	CLR
02/17/2001	6.13	Sat	10 PM - 6 AM	15	2	CLR
11/13/2001	6.13	Tues	7 PM - 3 AM	14	0	SCT
11/14/2001	7.74	Wed	4 AM - 12 PM	12	0	SCT
11/30/2001	5.90	Fri	9 PM - 5 AM	1	2	FEW
12/03/2001	6.30	Mon	8 AM - 4 PM	-3	1	CLR
12/04/2001	5.95	Tues	8 AM - 4 PM	2	3	FEW
12/05/2001	7.23	Wed	7 AM - 3 PM	3	3	BKN
12/07/2001	6.28	Fri	5 PM - 1 AM	-7	3	BKN
12/16/2001	9.78	Sun	12 PM -8 PM	-8	5	SCT
12/18/2001	7.40	Tues	9 AM - 5 PM	-6	3	SCT
01/25/2002	5.86	Fri	4 AM - 12 PM	2	5	CLR
02/6/2002	6.49	Wed	4 AM - 12 PM	18	0	SCT
12/5/2003	8.27	Fri	5 PM - 1 AM	8	2	CLR
01/01/2004	7.48	Thu	2 PM - 10 PM	4	0	SCT
01/03/2004	7.61	Sat	1 PM - 9 PM	11	2	CLR
01/04/2004	7.88	Sun	12 PM -8 PM	6	3	BKN
01/05/2004	8.11	Mon	10 AM - 6 PM	5	0	FOG
01/12/2004	5.87	Mon	5 PM - 1 AM	6	1	FEW
01/17/2006	6.09	Tues	6 AM - 2 PM	8	2	BKN
01/24/2006	6.11	Tues	4 AM - 12 PM	-5	1	SCT
11/29/2006	6.53	Wed	8 AM - 4 PM	14	0	SCT
12/29/08	6.30	Mon	7 AM - 3 PM	-4	3	BKN

\* Sky Cover is the fraction amount of sky obscured. CLR = 0, FEW = 1/8 - 2/8, SCT = 3/8 – 4/8, BKN = 5/8 – 7/8, OVC = 8/8

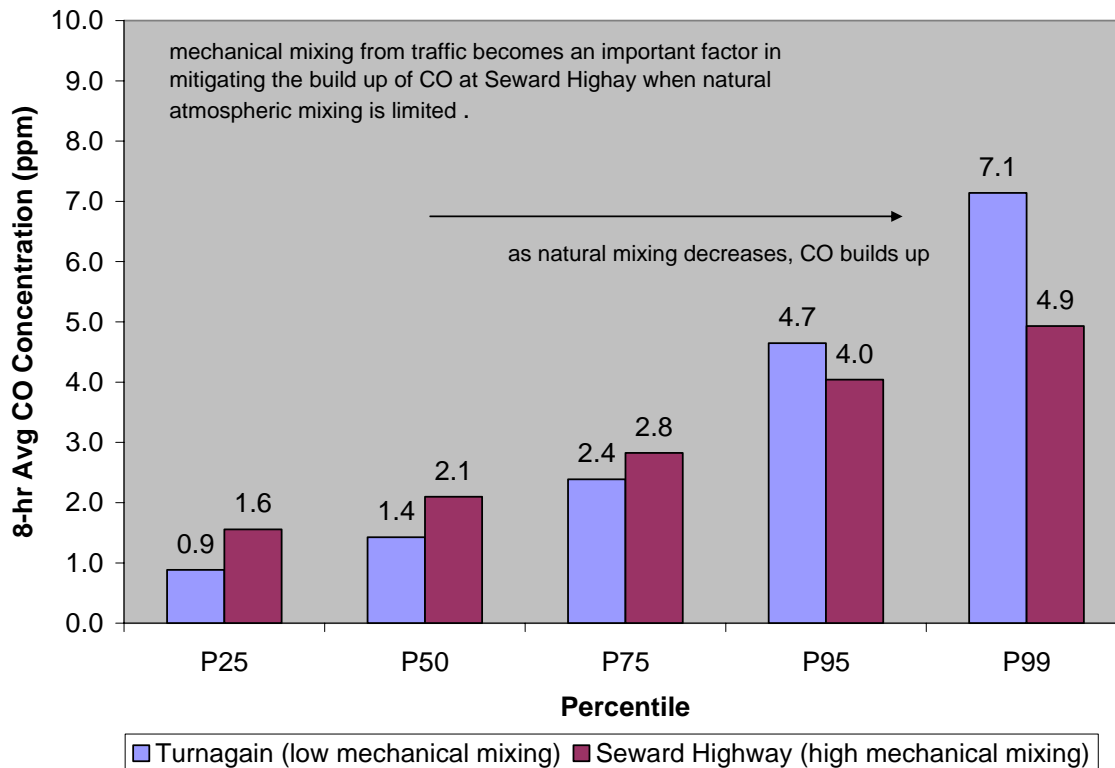
## Role of Mechanical Turbulence from Vehicle Traffic in Reducing Ambient CO Concentrations during Stagnation Conditions

As noted earlier, the highest CO concentrations in Anchorage tend to occur in residential neighborhoods rather than near major roadways where vehicle traffic volumes may be an order of magnitude greater. Although vehicle cold starts result in higher *per vehicle* emission rates in residential areas, total CO emissions in commercial areas in midtown Anchorage are greater due to the sheer volume of vehicles traveling along its major roadways. If the ambient CO concentration in a particular area were solely a function of the quantity of emissions produced there, CO concentrations near major roadways in midtown Anchorage should be higher than residential areas. Ambient monitoring data indicate that this is not the case.

Monitoring data suggest that mechanical mixing from high-speed vehicle traffic may reduce ambient CO concentrations near major traffic thoroughfares on severe stagnation days.

Figure 2-5 compares CO concentrations by percentile at the Seward Highway and Turnagain stations. Traffic volumes are an order of magnitude greater near the Seward Highway station than the Turnagain station. On days when natural atmospheric mixing from wind and thermal convection is good, the additional mixing provided by mechanical turbulence of vehicle traffic at Seward Highway is relatively unimportant. Under these conditions one would expect CO concentrations at Seward Highway to be higher than those at Turnagain because traffic and CO emissions are so much greater. Indeed, the lower quartile (P25) and median (P50) concentration are considerably higher at Seward than Turnagain. However, when a strong ground-based temperature inversion and lack of wind create very poor natural atmospheric mixing, mechanical mixing from vehicle traffic appears to be a very important factor in mitigating the build up of high CO concentrations. Under these extreme meteorological conditions concentrations at Turnagain are much higher than those at Seward Highway. The 99<sup>th</sup> percentile (P99) CO concentration at the Turnagain station is more than 40% higher than the Seward Highway station.

**Figure 2-5**  
Effect of Mechanical Mixing on CO Concentrations at Seward Highway and Turnagain Stations



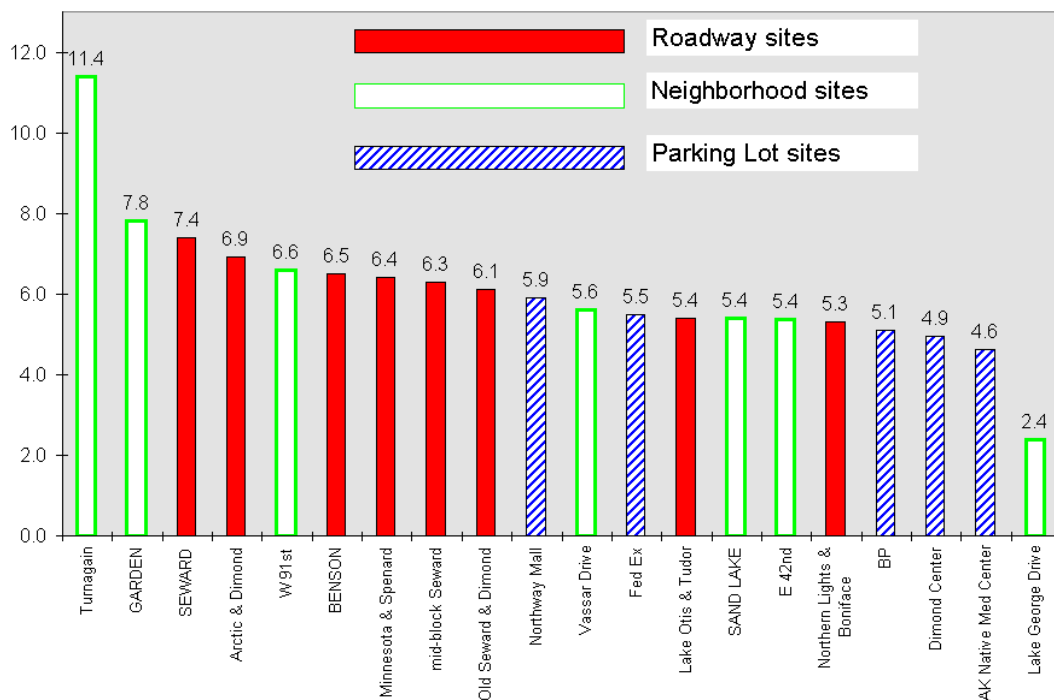
## Summary of Local Research

Beginning in 1997, the MOA in cooperation with the EPA, ADEC and the Fairbanks North Star Borough, conducted a number of studies to advance the understanding of the causes of the winter season CO problem in Anchorage and Fairbanks. In particular, these studies focused on quantifying the contribution of cold starts and warm up idling on the problem. These studies are summarized below.

### 1997 – 1998 CO Saturation Monitoring Study

The MOA performed additional CO monitoring during the period December 4, 1997 - February 4, 1998. Sixteen temporary monitoring sites were established to assess how well the four station permanent network was characterizing the air quality near congested roadway intersections, in neighborhoods and in parking lots. Monitoring was conducted at 20 locations during the study period. Eight sites were located near major roadway intersections, seven in neighborhoods, and five in large retail or employee parking lots. The maximum eight-hour concentrations measured at each of the 20 sites in the study are compared in Figure 2-6.

**Figure 2-6**  
**Maximum 8-hour CO Concentrations Measured during CO Saturation Monitoring Study**



The highest eight-hour CO concentrations were found at neighborhood locations with relatively low traffic volumes. The Turnagain neighborhood site recorded the highest and second highest eight-hour concentrations in the study. The next highest site was the Garden permanent station, also located in a neighborhood. Vehicle cold starts and warm-up idling by morning commuters were implicated as the cause of the elevated CO observed in these neighborhoods.

The permanent station at Seward Highway recorded the highest concentration of any of the eight roadway intersection sites. The study concluded that the Seward Highway station adequately characterized the upper range of CO concentrations experienced near major roadways in Anchorage. Lower than expected concentrations were found near a number of congested intersections. For example, the highest concentration measured near the busy intersection of Lake Otis Boulevard and Tudor Road was about 50% lower than the Turnagain neighborhood site.

CO concentrations at the five parking lot sites were generally lower than those found in

neighborhoods or near the major roadway intersections monitored during the study. This was somewhat surprising given the number of vehicle start-ups that originated in these parking lots. Many of these start ups, especially in retail shopping parking lots, were likely to be “hot starts,” however, meaning that engines were still warm from an earlier trip. Warmer engines emit considerably lower amounts of CO and this may account for the relatively low ambient concentrations observed.

#### Anchorage Winter Season Driver Idling Behavior Study (1997-98)

The municipality conducted a study between November 28, 1997 and January 31, 1998 aimed at quantifying the amount of warm up idling performed by Anchorage drivers. Field staff observed 1,321 vehicle starts at diverse locations in Anchorage. Warm-up idling duration was documented for trips that began at homes, work places, and other locations such as shopping centers, restaurants, and schools.

Field observations were used to estimate idle duration for each of the trip purpose categories described above. The longest warm-up idle times were associated with morning commute trips to work. The average idle duration for these trips for cars parked outside was about 12 minutes<sup>††</sup>. The average idle duration for evening commute trips beginning at the workplace was 3.4 minutes. The shortest idle durations were associated with morning and midday trips that began at sites other than work or home. Median idle time for these trips was less than one minute.

Engine soak times, the length of time that an engine sits in the cold between trips, were also estimated as part of the driver idling behavior study. Longer soak times result in colder engines and increased CO emissions. Data from a travel survey conducted by Hellenthal and Associates for the municipality in 1992 were used to estimate soak times by trip purpose and time of day.

The longest soak times and idle durations were associated with morning home-based work trips. Because most of these trips begin with a cold engine and involve long idles, start up and idle CO emissions are likely to be greater than other trip types. Conversely, non work-related trips originating from shopping centers, health clubs and similar non work-related locations typically involve short soak times and idle durations, and are therefore likely to have lower start up and idle emissions.

#### Alaska Cold Start and Idle Emissions Studies (Winter 1998-99 and Winter 2000-2001)

During the winter of 1998-99, Sierra Research conducted a study to quantify emissions from Alaskan vehicles during cold start and idling. This testing, which was coordinated jointly by the MOA, Fairbanks Northstar Borough and ADEC, measured emissions under winter conditions when the highest CO concentrations are likely to occur. Sierra Research equipped a large van with a modified Horiba IMVETS emissions test system that provided measurements of CO and hydrocarbon mass emissions on a second-by-second basis. The van could be driven from location to location to test a variety of vehicles representative of the fleet mix in both Anchorage and Fairbanks.

After an initial cold soak of four hours or more at ambient temperature, test vehicles were cold-started and mass emissions were measured for a period of 20 minutes subsequent to start-up. Testing was conducted at ambient temperatures that ranged from -6 °F to +23 °F in Anchorage and -36 °F to +14 °F in Fairbanks. The data collected during the study were used to help estimate idle emissions in the CO emissions inventories compiled for 1996 and 2000.

