



Air Quality in Anchorage
A Summary of Air Monitoring Data and Trends

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Preface

This report was prepared by the Environmental 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. The report is directed toward the general public and to professionals working in the air pollution field. Comments and suggestions on this report are encouraged. The Environmental Quality Program can be contacted at (907) 343-4713.

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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). These pollutants are known as criteria pollutants because a health-based air quality standard has been established for them. They are carbon monoxide, airborne particulate, airborne lead, sulfur dioxide, ozone and nitrogen dioxide. 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 2004.

National Ambient Air Quality Standards

The Clean Air Act, which was 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 National Ambient Air Quality Standard (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 (mg/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. 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. (Table was excerpted from EPA website <http://epa.gov/air/criteria.html>).

Table 1-1 Primary National Ambient Air Quality Standards		
Pollutant	Primary Stds.	Averaging Times
Carbon Monoxide	9 ppm (10 mg/m ³)	8-hour ¹
	35 ppm (40 mg/m ³)	1-hour ¹
Lead	1.5 µg/m ³	Quarterly Average
Nitrogen Dioxide	0.053 ppm (100 µg/m ³)	Annual (Arithmetic Mean)
Particulate Matter (PM ₁₀)	50 µg/m ³	Annual ² (Arith. Mean)
	150 µg/m ³	24-hour ¹
Particulate Matter (PM _{2.5})	15.0 µg/m ³	Annual ³ (Arith. Mean)
	65 µg/m ³	24-hour ⁴
Ozone	0.08 ppm	8-hour ⁵
	0.12 ppm	1-hour ⁶
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)
	0.14 ppm	24-hour ¹
	-----	3-hour ¹

¹ Not to be exceeded more than once per year.

² To attain this standard, the expected annual arithmetic mean PM₁₀ concentration at each monitor within an area must not exceed 50 µg/m³.

³ To attain this standard, the 3-year average of the annual arithmetic mean PM_{2.5} concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m³.

⁴ 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 65 µg/m³.

⁵ 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.

⁶ (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1, as determined by appendix H.

(b) The 1-hour NAAQS will no longer apply to an area one year after the effective date of the designation of that area for the 8-hour ozone NAAQS. The effective designation date for most areas is June 15, 2004. (40 CFR 50.9; see Federal Register of April 30, 2004 (69 FR 23996).)

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.

PM₁₀

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 PM₁₀. This designation is the result of air quality violations recorded between 1985 and 1987. A PM₁₀ control plan was developed to address the PM₁₀ problem in Eagle River. Because most of the PM₁₀ in Eagle River was emitted from unpaved roads, this plan focused on paving or surfacing gravel road 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 PM₁₀.

The Anchorage bowl is currently considered an attainment area for PM₁₀. However, Anchorage has experienced exceedances of the NAAQS related to natural events such as volcanic eruption and wind storms. Intense wind storms in March 2001 and March 2003 created blowing dust conditions that contributed to a number of exceedances of the NAAQS. 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 PM₁₀ was exceeded 18 times between 1993 and 1995. Because these exceedances were the largely the result of natural events, EPA has not considered them when evaluating Anchorage attainment status with respect to PM₁₀.

Although natural events have contributed to some exceedances, most PM₁₀ in Anchorage is believed to have manmade origins. PM₁₀ 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 PM₁₀ 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. Chemical deicers are being used in lieu of road sanding in some areas. Data suggest that these changes have had a positive impact on PM₁₀ air quality.

PM_{2.5}

Monitoring data collected between 1999 and 2004 indicate that Anchorage is in compliance with the NAAQS for PM_{2.5}. 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.

Although monitoring data for sulfur dioxide (SO₂), ground level ozone (O₃) and nitrogen dioxide (NO₂) 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 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.

Table 1-2	
Anchorage's Current Air Quality Status EPA Criteria Pollutants	
Pollutant	Current Status
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 ₁₀	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 _{2.5}	Data collected indicate that Anchorage is in attainment with the NAAQS for fine particulate.
Lead	Attainment
SO ₂	Attainment
O ₃	Attainment
NO ₂	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 National Ambient Air Quality Standard (NAAQS) for CO is set at 35 ppm (parts per million) 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. Anchorage has not exceeded the one-hour standard since 1980 while the eight-hour standard was exceeded on numerous occasions prior to 1997. Exceedances of eight-hour standard have been rare during the past seven years. No more than one exceedance has been measured in a single calendar year and Anchorage has been in compliance with the NAAQS during this period.