Sierra Research conducted a follow-up study in Fairbanks during the winter of 2000-2001. During

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<sup>††</sup> About 35% of morning trips involved vehicles parked overnight in heated garages. Idle duration for these vehicles averaged less than one minute. The average idle duration for vehicles parked outside was over 12 minutes. The weighted average idle duration for all work-related morning trips, including those originating from a garage was about 7 minutes.

this study, mass emission testing was conducted using a dynamometer which allowed emissions to be tested during a simulated, representative urban Alaska trip (i.e. varying speeds, accelerations, stops). Key findings from the 1998-99 and 2000 –2001 studies are summarized below:

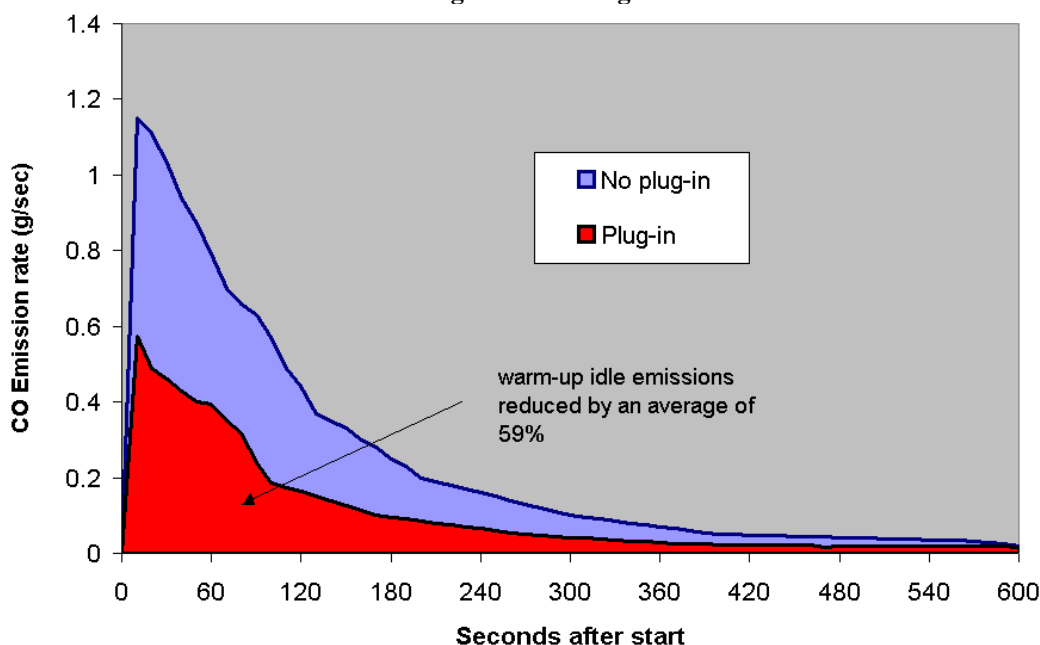
- *A large portion of CO emissions occur during cold start and warm-up idle.* In order to simulate a typical morning commute in Anchorage<sup>††</sup>, Sierra Research measured CO emissions from 35 cold-started vehicles during the course of a 10-minute warm-up and a subsequent 7.3-mile drive. The CO emitted during cold start and warm-up idle made up 68% of the total CO emitted. This suggests that more than two-thirds of the CO emissions generated by Anchorage's morning commuters occur before their vehicles even leave home.
- *To minimize emissions after a cold start, the optimum warm-up idle time is about 10 minutes.* On an overall trip basis (10-minute warm-up followed by a 7.3-mile drive), CO emissions actually increase when idle times are cut shorter than 10 minutes. When the idle time is cut to five minutes, Sierra Research found that overall trip emissions increased by an average of 8%, and by about 20% when the warm-up time was cut to 2 minutes. Warm-ups longer than 10 minutes increase emissions. A 15-minute idle increased emissions by about 10% when compared to a 10-minute idle.
- *Using an engine heater prior to a cold start cuts CO emissions dramatically.* Plugging in for two hours before a cold start cut emissions during a 10-minute warm-up idle period by an average of 59%. Overall trip emissions were cut by an average of 42%. (See Figure 2-7)
- *Turning a warmed up car off when doing short errands provides little or no air quality benefit.* Once a vehicle is warmed up, Sierra found that there was no air quality benefit from turning it off during a typical 20, 40 or 60-minute errand. In other words, total CO emissions were about the same whether the vehicle was left running or turned off and then restarted.
- *Tailpipe emissions of benzene and other air toxics appear to be closely correlated with CO emissions.* Sierra Research's testing data suggest that when CO emissions are high so are emissions of benzene and other air toxics. This suggests that strategies aimed at reducing CO emissions (i.e. plugging in and the vehicle I/M program) also reduce air toxic emissions.

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<sup>††</sup> Data collected in Anchorage show that the average warm-up idle time among morning commuters is 12 minutes. The average commute trip is about 7 miles.

Figure 2-7

Comparison of CO Emissions during 10 Minute Warm-up after Cold Start  
Plug-in vs. No Plug-in



**CO Concentrations in Anchorage Compared with Other Areas**

The EPA AQS database includes CO data from 388 monitoring stations in the U.S. for calendar year 2007.<sup>§§</sup> Concentrations measured in Anchorage were among the highest in the country; the Turnagain station had a maximum concentration (5.5 ppm) that ranked it in the top 2% of the stations reporting.

Concentrations from a number of selected metropolitan areas in the western U.S. are compared to Anchorage in Table 2-5 for calendar year 2007. The highest and second highest eight-hour averages are tabulated along with the number of exceedances recorded in each city during the year.

Comparison of data from different metropolitan areas should be done with caution. CO measurements are highly dependent on proximity to local sources (e.g. road ways, industrial sources) and may not necessarily be representative of area-wide air quality.

<sup>§§</sup> Complete data for 2008 were not available at the time this report was being written.

Table 2-5

**Comparison of Calendar Year 2007 CO Concentrations in  
Selected Western U.S. Metropolitan Areas**

<b>Metropolitan Area</b>	<b>Highest 8-hour Concentration (ppm)</b>	<b>2<sup>nd</sup> Highest 8-hour Concentration (ppm)</b>	<b>Number of Exceedances of the NAAQS</b>
Ogden, UT	9.9	5.7	1
Sacramento, CA	5.6	4.1	0
<b>Anchorage, AK</b>	<b>5.5</b>	<b>5.3</b>	<b>0</b>
Phoenix, AZ	4.6	4.1	0
Las Vegas, NV	4.1	3.8	0
El Paso, TX	3.8	3.2	0
Salt Lake City, UT	3.7	3.4	0
Albuquerque, NM	3.6	3.4	0
Reno, NV	3.6	3.3	0
Fairbanks, AK	3.4	3.2	0
Denver, CO	3.2	2.8	0
Spokane, WA	3.1	2.9	0
Portland, OR	3.1	2.7	0
Seattle, WA	1.0	1.0	0

## References

1. "Draft Anchorage Carbon Monoxide Maintenance Plan," Air Quality Program, Department of Health and Human Services, Municipality of Anchorage, April 2008.
2. "Anchorage 2007 Carbon Monoxide Emission Inventory and 2007-2023 Attainment Projections," Air Quality Program, Department of Health and Human Services, Municipality of Anchorage, January 2008."
3. EPA AirData website, Office of Air and Radiation, U.S. Environmental Protection Agency. <http://www.epa.gov/air/data/>
4. "Air Quality Criteria for Carbon Monoxide," U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington, DC, EPA 600/P-99/001F, 2000
5. "Winter 1997-98 Anchorage Carbon Monoxide Saturation Monitoring Study," Air Quality Program, Department of Health and Human Services, Municipality of Anchorage, September 1998.
6. "Analysis of Alaska Vehicle CO Emission Study Data," prepared for the Municipality of Anchorage by Sierra Research, Inc., February 3, 2000.
7. "Fairbanks Cold Temperature Vehicle Testing: Warm-up Idle, Between Trip Idle, and Plug-In," prepared for the Alaska Department of Environmental Conservation by Sierra Research, Inc., July 2001.

## Section 3 - Particulate Matter

### Health Effects of Particulate Matter

Airborne particulate matter is composed of dust, ash, soot, smoke or liquid droplets emitted into the air by industrial sources and fires, construction activities, paved and unpaved roads, and from natural sources like volcanoes, and wind blown dust.

Smaller size particulate is most likely to cause adverse health effects. These particles, called PM<sub>10</sub> (particulate matter less than 10 microns in diameter), can be inhaled into the thoracic or lower regions of the respiratory tract where they can be harmful. Epidemiological studies indicate that adverse health impacts can result from exposure to PM<sub>10</sub> at concentrations commonly experienced in many U.S. urban areas. These health impacts include aggravation of existing respiratory disease and decline in lung function. Studies in a number of cities have shown increases in morbidity and mortality when PM<sub>10</sub> levels are high. In Anchorage, evidence suggests an association between elevated PM<sub>10</sub> and increases in out-patient visits for asthma and upper respiratory illness (Gordian 1996, Chimonas 2006).

In September 2007 EPA revised the NAAQS for particulate. The revised standard includes more stringent limits on fine particulate matter less than 2.5 microns in diameter, called PM<sub>2.5</sub>. Recent epidemiological studies suggest that adverse health impacts are strongly related to exposure to fine particulate. A growing body of epidemiological evidence suggests that these sub-2.5 µm particles have a greater impact on human health than coarser particles in the 2.5 to 10 µm size range.

The EPA annual standard for PM<sub>2.5</sub> is 15 µg/m<sup>3</sup>. The revised 24-hour standard, established for the 98<sup>th</sup> percentile of monitored values is 35 µg/m<sup>3</sup>. This means that a community may exceed 35 µg/m<sup>3</sup> on up to 2% of the days monitored and still comply with the NAAQS. If monitoring is conducted 365 days per year, this amounts to seven days per year. Compliance with the annual and 24-hour NAAQS are determined by averaging over a three-year period.

EPA also revised the PM<sub>10</sub> NAAQS as part of their rulemaking. They retained the existing 24-hour NAAQS of 150 µg/m<sup>3</sup> but revoked the annual standard previously established at 50 µg/m<sup>3</sup>.

### Sources of PM<sub>10</sub> in Anchorage

Sources of PM<sub>10</sub> in Anchorage and Eagle River have been quantified by a technique known as chemical mass balance receptor modeling. Over 90% of the PM<sub>10</sub> matter is attributed to paved and unpaved roads. The combined impact of other sources, such as emissions from industrial sources, wood stoves and fireplaces, and automobiles amount to less than 10% of the particulate mass.

Unpaved roads were the major source of PM<sub>10</sub> in Eagle River prior to 1988. However, an ambitious road paving and surfacing program has largely eliminated this source of emissions and air quality has improved.

### PM<sub>10</sub> Monitoring in Anchorage and Eagle River

Over the years DHHS has relied largely on Andersen-head PM<sub>10</sub> samplers to measure PM<sub>10</sub>. The Andersen-head sampler has been designated by EPA as a reference method for PM<sub>10</sub> measurement and is used commonly throughout the U.S. In short, the method involves placing a pre-weighed quartz fiber filter in an Andersen sampler set to operate for a 24-hour period, from midnight to midnight. The filter is collected after the sampler has run, equilibrated to prescribed conditions in the laboratory, and then weighed again. The PM<sub>10</sub> mass is calculated by subtracting the weight of the filter before sampling. Once the PM<sub>10</sub> mass is known, the PM<sub>10</sub> concentration can be calculated from the sample duration and flow rate through the sampler. Adjustments are made to account for the temperature and barometric pressure on the sample day.

In recent years, DHHS has relied more on continuous PM<sub>10</sub> sampling systems that do not require manual deployment, retrieval and weighing of filters to determine PM<sub>10</sub> mass. These continuous systems provide data on an hourly basis to a centralized computer system that can be accessed at any time. DHHS is currently uses Met One beta attenuation monitors (BAMs) at three of its stations. The BAM draws air in at a known flow rate through a glass fiber filter. A low level beta radiation source in the instrument is directed through the filter where the particulate is deposited. The instrument estimates the mass of the particulate by measuring the attenuation in the beta radiation. A greater the particulate mass results in greater attenuation. The instrument then calculates the PM<sub>10</sub> concentration from mass and the flow data. DHHS also uses a Rupprecht & Patashnick tapered element oscillating microbalance (TEOM) to collect some PM<sub>10</sub> data. The TEOM uses a patented inertial mass measurement technique for making a direct measurement of the particle mass collected on a filter in real time. PM<sub>10</sub> data from the BAMs and TEOM are transmitted via modem to the DHHS central computer. DHHS is currently in the process of switching to an Internet-based system that will provide public access to real time data.

**Figure 3-1**  
**Allstate Building PM<sub>10</sub> and PM<sub>2.5</sub> Monitoring Station**



The Allstate Building PM<sub>10</sub> monitoring station, located off Tudor Road near Bragaw Street is shown in Figure 3-1. Monitors are typically placed on roof tops as shown. When the reference method is used, multiple monitors are necessary to conduct daily monitoring through weekends and holidays. Sampling is initiated and terminated by a timer set to conform to the prescribed 24-hour sampling period.

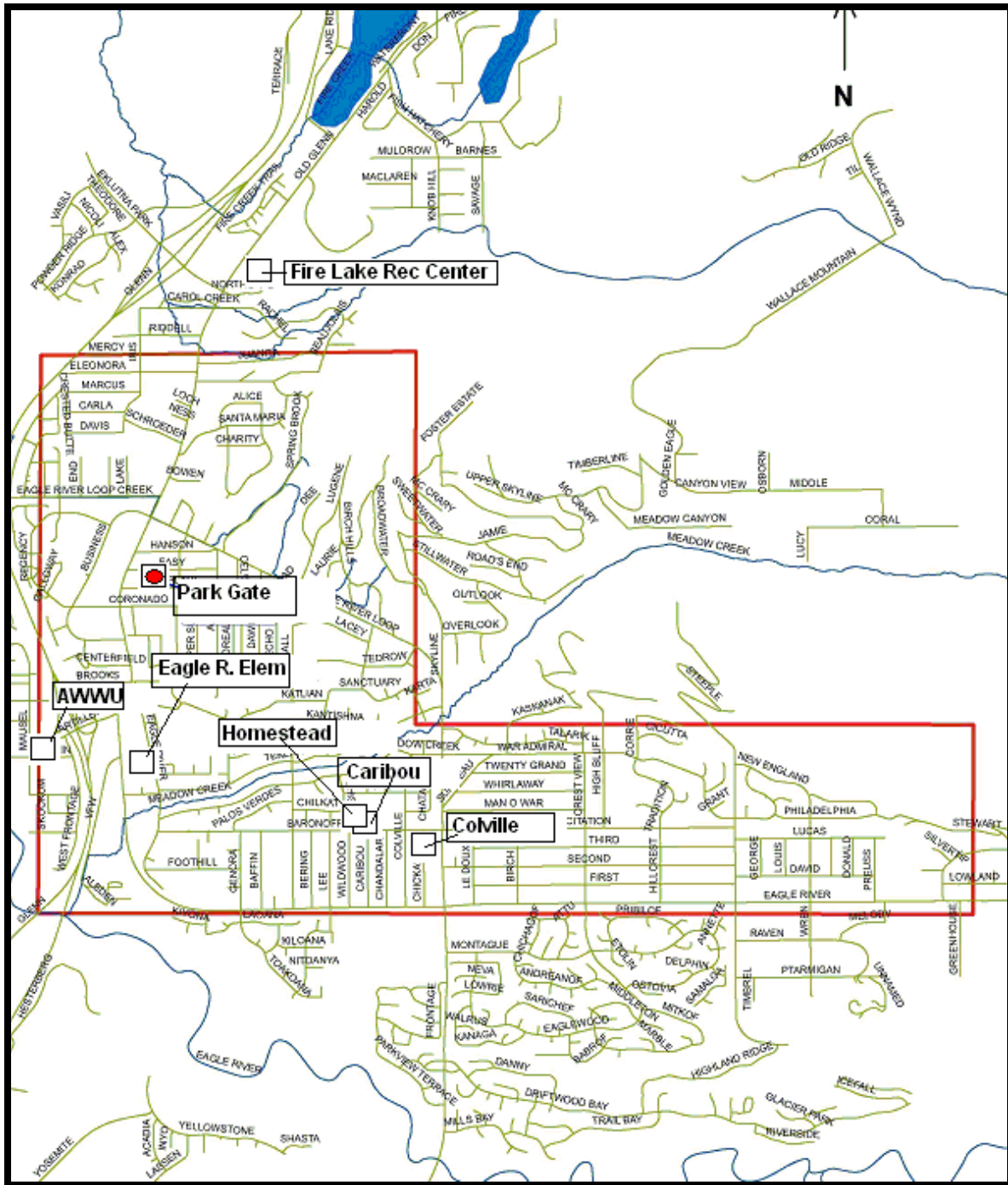
Over the years, PM<sub>10</sub> monitoring has been conducted at 16 different locations in Anchorage and Eagle River. Most were discontinued when sufficient data were collected to characterize PM<sub>10</sub> levels at those locations. In 2008 three stations were operated in the Anchorage bowl and one in Eagle River. Monitoring locations are identified in Figures 3-2 and 3-3.

**Figure 3-2**  
**Location of Active and Discontinued PM<sub>10</sub> Monitoring Stations in Anchorage**



	<b>Status (2008)</b>	<b>Location</b>
8 <sup>th</sup> & L Street	Active	727 W 8 <sup>th</sup> Avenue
Allstate	Active	3335 East Tudor Road
Garden	Active	3000 E 16 <sup>th</sup> Street
Gambell	Discontinued	Worthington Ford, 1950 Gambell Street
7 <sup>th</sup> & C Street	Discontinued	Downtown Fire Station, 625 C Street
Muldoon	Discontinued	1100 Muldoon Road
Oceanview	Discontinued	Oceanview School, 11911 Johns Road
Tudor	Discontinued	Old Public Works Complex, 3500 E Tudor Road
Spenard	Discontinued	3309 Spenard Road
Minnesota	Discontinued	3443 Minnesota Blvd.

**Figure 3-3**  
**Location of Active and Discontinued PM<sub>10</sub> Monitoring Stations in Eagle River**  
**(with PM<sub>10</sub> Nonattainment Boundary shown in Red)**



Site	Status (2008)	Location
Parkgate	Active	Parkgate Bldg., near Old Glenn Hwy & Easy Street
Caribou	Discontinued	Homestead School, 15 meters north of Baranof Drive
AWWU	Discontinued	AWWU Wastewater facility, Artillery Road
Fire Lake Rec Center	Discontinued	Fire Lake Recreation Center, Mile 2.2, Old Glenn Hwy
Homestead	Discontinued	Homestead School, 50 meters north of Baranof Drive
Colville	Discontinued	AWWU well house, intersection, Baranoff & Colville Streets
Eagle River Elementary	Discontinued	Eagle River Elementary School

## PM<sub>10</sub> Data Summary

Data from the four active and twelve discontinued PM<sub>10</sub> monitoring stations in Anchorage and Eagle River are summarized in Table 3-1(a) through 3-1(o) below. Eruptions of Mt. Redoubt in December 1989 and Mt. Spurr in August of 1992 were responsible for numerous exceedances of the 24-hour NAAQS in 1990 and 1992. Blowing dust from a windstorm with gusts clocked as high as 100 mph was responsible for a number of exceedances during the period March 7 – 13, 2003. These exceedances are flagged as "natural events" and they are not considered violations of the NAAQS.

### Active Sites:

Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1996 <sup>a</sup>	1 in 2	--	72	61	0
1997	1 in 2	26.9	127	93	0
1998	1 in 2	25.1	88	78	0
1999	1 in 2	24.1	90	86	0
2000	1 in 2	25.7	111	108	0
2001	1 in 2	24.9	150 <sup>b</sup>	127	0
2002	1 in 2	31.2	105	104	0
2003	1 in 2	26.8	421 <sup>c</sup>	179 <sup>c</sup>	2
2004	1 in 2	21.9	97	97	0
2005	1 in 2	24.5	145	145	0
2006	1 in 2	24.6	108	105	0
2007	1 in 2	23.8	99	98	0
2008	1 in 2	22.6	125	109	0

<sup>a</sup> Sampling began mid-October 1996

<sup>b</sup> Although the NAAQS is set at 150 µg/m<sup>3</sup> values below 155 µg/m<sup>3</sup> are not considered an exceedance.

<sup>c</sup> Exceedances measured on March 7 and March 12, 2003 were attributed to high winds. .

Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1999 <sup>a</sup>	1 in 6	16.2	73 <sup>a</sup>	33	0
2000	1 in 6	16.8	53	52	0
2001	1 in 6	16.4	57	54	0
2002	1 in 6	14.4	46	40	0
2003	1 in 6	19.3	226 <sup>b</sup>	57	1
2004	1 in 6	15.5	38	37	0
2005	1 in 6	15.9	70	52	0
2006	1 in 6	15.7	59	48	0
2007	1 in 6	16.5	96	56	0
2008	1 in 6	15.2	51	49	0

<sup>a</sup> This value attributed to July 4<sup>th</sup> fireworks.

<sup>b</sup> This value attributed to high winds on March 12, 2003.

<b>Table 3-1(c)</b> <b>Parkgate PM<sub>10</sub> Station</b> <b>Parkgate Building, Old Glenn Hwy &amp; Easy Street, Eagle River</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1985 <sup>a</sup>	every day	--	219	194	3
1986	every day	40.3	336	326	6
1987	every day	29.0	219	147	1
1988	every day	26.2	83	83	0
1989	every day	19.6	69	56	0
1990	1 in 6 <sup>b</sup>	26.8	143	106	0
1991	1 in 6	28.2	78	72	0
1992	1 in 6	31.5	165 <sup>c</sup>	128	1 <sup>c</sup>
1993	1 in 6	23.1	79	77	0
1994	1 in 6	21.9	94	60	0
1995	1 in 6	19.4	60	51	0
1996	1 in 6	19.4	91	49	0
1997	1 in 6	23.0	61	59	0
1998	1 in 6	17.7	59	55	0
1999	1 in 6	18.6	90	66	0
2000	1 in 6	18.6	64	53	0
2001	1 in 6	19.8	69	66	0
2002	1 in 6	18.5	46	40	0
2003	1 in 6	32.1 <sup>d</sup>	590 <sup>d</sup>	92	1
2004	1 in 6	16.7	70	43	0
2005	1 in 6	17.4	90	65	0
2006	1 in 6	18.9	65	60	0
2007	1 in 6	19.3	223 <sup>e</sup>	48	1
2008	1 in 6	16.6	70	53	0

<sup>a</sup> Incomplete data for year, sampling began early October 1985

<sup>b</sup> Sampling frequency switched from every day sampling to once every six days in July 1990

<sup>c</sup> Exceedances in 1992 attributed to resuspended ash from Mt. Spurr

<sup>d</sup> Exceedance on March 12, 2003 attributed to high winds. This value and 92 µg/m<sup>3</sup> value measured on March 10, 2003 contributed disproportionately to high annual average for 2003.

<sup>e</sup> Exceedance on December 2, 2007 attributed to high winds.

Discontinued Sites

**Table 3-1(d)**  
**Muldoon PM<sub>10</sub> Station**  
**1100 Muldoon Road, Anchorage**

Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1995 <sup>a</sup>	1 in 2	--	116	89	0
1996	1 in 2	23.8	98	94	0
1997	1 in 2	24.2	125	100	0
1998	1 in 2	20.7	76	58	0
1999	1 in 2	18.8	94	64	0
2000	1 in 2 <sup>b</sup>	--	89	78	0
2001	1 in 2 <sup>b</sup>	--	180 <sup>c</sup>	82	1
2002	1 in 2 <sup>b</sup>	--	63	58	0
2003	1 in 2 <sup>b</sup>	--	277 <sup>d</sup>	187 <sup>e</sup>	3 <sup>f</sup>
2004	1 in 2 <sup>b</sup>	--	83	55	0
2005	1 in 2 <sup>b</sup>	--	112	82	0

<sup>a</sup> Sampling began mid-April 1995

<sup>b</sup> Sampling conducted during peak PM<sub>10</sub> periods in spring and fall only

<sup>c</sup> Exceedance measured on March 18, 2001 was attributed to high winds.

<sup>d</sup> Exceedance measured on March 12, 2003 was attributed to high winds.

<sup>e</sup> Exceedance measured on April 19, 2003 was attributed to parking lot sweeping activity.

<sup>f</sup> 3<sup>rd</sup> exceedance measured on March 13, 2003 attributed to high winds.

**Table 3-1(e)**  
**Gambell PM<sub>10</sub> Station**  
**1950 Gambell Street, Anchorage**

Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1988	1 in 2	27.6	134	132	0
1989	1 in 2	30.5	137	104	0
1990	1 in 2 <sup>a</sup>	39.6	260 <sup>b</sup>	188 <sup>b</sup>	2 <sup>b</sup>
1991	every day	36.6	144	141	0
1992	every day	49.4	565 <sup>c</sup>	446 <sup>c</sup>	11 <sup>c</sup>
1993	every day	40.2	185	174	6
1994	every day	39.2	242	198	5
1995	every day	38.5	206	192	5
1996	every day	35.7	210 <sup>d</sup>	158 <sup>e</sup>	2 <sup>d,e</sup>
1997	every day	32.0	128	127	0
1998	every day	26.4	115	98	0
1999 <sup>f</sup>	every day	--	87	73	0

<sup>a</sup> Sampling frequency changed from once every two days to every day sampling in July 1990

<sup>b</sup> Exceedances in 1990 attributed to resuspended volcanic ash from Mt. Redoubt

<sup>c</sup> Exceedances in 1992 attributed to resuspended volcanic ash from Mt. Spurr

<sup>d</sup> Exceedance in 1996 attributed to Houston - Big Lake Fire on 6/4/96.

<sup>e</sup> Exceedance in 1996 attributed to blowing dust from high winds on 5/14/96.

<sup>f</sup> Sampling discontinued April 30, 1999.

Table 3-1(f) Oceanview School PM <sub>10</sub> Station 11911 Johns Road, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1990 <sup>a</sup>	1 in 2	--	81	77	0
1991	1 in 2	24.1	130	99	0
1992	1 in 2	29.9	549 <sup>b</sup>	331 <sup>b</sup>	5 <sup>b</sup>
1993	1 in 2	21.1	123	69	0
1994	1 in 2	21.6	84	79	0
1995	1 in 2	20.3	147	102	0
1996	1 in 2	20.7	147	85	0
1997	1 in 2	18.4	136	95	0
1998	1 in 2	15.9	61	54	0
1999 <sup>c</sup>	1 in 2	15.0	90	41	0

<sup>a</sup> Incomplete data for year, sampling began early October 1990

<sup>b</sup> Exceedances in 1992 attributed to resuspended volcanic ash from Mt. Spurr

<sup>c</sup> Sampling discontinued in February 2000

Table 3-1(g) Minnesota PM <sub>10</sub> Station 3443 Minnesota Blvd., Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1997 <sup>a</sup>	1 in 2	--	95	91	0
1998	1 in 2	--	59	48	0

<sup>a</sup> Sampling began March 1997 and ended May 1998

Table 3-1(h) Spenard PM <sub>10</sub> Station 3309 Spenard Road, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1997 <sup>a</sup>	1 in 2	--	139	116	0
1998	1 in 2	--	72	65	0

<sup>a</sup> Sampling began February 1997 and ended May 1998

<b>Table 3-1(i)</b> <b>Caribou PM<sub>10</sub> Station</b> <b>Homestead Elementary School, Eagle River</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1992 <sup>a</sup>	every day	--	304 <sup>b</sup>	170 <sup>b</sup>	3 <sup>b</sup>
1993	every day	16.5	71	66	0
1994	every day	16.3	90	66	0
1995	every day	14.3	102	80	0
1996 <sup>c</sup>	every day <sup>c</sup>	--	81	68	0

<sup>a</sup> Incomplete data for year, sampling began late May 1992

<sup>b</sup> Exceedances in 1992 attributed to resuspended volcanic ash from Mt. Spurr