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.¹ 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 2004, 77% 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 a very important component 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.¹ Area-wide, warm-up idling accounts for 21% of total CO emissions and almost a third 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 2004 in Table 2-1.²

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

² 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.

Table 2-1
Sources of CO Emissions in 2004
Typical Winter Weekday

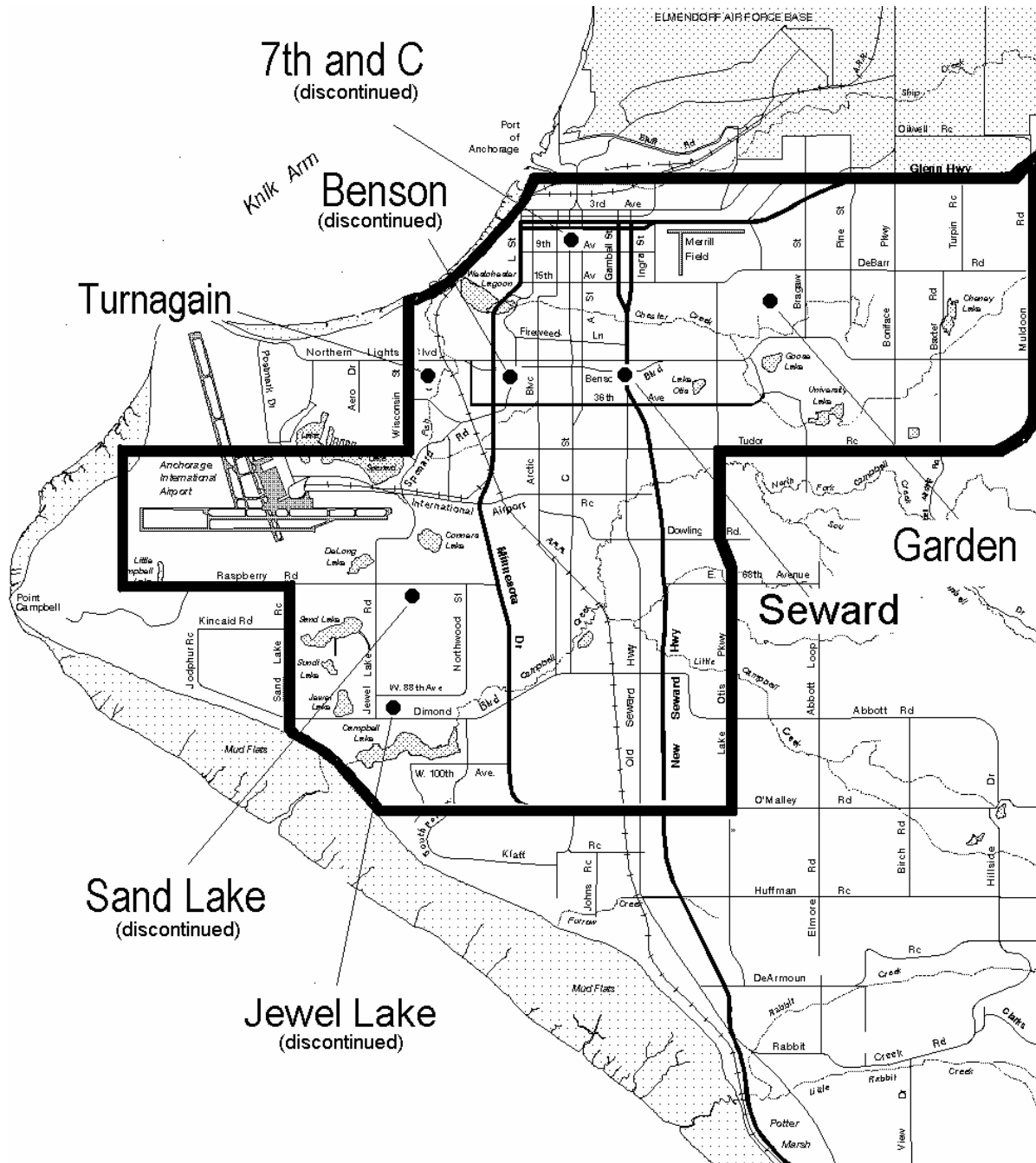
Source Category	CO Emitted (tons per day)	% of total*
Motor vehicle – on-road travel	67.6	56.2%
Motor vehicle – warm-up idle	25.3	21.0%
Ted Stevens Anchorage International Airport Operations	11.8	9.9%
Merrill Field Airport Operations	1.0	0.9%
Wood burning – fireplaces and wood stoves	5.8	4.8%
Space heating – natural gas	3.6	3.0%
Miscellaneous (snowmobiles, snow removal, welding, etc.)	3.7	3.1%
Point sources (power generation, sewage sludge incineration)	1.5	1.2%
TOTAL	120.3	100%