<sup>c</sup> Incomplete data, sampling discontinued after October 1, 1996

<b>Table 3-1(j)</b> <b>Colville PM<sub>10</sub> Station</b> <b>AWWU well house, northeast of Baronoff &amp; Colville Streets, Eagle River</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1988 <sup>a</sup>	every day	--	140	130	0
1989	every day	23.6	108	106	0
1990	every day	21.3	101	83	0
1991	every day	28.2	180	148	1
1992 <sup>b</sup>	every day	--	147	116	0

<sup>a</sup> Incomplete data available for year, sampling began late August 1988

<sup>b</sup> Sampling discontinued May 1992

<b>Table 3-1(k)</b> <b>7th &amp; C Street PM<sub>10</sub> Station</b> <b>Downtown Fire Station, Anchorage Fire Department, 625 C Street, Anchorage</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1985 <sup>a</sup>	every day	--	76	66	0
1986	every day	31.3	115	105	0
1987	1 in 6	20.9	63	59	0
1988	1 in 6	18.1	47	46	0
1989	1 in 6	17.7	63	41	0
1990 <sup>b</sup>	1 in 6	--	108	94	0

<sup>a</sup> Only one quarter of data available for year, sampling began early October 1985

<sup>b</sup> Sampling discontinued late September 1990

<b>Table 3-1(l)</b> <b>Old Public Works Building PM<sub>10</sub> Station</b> <b>Municipal Public Works Building, 3500 E. Tudor Road, Anchorage</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1985 <sup>a</sup>	1 in 6	--	115	40	0
1986	1 in 6	25.7	96	92	0
1987 <sup>b</sup>	1 in 6	19.5	65	47	0

<sup>a</sup> Only one quarter of data available for year, sampling began early October 1985

<sup>b</sup> Sampling discontinued late December 1987

<b>Table 3-1(m)</b> <b>Homestead Elementary School PM<sub>10</sub> Station</b> <b>18001 Baronoff Avenue, Eagle River</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1987 <sup>a</sup>	1 in 2	--	40	39	0
1988 <sup>b</sup>	1 in 2	--	55	48	0

<sup>a</sup> Sampling conducted from early May 1987 through late November 1987

<sup>b</sup> Sampling conducted from early April 1988 through late October 1988

<b>Table 3-1(n)</b> <b>Anchorage Wastewater Treatment Facility PM<sub>10</sub> Station</b> <b>Artillery Road, Eagle River</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1987 <sup>a</sup>	1 in 2	--	24	19	0

<sup>a</sup> Sampling conducted from early May 1987 through early December 1987

<b>Table 3-1(o)</b> <b>Eagle River Elementary School PM<sub>10</sub> Station</b> <b>Old Eagle River Road, Eagle River</b>					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1987 <sup>a</sup>	1 in 2	--	40	40	0

<sup>a</sup> Sampling conducted from early May 1987 through early December 1987

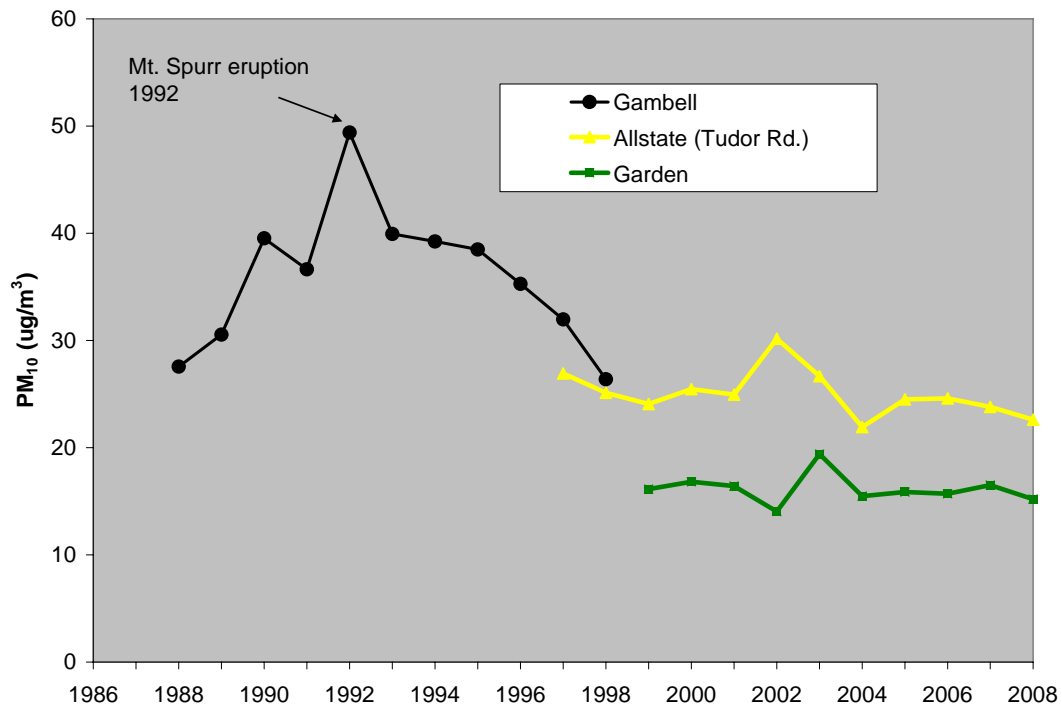
Table 3-1(p) Fire Lake Recreation Center PM <sub>10</sub> Station East of Old Glenn Highway, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2nd Highest 24-Hour Avg (µg/m <sup>3</sup> )	No of Days Exceeding NAAQS
1987 <sup>a</sup>	1 in 2	--	21	19	0

<sup>a</sup> Sampling conducted from early May 1987 through early December 1987

### PM<sub>10</sub> Trends in Anchorage

It is difficult to evaluate long term PM<sub>10</sub> trends for Anchorage because no single monitoring station has been operating for the entire period of interest (1980–2008). Figure 3-4 shows annual average PM<sub>10</sub> concentration at the Gambell, Allstate and Garden station. The Gambell station collected eleven years of data beginning in 1988 but had to be discontinued in 1998 when the building it was on was razed. PM<sub>10</sub> data has been collected at the Allstate building on Tudor Road from 1996 through 2008. Data have been collected at the Garden station, located in an east Anchorage residential area, since 1999.

Figure 3-4  
Trends at Anchorage PM<sub>10</sub> Stations



Elevated PM<sub>10</sub> levels were observed during the months following the eruptions of Mount St. Augustine in 1986, Redoubt in 1989 and Spurr in 1992. The eruption of Mt. Spurr was a particularly significant event; PM<sub>10</sub> impacts persisted for a number of years following the eruption. Microscopic techniques were used to quantify the impact of Mt. Spurr ash on PM<sub>10</sub> levels in Anchorage following the eruption in August 1992. Mt. Spurr ash accounted for about 90% of the PM<sub>10</sub> on days immediately following the eruption. Microscopic analysis of PM<sub>10</sub> samples collected

in 1994 indicated that 20 to 30% of the PM<sub>10</sub> mass was composed of volcanic ash suggesting that it was a significant contributor to PM<sub>10</sub> two years after the eruption.

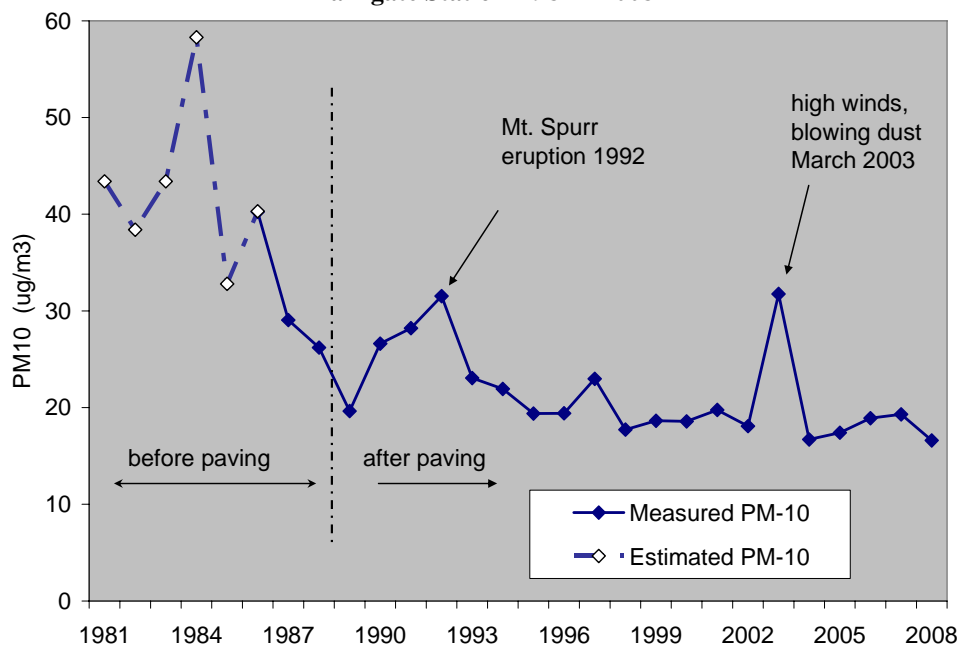
PM<sub>10</sub> concentrations are substantially higher along major roadways. The Gambell and Allstate stations are located on major roadways with average traffic exceeding 50,000 vehicles per day. Average PM<sub>10</sub> concentrations at these two roadway sites are 50 to 100% higher than the Garden station which is located in a residential area with much lower traffic volumes.

Significant changes in road sanding and clean-up methods were made beginning in 1996 in order to address roadway PM<sub>10</sub> emissions. The amount of winter traction sand applied to roadways was cut by more than half. The amount of fines allowed in the sand has been cut from 5% to less than 1%. The municipality has been applying magnesium chloride brine to dust laden roadway shoulders and medians in an effort to reduce to PM<sub>10</sub> emissions. Although year-to-year variability in PM<sub>10</sub> concentrations resulting from natural events such as wind storms and volcanic eruptions make it difficult to discern and quantify the impact that changes in street maintenance practices have had on PM<sub>10</sub> concentrations, there appears to be some evidence that PM<sub>10</sub> concentrations have been reduced. During the past 12 years the Allstate station has exhibited a weak downward trend in annual average PM<sub>10</sub> concentrations averaging about 1% per year.

### PM<sub>10</sub> Trends in Eagle River

An extensive historical record of particulate concentrations is available from the Parkgate station in Eagle River. Total suspended particulate (TSP) monitoring began at Parkgate in 1973 and continued through the end of 1986. PM<sub>10</sub> monitoring was initiated in October of 1985 and continues to present. Concurrent TSP and PM<sub>10</sub> monitoring between October 1985 and December 1986 enabled a linear regression relationship between PM<sub>10</sub> and TSP to be developed. This allowed PM<sub>10</sub> concentrations to be predicted from TSP measurements made from in 1981 through 1985, before PM<sub>10</sub> data were collected. Annual average PM<sub>10</sub> concentrations are plotted in Figure 3-5.

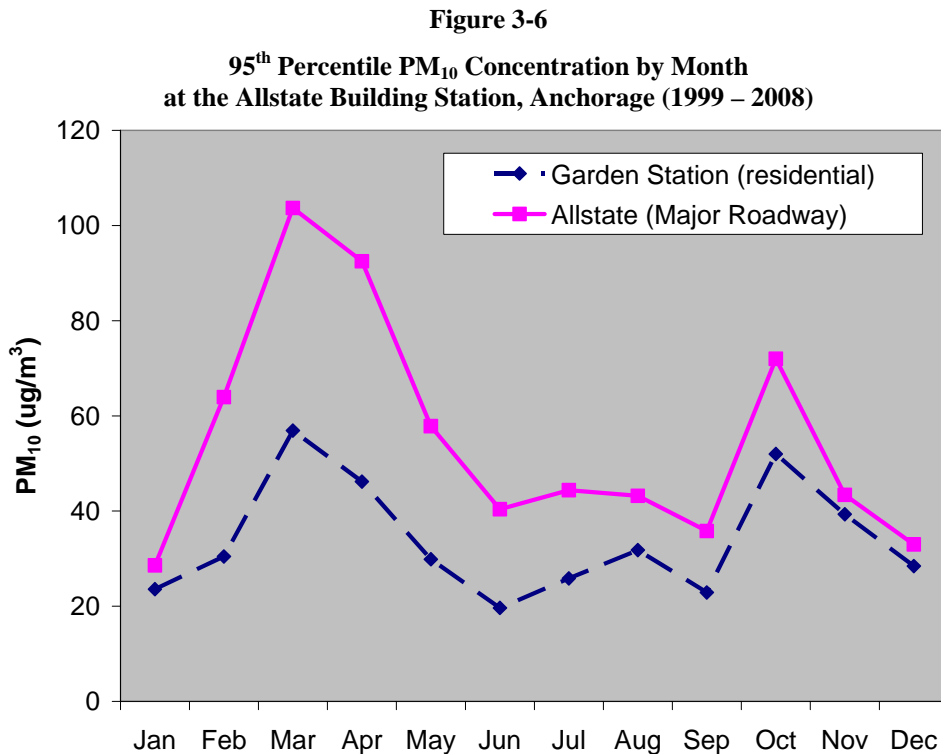
**Figure 3-5**  
**Trend in Average Annual PM<sub>10</sub> Concentrations at Eagle River**  
**Parkgate Station 1981 – 2008**



The EPA declared Eagle River a PM<sub>10</sub> nonattainment area as a result of violations of the NAAQS in 1985, 1986 and 1987. In September of 1988, many of the roads surrounding this site were paved or surfaced with recycled asphalt. As one might expect, PM<sub>10</sub> concentrations declined. On average, PM<sub>10</sub> levels at Parkgate dropped by almost 50% after roads were paved or surfaced with recycled asphalt. Elevated annual averages in 1990, 1991, and 1992 reflect the impact of ash fall from the eruption of Mt. Redoubt (December 1989) and Mt. Spurr (1992). The elevated annual average in 2003 was largely the result of a week long wind storm in March 2003. Blowing dust, much of it from glacier river drainages in the Matanuska Valley, was a major contributor to the high concentrations. Except for natural events such as volcanic eruptions and wind/dust storms, Eagle River has been in compliance with the NAAQS since 1988. DHHS recently prepared a draft PM<sub>10</sub> maintenance plan that requests that EPA redesignate Eagle River as an attainment area for PM<sub>10</sub>.

### Seasonality of PM<sub>10</sub> Concentrations in Anchorage and Eagle River

The highest PM<sub>10</sub> concentrations occur during "break-up" in late March and early April and during "freeze-up" in late October and early November. Typically, concentrations are lowest in mid-summer and mid-winter. Upper 95<sup>th</sup> percentile concentrations from the Allstate station near Tudor Road and Garden station in east Anchorage are plotted by month in Figure 3-6.



### Influence of Weather on PM<sub>10</sub> Concentrations

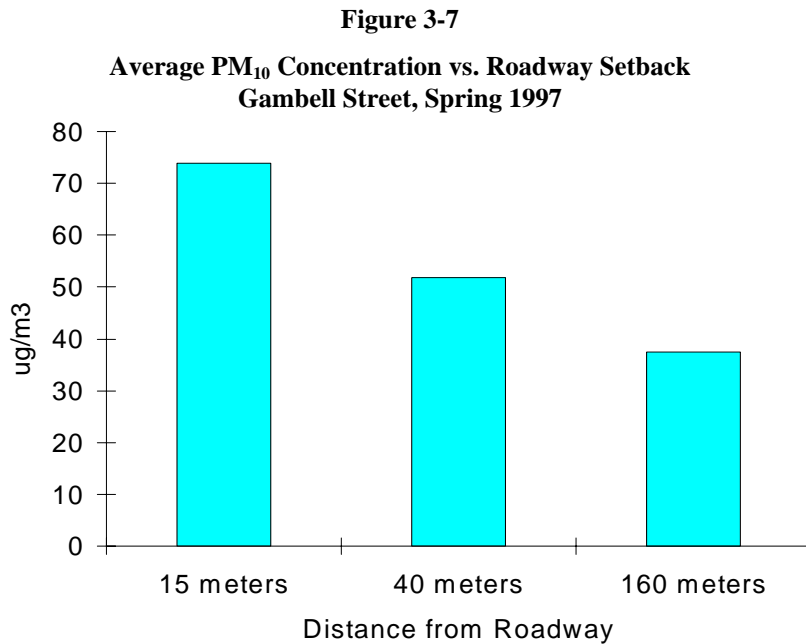
Weather strongly influences PM<sub>10</sub> concentrations in Anchorage and Eagle River. Because road dust emissions are the largest source of PM<sub>10</sub>, exceedances of the NAAQS are almost always associated with prolonged periods of dry, cool weather. Lower than normal precipitation in April and lack of snow cover in the late fall months are associated with high PM<sub>10</sub>. During the spring break-up period the highest PM<sub>10</sub> concentrations occur when temperatures fall below freezing at night and warm-up

during the day. Melting during the day provides a mechanism to carry fine dust particles from roadway shoulders heavily laden with accumulated road sand into the traveled portion of the road surface. The melt water dries up at night when temperatures fall below freezing leaving these fine dust particles where they can be more easily re-entrained by passing traffic. Elevated PM<sub>10</sub> concentrations occur during the period when temperatures fall below freezing, particularly during the morning commute when traffic is heavy.

It should be noted that the highest PM<sub>10</sub> levels normally occur on days with low wind speeds. When wind speeds are low, atmospheric mixing is often poor and PM<sub>10</sub> emissions are trapped close to the ground. Moderately windy days, with improved atmospheric mixing, normally have lower PM<sub>10</sub> levels. However, during periods of extreme winds, (i.e. sustained winds of more than 25 mph) PM<sub>10</sub> levels can be very high because of an increase in wind blown dust.

### Effect of Proximity to Roadways on PM<sub>10</sub> Concentrations

PM<sub>10</sub> monitoring in Anchorage implicates major roadways as the source of PM<sub>10</sub> emissions and the data suggest that except for natural events like volcanic eruptions or wind storms, PM<sub>10</sub> exceedances occur only near major roadways. PM<sub>10</sub> drops dramatically as the distance from the roadway increases. In 1997, during the spring break-up period, PM<sub>10</sub> concentrations measured 40 meters from Gambell were about 30% lower than those measured 15 meters from the road and 50% lower at a monitor 160 meters from the road.



## PM<sub>10</sub> Concentrations in Anchorage Compared with Other Areas

PM<sub>10</sub> concentrations from a number of other selected western cities are compared to Anchorage in Table 3-2. Data were compiled from the EPA AIRdata database (<http://www.epa.gov/oar/data/>) which summarizes PM<sub>10</sub> data collected from 1,114 monitors operated in the U.S during 2007. The Allstate monitor on Tudor Road in Anchorage measured a maximum 24-hour concentration of 99 µg/m<sup>3</sup> in 2007. The Park Gate monitor in Eagle River measured 223 µg/m<sup>3</sup> during a wind storm that stirred up dust from glacier river drainages in the Mat Su Valley on December 2.

Comparison of data from different cities should be done with caution. PM<sub>10</sub> measurements are highly dependent on proximity to local sources (e.g. road ways, industrial sources, etc.) and may not necessarily be representative of area-wide air quality.

Metropolitan Area	Annual Avg PM <sub>10</sub> (µg/m <sup>3</sup> )	Highest 24-Hour Avg (µg/m <sup>3</sup> )	2 <sup>nd</sup> Highest 24-Hour Avg (µg/m <sup>3</sup> )
Phoenix, AZ	42	267	149
<b>Eagle River, AK</b>	<b>19</b>	<b>223</b>	<b>48</b>
Albuquerque, NM	35	194	130
El Paso, TX	34	181	167
Salt Lake City, UT	46	174	172
Reno, NV	44	130	115
Las Vegas, NV	39	127	127
San Diego, CA	30	110	58
<b>Anchorage, AK</b>	<b>24</b>	<b>99</b>	<b>98</b>
Spokane, WA	24	89	79
Portland, OR	25	82	68
Eugene, OR	16	78	70
Seattle, WA	20	60	53
Juneau, AK	7	45	21

## PM<sub>2.5</sub> Data Summary

Sampling with EPA-approved reference samplers began in Anchorage in November 1998. PM<sub>2.5</sub> data from the Garden and Allstate stations are summarized in Tables 3-3(a) and (b). Monitoring at the Allstate site was discontinued at the end of 2002. Annual average and 24-hour concentrations measured at both sites have been well below the NAAQS. In 2005, the maximum 24-hour PM<sub>2.5</sub> concentration reached 55.9 µg/m<sup>3</sup> on July 15 when smoke from the Fox Creek fire, south of Tustumena Lake on the Kenai Peninsula, blanketed Anchorage.

The PM<sub>2.5</sub> NAAQS is set at 15 µg/m<sup>3</sup> as an annual average. The 24-hour average NAAQS is set at 35 µg/m<sup>3</sup> for the 98<sup>th</sup> percentile value. No more than 2% of the days sampled may exceed this value.

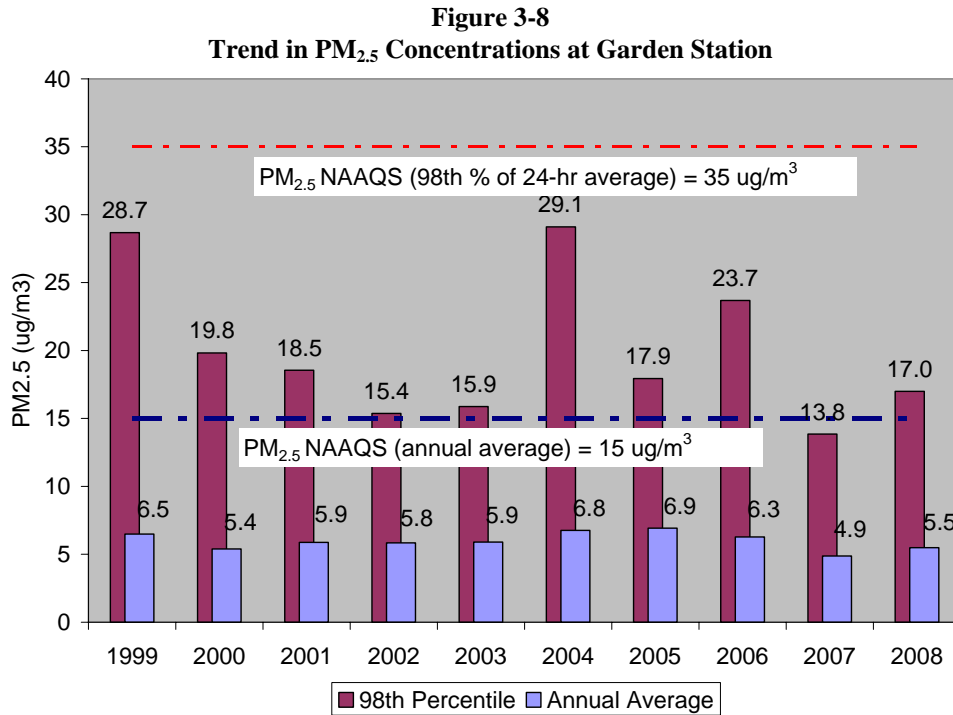
<b>Table 3-3(a)</b> <b>PM<sub>2.5</sub> Data Summary</b> <b>Garden Station (1999 – 2008)</b> 3000 E 16 <sup>th</sup> Street, Anchorage			
	Annual Average	Annual Max	98 <sup>th</sup> Percentile
1999	6.5	69.8 <sup>a</sup>	28.7
2000	5.4	38.9	19.8
2001	5.9	27.8	18.5
2002	5.8	16.9	15.4
2003	5.9	25.4	15.9
2004	6.8	32.1	29.1
2005	6.9	55.9	17.9
2006	6.3	34.1	23.7
2007	4.9	17.6	14.5
2008	5.5	22.1	17.0

<b>Table 3-3(b)</b> <b>PM<sub>2.5</sub> Data Summary</b> <b>Allstate Building Station (1999 – 2002)</b> 3335 East Tudor Road, Anchorage			
	Annual Average	Annual Max	98 <sup>th</sup> Percentile
1999	6.8	43.7	21.6
2000	6.1	32.8	16.3
2001	6.2	30.0	15.5
2002	6.9	20.8	17.4
2003	---	---	---
2004	---	---	---
2005	---	---	---
2006	---	---	---
2007	---	---	---
2008	---	---	---

<sup>a</sup> This value is considered suspect. Although no specific cause was identified that would allow this value to be flagged or discounted, it is inconsistent with other data collected.

### Anchorage PM<sub>2.5</sub> Trends

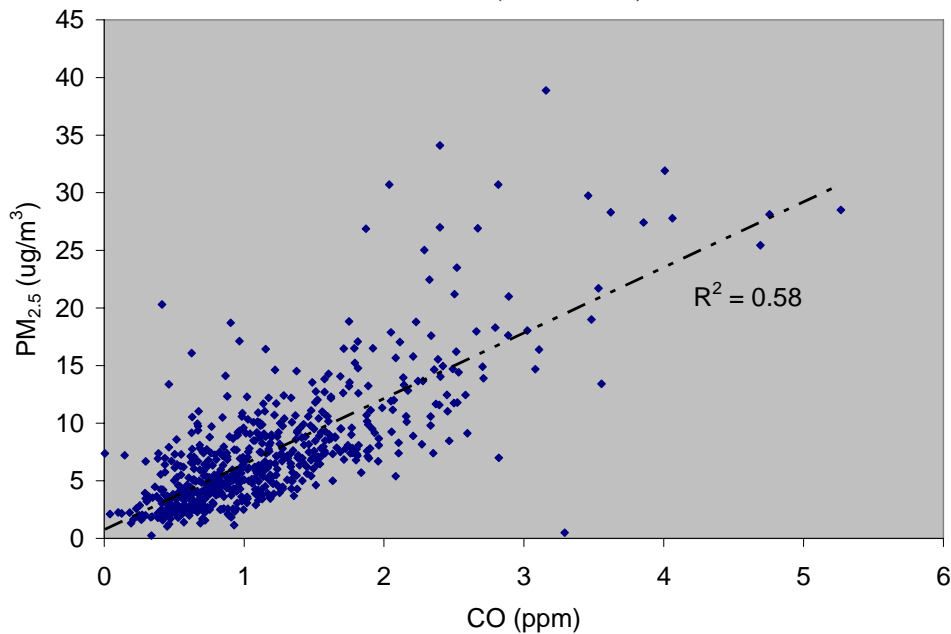
Annual average and 98<sup>th</sup> percentile PM<sub>2.5</sub> concentrations from 1999 through 2008 are plotted in Figure 3-8. No clear trend is evident. The plot shows that PM<sub>2.5</sub> concentrations at the Garden station are in compliance with the annual average and 24-hour average PM<sub>2.5</sub> NAAQS.



### Sources of PM<sub>2.5</sub> in Anchorage

Data collected thus far in Anchorage suggests that PM<sub>2.5</sub> originates from different sources than PM<sub>10</sub>. While the majority of PM<sub>10</sub> in Anchorage has been shown to be of geological origin, PM<sub>2.5</sub> appears to have a different source. The highest PM<sub>2.5</sub> concentrations usually occur on days when the CO concentrations are also high. This suggests that the same source that contributes the majority of CO emissions, motor vehicle exhaust, is also the main source of PM<sub>2.5</sub>. Fireplaces and woodstoves are also suspected as a significant source. Figure 3-9 shows a scatter plot comparison of PM<sub>2.5</sub> and CO measured at the Garden Station. The strong association between PM<sub>2.5</sub> and CO measurements ( $R^2 = 0.58$ ) suggests that these two pollutants have a common source.

**Figure 3-9**  
**Scatterplot Comparison of PM<sub>2.5</sub> and CO Concentrations at Garden Station (1999 – 2008)**



### PM<sub>2.5</sub> Concentrations in Anchorage Compared with Other Areas

PM<sub>2.5</sub> concentrations from a number of other selected western cities are compared to Anchorage in Table 3-9. Data were compiled from the EPA AIRdata database (<http://www.epa.gov/oar/data/>) which summarizes PM<sub>2.5</sub> data collected from 1,136 monitors operated in the U.S during 2007. Anchorage PM<sub>2.5</sub> concentrations were low relative to most other cities; concentrations measured at the Garden station were among the lowest 2% in the U.S.