* Total does not sum exactly to 100% due to rounding

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. Between 1997 and 2004, however, Anchorage compiled seven consecutive years of 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 boundaries of the maintenance area are shown in Figure 2-1. The locations of Anchorage CO monitoring stations, both current and discontinued are also shown.

Figure 2-1
Anchorage CO Monitoring Network and Maintenance Boundary



CO Monitoring in Anchorage

In 2004, the Anchorage CO monitoring network was comprised of three sampling stations. The Municipality of Anchorage Department of Health and Human Services (DHHS) uses TECO48 CO analyzers at each station. These instruments meet all specifications required by the Environmental Protection Agency (EPA) for ambient CO monitoring and are designated by the EPA as a "reference method" for CO.

Monitoring is performed 24 hours a day from October 1 through March 31 and is conducted in conformance with guidelines established in federal regulations. 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 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 25 years, several monitoring stations have been discontinued because they have been found redundant. Others have been added to meet new monitoring objectives.

Table 2-2	
Description of Anchorage CO Monitoring Sites	
Location	Site Description
7th & C Street (discontinued)	This station was located mid-block between 6 th and 7th Avenue on C Street. Monitoring began here in 1973 and was discontinued in 1995. The last exceedance at this site was recorded in 1990.
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. The CO data collected here were similar, but of slightly lower magnitude, to data collected at the Seward Highway station
Garden	Monitoring began at this neighborhood location at 16th and Garden Street in 1979. On occasion, concentrations at this "neighborhood-scale" site exceed those measured at micro-scale monitors located near major traffic corridors.
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. The last exceedance was recorded here in 1989.
Seward Highway	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.
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.
Jewel Lake	Monitoring began here in October 2002 and was terminated in March 2004. CO concentrations at this site were lower than the other three sites (Garden, Seward Highway, and Turnagain) in the network.

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, 2002, 2003 or 2004.

The highest and second highest 8-hour averages for five Anchorage monitoring stations are tabulated by year, 1980 – 2004, 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 25 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.

Table 2-3
Summary of CO Data from Anchorage Monitoring Stations (1980 –2004)

Year	Benson (microscale) 2902 Spenard Road			Garden (neighborhood) 3000 E 16 th Street			Sand Lake (neighborhood) 3426 Raspberry Road			Seward (microscale) 3002 New Seward Highway			Turnagain (neighborhood) 3201 Turnagain Street		
	max	2 nd max	# days ≥9.5	max	2 nd max	# days ≥9.5	max	2 nd max	# days ≥9.5	Max	2 nd max	# days ≥9.5	max	2 nd 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		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

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

Annual second maximum concentrations recorded at the four sites with the longest continuous data records (Benson, Garden, Sand Lake and Seward Highway) are plotted in Figures 2-3 (a-d). Available data from each site during the twenty-five year period 1980 -2004 are plotted. During this period, the annual second maximum CO concentration declined by 66% at Garden. Second

maximum concentrations at Benson declined by 76% between 1980 and 2001 when monitoring was discontinued.