Comparison of data from different cities should be done with caution. Measurements are highly dependent on proximity to local sources (e.g. road ways, industrial sources, etc.) and may not necessarily be representative of area-wide air quality.

Table 3-4		
Comparison of Calendar Year 2007 PM <sub>2.5</sub> Concentrations in Selected Western Metropolitan Areas in the U.S.		
Metropolitan Area	98 <sup>th</sup> Percentile of 24-hour Average (µg/m <sup>3</sup> )	Annual Average (µg/m <sup>3</sup> )
Salt Lake City, UT	79.2	16.1
Juneau, AK	39.6	6.6
San Diego, CA	36.9	12.7
Eugene, OR	36.3	7.3
Phoenix, AZ	29.2	12.3
El Paso, TX	28.7	11.7
Spokane, WA	28.3	9.6
Seattle, WA	26.2	9.6
Reno, NV	24.0	8.0
Las Vegas, NV	22.6	10.3
Portland, OR	20.9	10.2
Albuquerque, NM	18.4	6.7
<b>Anchorage, AK</b>	<b>14.5</b>	<b>4.9</b>

## References

1. Aerometric Information and Retrieval System (AIRS), Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency.
2. "Particulate Air Pollution and Disease in Anchorage, Alaska," Gordian M.E.; Ozkaynak, H.; Xue, J.; Morris, S.S.; Spengler, J.D. *Environmental Health Perspectives*, 104:290-297, March 1996
3. "Source of Particles on PM<sub>10</sub> Filters, Anchorage, Alaska," Laboratory Report from Microlab Northwest for the Municipality of Anchorage, Report No. 1062-94, October 17, 1994
4. "Eagle River PM<sub>10</sub> Control Plan," Municipality of Anchorage, Department of Health and Human Services, September 24, 1991
5. "Aerosol Characterization Study of Anchorage, Alaska: Chemical Analysis and Source Apportionment," prepared by NEA, Inc. for the Municipality of Anchorage, January 23, 1985
6. "Source Apportionment by Chemical Mass Balance Technique of PM<sub>10</sub> Sources in Eagle River and Juneau, Alaska," prepared for the Alaska Department of Environmental Conservation by NEA, Inc., May 23, 1988
7. "Identification, Quantification, and Control of PM<sub>10</sub> Sources in Anchorage," prepared by the Midwest Research Institute for the Municipality of Anchorage, April 15, 1999

## **Section 4 - Airborne Lead**

### **Health Effects of Lead**

Exposure to airborne lead can occur directly by breathing or indirectly by eating lead-contaminated food, water, or non-food materials including dust and soil. The most common source of lead exposure is lead-contaminated dust from lead-based paint. Lead-based paint is common in older homes.

Fetuses, infants and children are most sensitive to lead exposure. Central nervous system damage can occur even at low exposures. There is an association between elevated blood lead levels and lower IQ test scores in children. Studies have implicated lead as a factor in high blood pressure and heart disease. Exposure to lead has declined dramatically in the late 1980's as a result of the reduction of lead in gasoline, paint, and the elimination of lead from soldered cans.

In October 2008 EPA lowered the NAAQS for airborne lead ten-fold after reviewing new health and epidemiological data and concluding that health effects occur at much lower levels than previously believed. The NAAQS was lowered from 1.5  $\mu\text{g}/\text{m}^3$  to 0.15  $\mu\text{g}/\text{m}^3$ .

### **Sources of Lead in Anchorage**

In the mid and early 1980's the main source of airborne lead in Anchorage was leaded gas. This source has been virtually eliminated as the result of federal regulation and voluntary efforts from local gasoline distributors. EPA reduced the allowable lead content in gasoline from an average of 1.0 grams per gallon to 0.1 grams per gallon by January 1, 1986. Nationwide, sales of leaded gasoline fell from about 40% of the retail market in 1984 to about 1% 1993. In Anchorage, none of the major gasoline retailers have offered leaded gasoline since 1993.

### **Airborne Lead Monitoring in Anchorage**

Airborne lead is sampled in much the same way as airborne particulate. A high volume sampler is used to draw large amounts of ambient air through a quartz fiber filter. The filter is analyzed by atomic absorption spectrophotometry to determine the mass of lead collected in the filter. The concentration of lead in the air can be calculated if the volume of air and mass of lead in the sample are known.

Ambient concentrations of lead were measured at a five locations in Anchorage in the early and mid-1980's. Locations of the four lead sampling stations are described in Table 4-1. Lead monitoring was discontinued in 1987 when it became apparent that ambient lead levels in Anchorage had declined to levels well below the NAAQS as a result of the reduction of lead in gasoline.

Now that a new, more stringent lead NAAQS has been established, monitoring will again be performed in Anchorage to determine whether airborne levels are in compliance with the new standard. Monitoring is expected to begin in 2010 or 2011.

<b>Table 4-1</b>		
<b>Description of Airborne Lead Monitoring Stations in Anchorage</b>		
<b>Site Name</b>	<b>Monitoring Duration</b>	<b>Location</b>
Gambell	October 1984 through December 1987	1950 Gambell Street
7th & C Street	March 1980 through March 1986	625 C Street at the old Anchorage Fire Department downtown station
8th & L Street	March 1980 through October 1982	Located near the northeast corner of 8th & L Street.
Cheechako Street	Oct 1983 through March 1984	Located on Cheechako Street just south of Northern Lights Boulevard.
Jefferson Avenue	Oct 1983 through March 1984	Located on Jefferson Avenue just west of Minnesota Drive

#### **Summary of Anchorage Airborne Lead Data**

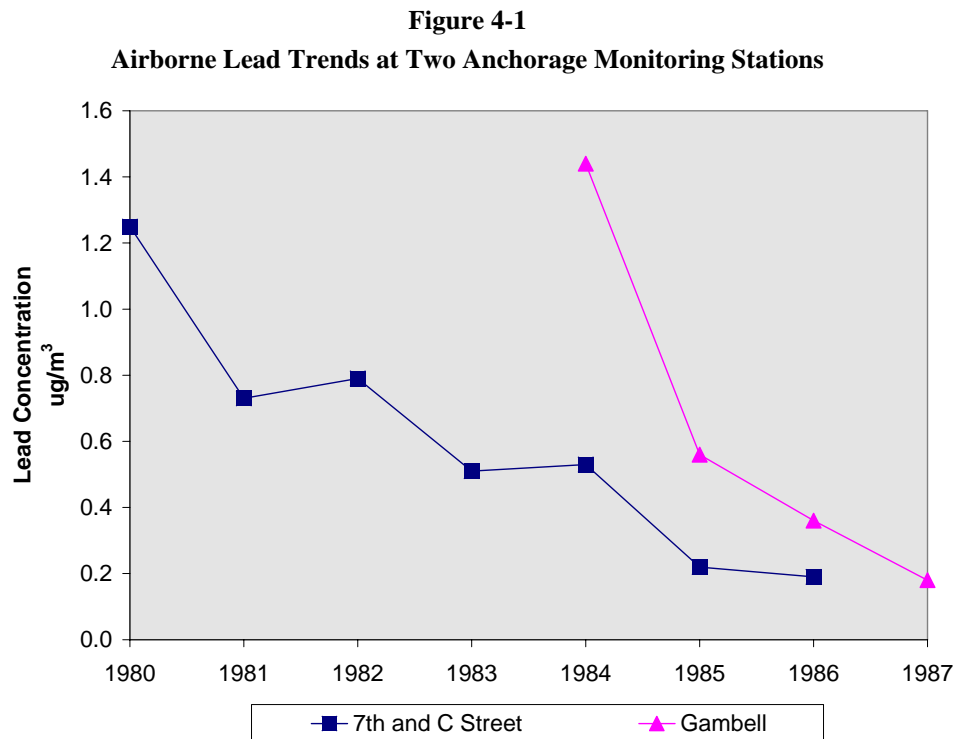
Quarterly average airborne lead concentrations declined from above 1.0  $\mu\text{g}/\text{m}^3$  in 1980 to less than 0.2  $\mu\text{g}/\text{m}^3$  in 1987 when monitoring was terminated. In Anchorage, airborne lead concentrations were highest during the winter months. Lead data are summarized in Table 4-2.

<b>Table 4-2</b>					
<b>Quarterly Average Lead Concentrations at Anchorage Monitoring Stations</b>					
<b>Highest Quarterly Average Measured in Each Calendar Year</b>					
<i>(all values in <math>\mu\text{g}/\text{m}^3</math>)</i>					
<b>Year</b>	<b>7th &amp; C Street</b>	<b>Gambell</b>	<b>8th &amp; L Street</b>	<b>Jefferson Avenue</b>	<b>Cheechako Street</b>
1980	1.25*	na	1.08*	na	na
1981	0.73	na	0.56	na	na
1982	0.79	na	0.47*	na	na
1983	0.51	na	na	1.41*	1.51*
1984	0.53	1.44*	na	1.03*	1.43*
1985	0.22	0.56	na	na	na
1986	0.19*	0.36	na	na	na
1987	na	0.18	na	na	na

\* Data from one or more quarters are missing

## Airborne Lead Trends in Anchorage

The downward trend in the maximum quarterly lead concentration at the Gambell and 7th & C Street stations is illustrated in Figure 4-1. The NAAQS at the time this monitoring was conducted was set at  $1.5 \mu\text{g}/\text{m}^3$ . The new EPA standard is now set at  $0.15 \mu\text{g}/\text{m}^3$ .



## Lead Concentrations in Anchorage Compared with Other Areas

In 1984, the maximum quarterly average lead concentration in Anchorage was higher than 95% or more of the 204 sites monitoring for lead in the U.S. At the current time, the status of Anchorage lead levels with respect to other cities is unknown.

## References

1. "National Air Quality and Emissions Trends Report, 1993," U.S. Environmental Protection Agency, EPA 454/R-94-026, October 1994
2. "Fact Sheet – Final Revisions to the Ambient Air Quality Standards for Lead, EPA, October 2008, <http://www.epa.gov/air/lead/pdfs/20081015pbfactsheet.pdf>

## Section 5 - Sulfur Dioxide

### Health Effects of Sulfur Dioxide

High concentrations of sulfur dioxide (SO<sub>2</sub>) may aggravate existing respiratory and cardiovascular disease. Asthmatics, and those with emphysema or bronchitis are the most sensitive to SO<sub>2</sub> exposure. Children and the elderly may also be more sensitive. SO<sub>2</sub> also contributes to acid rain. Acid rain can lead to the acidification of lakes and streams, and damage trees. Acid aerosols can also lead to the erosion of historic building and statues, especially those constructed from limestone or marble.

### Sources of SO<sub>2</sub> in Anchorage

There are no significant sources of SO<sub>2</sub> in Anchorage. SO<sub>2</sub> is emitted primarily from stationary source coal and oil combustion, steel mills, refineries, pulp and paper mills, and from non-ferrous smelters. These activities are very limited or non-existent in Anchorage. Natural gas is used almost exclusively to fuel electrical power generating facilities in the Anchorage area.

### SO<sub>2</sub> Monitoring in Anchorage

SO<sub>2</sub> was monitored in Anchorage from April 1983 through December 1984 at a site located downtown at 820 West 4th Avenue. The levels of SO<sub>2</sub> measured were uniformly low and well below the NAAQS in effect at that time. Data are summarized and compared to the NAAQS in Table 5-1.

<b>Averaging Period</b>	<b>Highest Concentration Measured in Anchorage</b>	<b>NAAQS* for Averaging Period</b>
Three-hour	27 ppb	500 ppb
24-hour	9 ppb	140 ppb
Annual	0.2 ppb	30 ppb

\* This was the NAAQS in effect when monitoring was performed. The three-hour standard has been revoked, the 24-hour and annual average standard remain the same today.

### SO<sub>2</sub> Concentrations in Anchorage Compared with Other Areas

In 1983 and 1984, SO<sub>2</sub> levels in Anchorage were lower than 95% or more of the SO<sub>2</sub> monitoring stations operating in the U.S. at that time.

### References

1. "National Air Quality and Emissions Trends Report, 1993," U.S. Environmental Protection Agency, EPA 454/R-94-026, October 1994.

## Section 6 - Ozone

### Health Effects of Ozone

Ozone (O<sub>3</sub>) is a highly reactive gas that damages lung tissue, reduces lung function, and sensitizes the lung to other irritants. While stratospheric ozone shields the earth from damaging ultraviolet radiation, terrestrial or ground level ozone is a highly damaging air pollutant and is the primary component of smog. Scientific evidence suggests that the ambient ozone levels experienced in some urban areas not only affect people with existing lung problems, but healthy people as well. Recent studies show a correlation between hospital visits and ozone levels in several U.S. cities.

### Sources of O<sub>3</sub> in Anchorage

The vast majority of terrestrial ozone is formed as the result of complex photochemical reactions in the atmosphere involving volatile organic compounds (VOCs), nitrogen oxides (NO<sub>x</sub>) and oxygen (O<sub>2</sub>). Warm temperatures and sunlight enhance ozone formation. In the lower-48, peak ozone concentrations typically occur during hot, dry, stagnant summer-time conditions. Meteorological conditions in Anchorage do not favor ground level ozone formation. Temperatures above 80°F are very unusual even in summer. Anchorage receives a long period of sunlight in the summer months, but the intensity of the sun is diminished by the oblique angle that the sun rays are received at Anchorage's high (61°N) latitude.

### O<sub>3</sub> Monitoring in Anchorage

Ozone has been monitored at two locations in the Municipality of Anchorage. Monitoring was conducted in east Anchorage at the Airport Heights Fire Department Training Facility between April and December of 1983. Later, monitoring was also conducted in Eagle River, near the Anchorage Water and Wastewater Treatment Plant on Artillery Road between April and September of 1985. At both locations, the highest one-hour average concentrations of O<sub>3</sub> were found to be about one-half of the NAAQS in effect at that time. Ozone measurements at these two sites are compared to the NAAQS in Table 6-1.

<b>Monitoring Site</b>	<b>Period When Monitoring was Performed</b>	<b>Highest 8-Hour O<sub>3</sub> Measurement</b>
Airport Heights (Anchorage)	April 1983 - December 1983	29 ppb
AWWU Wastewater Plant (Eagle River)	April 1985 - September 1985	36 ppb

\* This was the NAAQS in effect when monitoring was performed. The current NAAQS is set at 75 ppb for an 8-hour average.

### O<sub>3</sub> Concentrations in Anchorage Compared with Other Areas

In 1985, the last year data was collected in Anchorage, peak hourly O<sub>3</sub> levels in Anchorage were lower than 95% or more of the stations operating in the U.S

### References

1. "National Air Quality and Emissions Trends Report, 1993," U.S. Environmental Protection Agency, EPA 454/R-94-026, October 1994.

## **Section 7 - Nitrogen Dioxide**

### **Health Effects of Nitrogen Dioxide**

Nitrogen dioxide (NO<sub>2</sub>) is a brownish, highly reactive gas that can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Continued and repeated exposure to high concentrations of NO<sub>2</sub> may cause acute respiratory disease in children.

NO<sub>2</sub> is an important precursor in the formation of ozone or smog. Consequently, control of NO<sub>2</sub> emissions is an important component of overall pollution reduction strategies in areas with ozone problems.

NO<sub>2</sub> is also a precursor in the formation nitric acid and other acid aerosols that may affect aquatic and terrestrial ecosystems.

### **Sources of NO<sub>2</sub> in Anchorage**

Nationwide, the main sources of NO<sub>2</sub> are industrial fuel combustion, electrical power generation and air and land transportation. In Anchorage, a comprehensive NO<sub>2</sub> inventory has not been prepared. However, the main sources of NO<sub>2</sub> in Anchorage are probably similar to the U.S. as a whole. Motor vehicles, natural gas combustion for electrical power, and aircraft are likely the major sources of NO<sub>2</sub> in Anchorage.

### **NO<sub>2</sub> Monitoring in Anchorage**

The DHHS has not monitored for NO<sub>2</sub>. No data are presented here.

### **NO<sub>2</sub> Concentrations in Anchorage Compared with Other Areas**

Since 1992, all areas of the country, including Los Angeles, which regularly experiences the highest concentrations of NO<sub>2</sub>, have been in compliance NAAQS. Although monitoring data are unavailable for Anchorage, it is very unlikely that Anchorage exceeds the NAAQS.

### **References**

1. "National Air Quality and Emissions Trends Report, 1993," U.S. Environmental Protection Agency, EPA 454/R-94-026, October 1994.

## **Section 8 - Volatile Organic Compounds**

### **Health Effects of Volatile Organic Compounds**

Volatile organic compounds (VOCs) include a vast array of carbon-based compounds that can be volatilized into the air. Most of these compounds are liquids at room temperature, however, a fraction of these liquids are vaporized or volatilized into the atmosphere. The volatility of each compound is a function of its vapor pressure.

Some of these compounds, such as benzene, 1,3-butadiene, formaldehyde and acetaldehyde are known or suspected carcinogens or cancer-causing agents. Long-term exposure to high levels of benzene in air has been shown to cause leukemia. Leukemia and lymphomas and other tumor types have been observed in experimental animals exposed to benzene by inhalation or oral administration. A number of adverse non-cancer effects have been associated with exposures to high levels (>50,000 ppb) for long periods of time. Studies addressing the risk of leukemia at moderate or low levels of exposure have been inconclusive. Mortality rates for leukemia among workers potentially exposed to petroleum products (and presumably benzene) have not been shown to be higher than the general population. However, a recent study has shown higher levels of nonlymphocytic leukemia in truck drivers, gas station attendants and those employed in jobs with greater exposure to petroleum products.

Ambient or outdoor levels of benzene exposure are substantially lower than the occupational exposures in the studies above. In the U.S., benzene concentrations in outdoor or ambient air rarely exceed 10 ppb even in the most polluted urban areas. Ambient concentrations of benzene are generally an order of magnitude or greater below the levels found in occupational settings involving contact with petroleum products.

Animal studies suggest that high concentrations of 1, 3-butadiene, formaldehyde, and acetaldehyde cause cancer in animals exposed through inhalation. Human epidemiological studies on these compounds are limited. Epidemiological evidence has implicated formaldehyde with increases in nasopharyngeal, nasal cavity and sinus cancers.

Unlike the criteria pollutants discussed earlier in this report (CO, PM<sub>10</sub>, lead, SO<sub>2</sub>, O<sub>3</sub>, and NO<sub>2</sub>), EPA has not established ambient air quality standards for VOCs.

### **VOC Monitoring in Anchorage**

Because benzene and other VOCs are not regulated by EPA as criteria pollutants, there has been less monitoring. However, DHHS is currently engaged in monitoring for a number of VOCs and semi-volatile air toxic compounds. This one-year monitoring study began in October 2008 and will gather baseline data on the concentration of benzene and other air toxics prior to EPA-mandated changes in the allowable benzene content of gasoline. New EPA rules are expected to reduce the benzene content of gasoline in Anchorage by three-fold or more by 2012. A follow-up monitoring study is planned to determine whether these rules will result in lower concentrations of benzene in Anchorage air.

Over the years, DHHS has conducted three ambient (outdoor) VOC monitoring studies. These include the "Ted Stevens Anchorage International Airport Air Toxics Monitoring Study" conducted in 2002, "Assessment of Indoor and Outdoor Concentrations of BETX and Carbonyl Compounds in Anchorage, Alaska" conducted 1994-96, and the "Final Report on the Operations and Findings of the Anchorage VOC Monitoring Project," conducted 1992-93. DHHS prepared a full report for each of these studies. Brief summaries of these three reports follow.

Ted Stevens Anchorage International Airport Air Toxics Monitoring Study - 2002

The purpose of this ambient monitoring study was to address concerns about toxic air pollution and associated odors in parklands and neighborhoods adjacent to the Ted Stevens Anchorage International Airport. It was prompted by odor complaints and concerns from residents living near the airport and users of Kincaid Park adjacent to the airport. Complaints were most common during the winter.

Sampling was performed using EPA Method TO-15 utilizing Summa canisters to collect 24-hour samples from each of the ten sites included in the study. Sampling was conducted during fourteen separate 24-hour periods between January 19, 2002 and February 28, 2002. Sampling sites are shown in Figure 8-1. Six of the ten sites were located either on or in close proximity to airport property. Four “non-airport” sites were selected for comparison. Three of these sites, the Seward Highway, Garden and Turnagain sites were placed at long-standing CO monitoring stations where VOC sampling had been conducted previously.

**Figure 8-1**

Location of Canister Sampling Sites for  
Ted Stevens Anchorage International Airport Air Toxics Monitoring Study



Site	Site Name	Location / Description
1	Kincaid	Kincaid Park approx 300 meters north of ski chalet
2	Little Campbell Lake	On airport fence line approx 200 meters northeast of Little Campbell Lake
3	NWS	National Weather Service office complex, 6930 Sand Lake Road
4	B-Concourse	Roof of Concourse B Passenger Terminal
5	North Runway	End of North Runway along airport fence line
6	Jones Lake	Turnagain residential area near Jones Lake
7	Turnagain	Permanent CO monitoring station, 3201 Turnagain Blvd.
8	Seward Hwy	Permanent CO monitoring station, 3002 New Seward Hwy
9	Garden	Permanent CO monitoring station, 3000 E. 16 <sup>th</sup> Street
10	Ocean Dock Road	Ocean Dock Road southwest of Port of Anchorage

**Figure 8-2**

B-Concourse Sampling Site (site #4)  
Summa canister located in lower right of photo



The Summa canister samples were analyzed for a total of 33 different VOC compounds. Only 5 of these were found at levels consistently above the detection limit. These compounds were benzene, toluene, ethylbenzene, m,p-xylene, and o-xylene; this group of VOCs is commonly called the BETX compounds. Figure 8-3 shows the average concentration for each of these five VOCs during the study.

**Figure 8-3**

Average Concentration of BETX Compounds at Canister Sampling Sites  
Ted Stevens Anchorage International Airport Air Toxics Monitoring Study  
January 19 – February 28, 2002

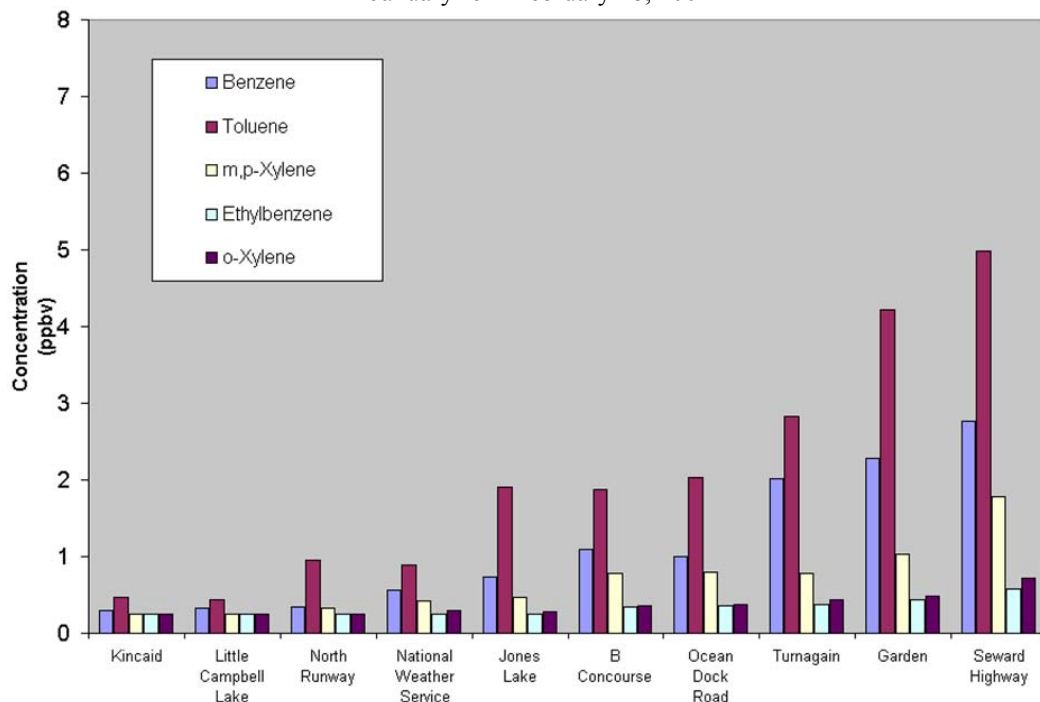


Figure 8-3 shows that BETX concentrations at the six sites nearest the airport were lower than the four “non-airport” sites. This was not surprising. Each of the BETX compounds are a significant component of gasoline and motor vehicle emissions are the predominant source of these compounds in ambient air. Canister sites located in areas with the most motor vehicle activity had the highest BETX concentrations. For example, the highest average BETX concentration was measured at the Seward Highway site, located at the busiest intersection in Anchorage. Motor vehicle activity at the six airport sites was relatively low. The two lowest concentration sites, at Kincaid Park and Little Campbell Lake were a significant distance from roadways and parking lots.

The data from this study were examined to determine whether any of the VOCs tested might be specifically associated with diesel and/or aircraft exhaust. No associations were found. This suggests that the compounds causing odors were not among the compounds analyzed or that the compounds creating odors are present at levels below the reporting limit of the analytical method employed in this study. Twenty-eight of the 33 compounds tested were consistently below their reporting limit.

#### 1994-96 Indoor and Outdoor VOC Assessment

The purpose of this air quality monitoring study was to measure and assess indoor and outdoor concentrations of volatile organic compounds during the period when ethanol-blended gasoline was being used in Anchorage. This study was conceived to help address concerns about possible health impacts of using ethanol-blended gasoline in a sub-arctic climate and to gather baseline information on indoor VOC exposures and sources within the home.

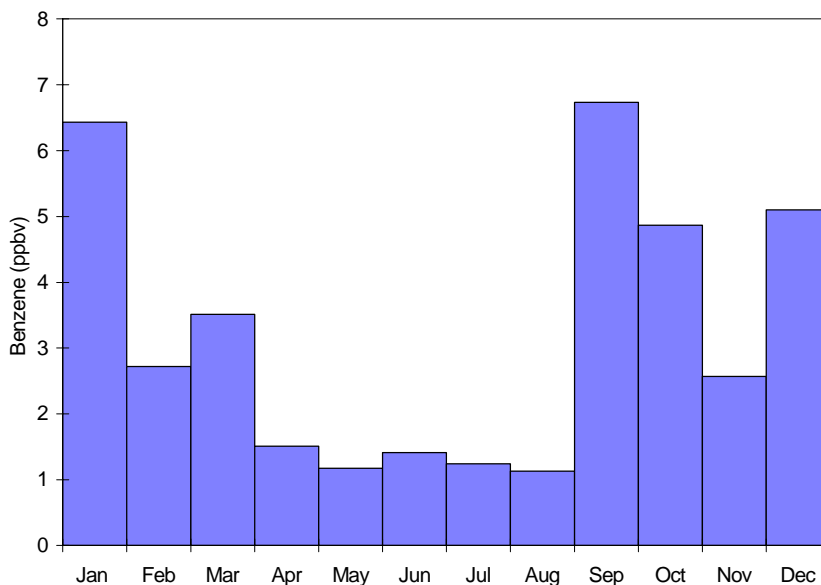
Eighteen different VOCs were measured in this study. Ambient monitoring was performed for 24-hours every twelve days at three outdoor sites from December 1994 through February 1996. These three outdoor sites were located at three of the permanent CO stations (Garden, Benson, and Sand Lake) to investigate the relationship between VOC concentrations and CO. Indoor sampling was also performed in Anchorage homes following an identical one-in-twelve day schedule. Three to five homes were sampled during each sampling period. During the course of the study, samples were collected from 137 homes in Anchorage.

The 18 VOCs measured in this study included the class of hydrocarbons known as carbonyls (these include the aldehydes and ketones) and the non-polar BETX (benzene, ethyl benzene, toluene, and xylene) compounds.

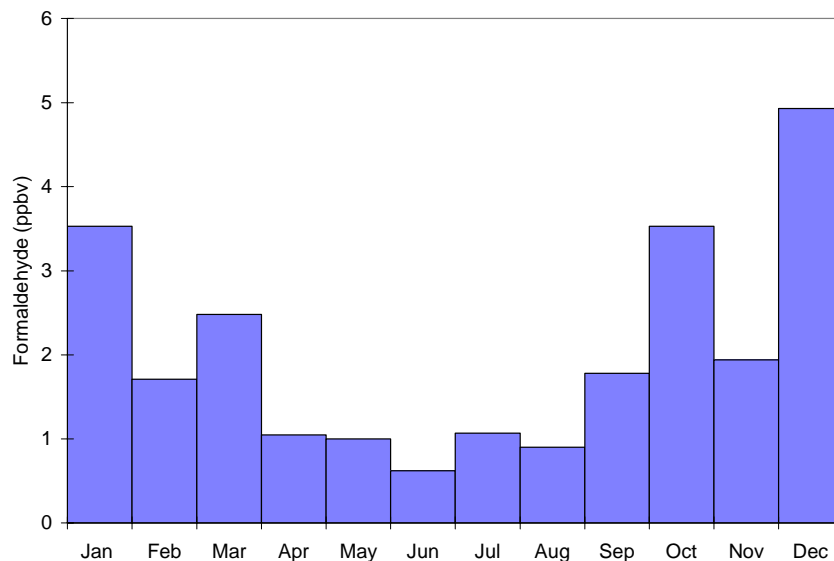
#### *Results of Outdoor Monitoring*

Monthly average formaldehyde and benzene concentrations at the Benson SLAMS site are plotted in Figures 8-4 (a-b). Concentrations of carbonyls and BETX tended to be higher in the winter months and lower in summer. A similar seasonal pattern was also observed at the Garden site.

**Figure 8-4(a)**  
Mean Benzene Concentrations by Month at Benson Site  
1994-96 VOC Assessment



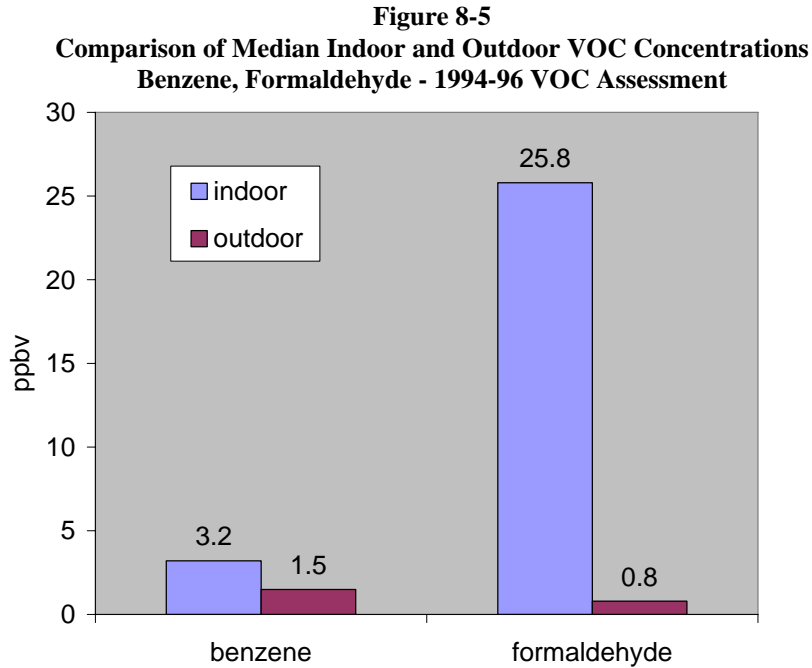
**Figure 8-4(b)**  
Mean Formaldehyde Concentrations by Month at Benson Site  
1994-96 VOC Assessment



Data from the study suggested that motor vehicle emissions were a major contributor to benzene, formaldehyde, acetaldehyde and other VOCs measured in the ambient air. Concentrations of these compounds were highest in the winter months of the study and were strongly correlated with carbon monoxide (CO) measurements. The strong associations observed between VOCs and CO implicate motor vehicle emissions as a major contributor to ambient VOCs in Anchorage.

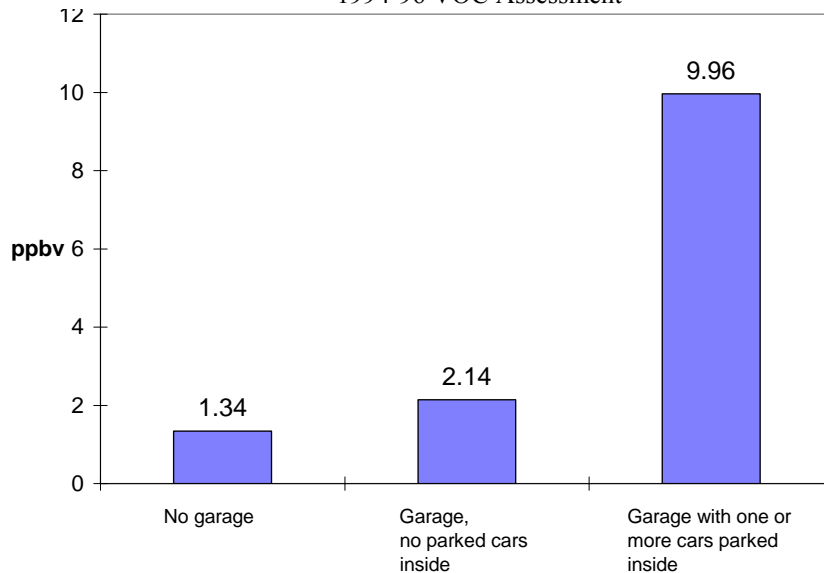
*Results of Indoor Monitoring*

Indoor concentrations of VOCs were 2 to 50 times higher than those measured outside. Indoor and outdoor concentrations of benzene and formaldehyde are compared in Figure 8-5.



Because people typically spend 90% or more of their time indoors, the majority of personal exposure to many VOCs is likely to be in the home or other indoor environments. The highest concentrations of BETX compounds were observed in homes with attached garages, especially if cars were parked inside. Figure 8-6 shows that the median concentration of benzene measured in households with attached garages was higher than those without particularly if the attached garage was used for parking.

**Figure 8-6**  
**Comparison of Median Benzene Concentrations in Anchorage Homes by Garage Configuration**  
**1994-96 VOC Assessment**



The data suggested that motor vehicle and/or gasoline-related emissions were not a significant source of indoor formaldehyde or acetaldehyde, however. These compounds were not correlated with the indoor BETX measurements indicating that they have a different source than the BETX compounds.

1993-94 VOC Monitoring Study

The primary purpose of this study was to address concerns about VOC exposures among residents of the Anchorage’s Government Hill neighborhood just north of downtown. Government Hill was bounded on the west and east by fuel storage facilities (tank farms) and these facilities created fuel odors that were the source of frequent complaints and concern by nearby residents.

VOC sampling was conducted at three sites in Government Hill and at eight other locations in Anchorage for comparison. The locations of the sites are shown in Figure 8-7.

**Figure 8-7**  
**Anchorage VOC Monitoring Study (1993-94) Sampling Locations**



Twenty-four hour samples were collected every twelve days during the 14 month study using Summa canisters. The sampling protocol employed in the Anchorage study was modeled after the EPA TAMS (Toxic Air Monitoring System) study conducted to measure levels of VOCs in four U.S. cities in 1987-88. Sampling and analytical protocols are described in EPA Method TO-14. Polar compounds such as aldehydes and ketones cannot be determined by this method. Samples were analyzed by gas chromatography for 37 possible VOCs.

Quantifiable levels of seven VOCs were regularly observed in the samples. Benzene, toluene, ethyl benzene, m & p-xylene, o-xylene, and 1,3,5 & 1,2,4 trimethylbenzene were all found in reportable quantities. Because of its known carcinogenicity, benzene was of the greatest interest. Benzene data are summarized in Table 8-1.

Site	Location	Mean Concentration (ppb)	Max Concentration (ppb)	Min Concentration (ppb)
1	Downtown	2.5	8.8	0.4
2	Gov Hill (bluff)	3.7	8.7	0.6
3	Gov Hill (Delaney St.)	2.3	7.0	1.0
4	Gov Hill School	1.8	7.8	0.4
5	Benson / Spenard Blvd.	5.4	20.8	1.0
6	Airport Post Office	2.0	7.0	0.3
7	Tanaina Drive	1.2	3.3	0.2
8	Sand Lake	2.4	10.4	0.4
9	Lower Hillside	1.4	3.7	0.3
10	16 <sup>th</sup> and Garden St	3.6	14.0	0.5
11	Muldoon	2.2	11.0	0.4

The highest concentrations of benzene were found in central Anchorage at the Benson CO monitoring station (VOC Site #5) near the intersection of Spenard Road and Benson Boulevard. The mean annual concentration at this high traffic volume intersection was 30% higher than the next highest site. The second highest concentration was found at Site #2 in Government Hill. Site #2 was located on the fence line just above one of the tank farms and was likely impacted by evaporative VOC emissions from the tanks.

Data collected strongly suggested that motor vehicles were the primary source of benzene and other VOCs in most of Anchorage. A very strong association was observed between CO concentrations and VOCs. The Pearson correlation coefficient (r) between CO and benzene was greater than 0.95 at all three sites where collocated VOC and CO measurements were taken.

In Government Hill, evaporative emissions from the tank farm appeared to be a significant source of ambient benzene and other VOCs. The highest benzene and VOC concentrations were found at sites closest to the tanks. Evaporative emissions from the tank farm appear to be the primary source of ambient benzene at the bluff site and contributed to the relatively high concentrations measured there. At the other two Government Hill sites, located further away from the tanks, motor vehicle emissions appeared to be the source of the majority of the ambient benzene. Evaporative emissions from the tanks, however, still contributed significantly to ambient benzene concentrations. Overall, ambient benzene exposures at these two sites were typical of other Anchorage residential areas even with the added contribution from the tank farm.

## Ambient VOC Trends

It is very difficult to determine trends in Anchorage VOC data because data have been collected sporadically. There is some evidence, however, that suggests that concentration of benzene and the other BETX has declined in proportion to the decline in ambient CO concentrations. Ambient CO is highly correlated with benzene and the other BETX compounds. Because ambient CO has declined by about 60%, it suggests that ambient BETX concentrations would have also declined by a like amount.

## Ambient Benzene Concentrations in Anchorage Compared with Other Cities

It is difficult to compare VOC data collected in Anchorage to other cities because of lack of recent data. The data collected thus far in the ongoing benzene monitoring study do not provide a sufficiently representative evaluation of year-long concentrations. The last time long-term VOC data were collected in Anchorage was the period from December 1994 – February 1996.

Because there is such a strong correlation between benzene and CO ( $r > 0.95$ ), ambient benzene concentrations can be reasonably estimated from CO concentrations. Using the observed relationship between CO and benzene concentrations, the average annual benzene concentration at the Garden station in east Anchorage was estimated to be 1.6 ppb (parts per billion) in 2007.\*\*\* This *estimated* concentration is compared with *measured* concentrations in other selected U.S. cities for 2007 in Table 8-2. This data suggests that Anchorage likely has an annual average benzene concentration that is among the highest in the country.

Metropolitan Area	Average Annual Benzene Concentration (ppb)
Tonawanda, NY	3.7
Houston, TX	1.4
<b>Anchorage**</b>	<b>1.4</b>
El Paso, TX	1.2
Phoenix, AZ	0.7
Los Angeles, CA	0.5
New York, NY	0.4
Seattle, WA	0.3
Boston, MA	0.3
Portland, OR	0.2

\*\* Anchorage benzene concentration was estimated from CO concentration at Garden station.

\*\*\* The relationship between benzene and CO is expressed by the following expression determined from coincident CO and benzene sampling at the Garden station:

$$[\text{benzene}] = 0.0028[\text{CO}] - 0.00013 \text{ where the CO and benzene concentration are expressed in ppm.}$$

The average measured CO concentration in the winter of 2007 (Jan – Mar, Oct-Dec) was 0.83 ppm and the summer CO concentration was estimated to be 0.25 ppm. Thus, the average annual CO concentration was approximately 0.54 ppm. The average annual benzene concentration is therefore:

$$[\text{benzene}] = 0.0028[0.54] - 0.00013 = 0.0014 \text{ ppm} = 1.4 \text{ ppb.}$$

## References

1. "Final Report on the Operations and Findings of the Toxic Air Monitoring System (TAMS)," G. Evans, Atmospheric Research and Exposure Assessment Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, N.C., 1990
2. "Benzene Toxicity - Case Studies in Environmental Medicine," Toxic Substances Disease Registry, Public Health Service, U.S. Department of Health & Human Services, October 1992/Revised June 2000
3. "Motor Vehicle Related Air Toxics Study," Office of Mobile Sources, U.S. Environmental Protection Agency, EPA 420-R-93-005, April 1993
4. "Final Report on the Operations and Findings of the Anchorage VOC Monitoring Project," L. Taylor, S. Morris, Document # 95-RA110.04, presented at the 88<sup>th</sup> Annual Meeting of the Air & Waste Management Association (San Antonio, TX) June 1995
5. "Architectural, Behavioral and Environmental Factors Associated with VOCs in Anchorage Homes," A. Schlapia, S. Morris, Document # 98-A504 , presented at the 91st Annual Meeting of the Air & Waste Management Association (San Diego, CA) June 1998
6. "Assessment of Indoor and Outdoor Concentrations of BETX and Carbonyl Compounds in Anchorage, Alaska," Municipality of Anchorage Air Quality Program, September 1996
7. "Ted Stevens Anchorage International Airport Air Toxics Monitoring Study," Municipality of Anchorage Air Quality Program, April 21, 2003
8. EPA AirData website, Office of Air and Radiation, U.S. Environmental Protection Agency. <http://www.epa.gov/air/data/>