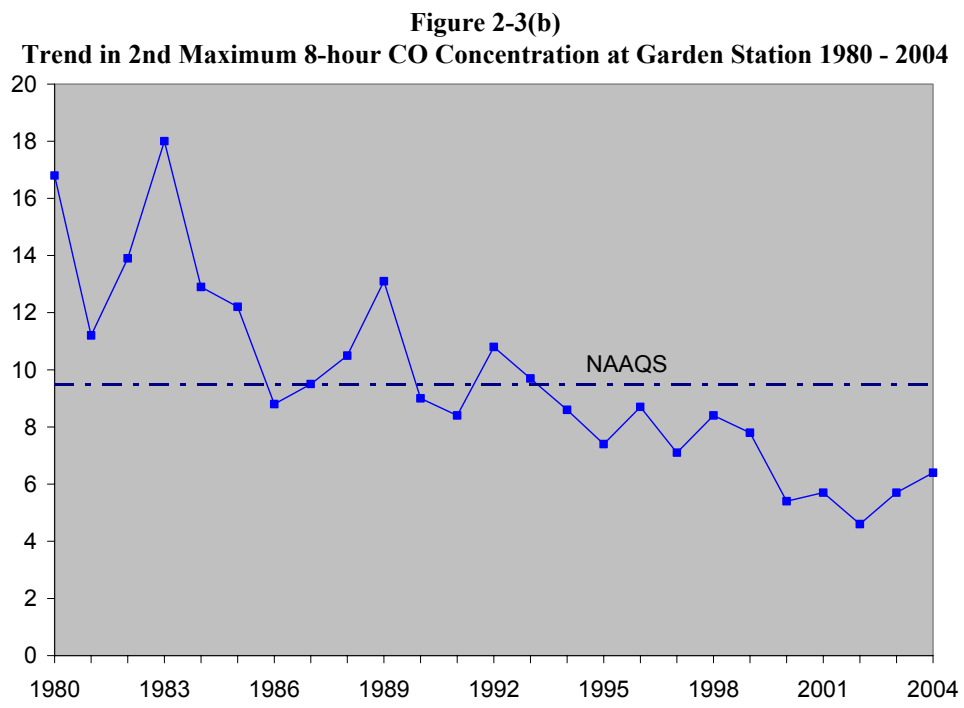
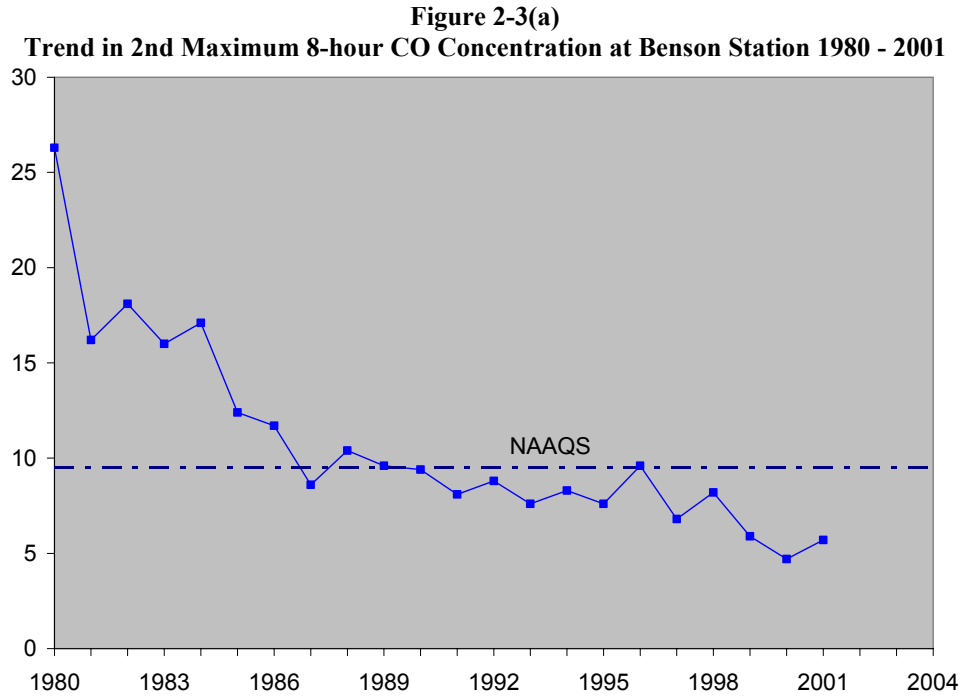


Figure 2-3(c)
Trend in 2nd Maximum 8-hour CO Concentration at Sand Lake Station 1980 - 1997

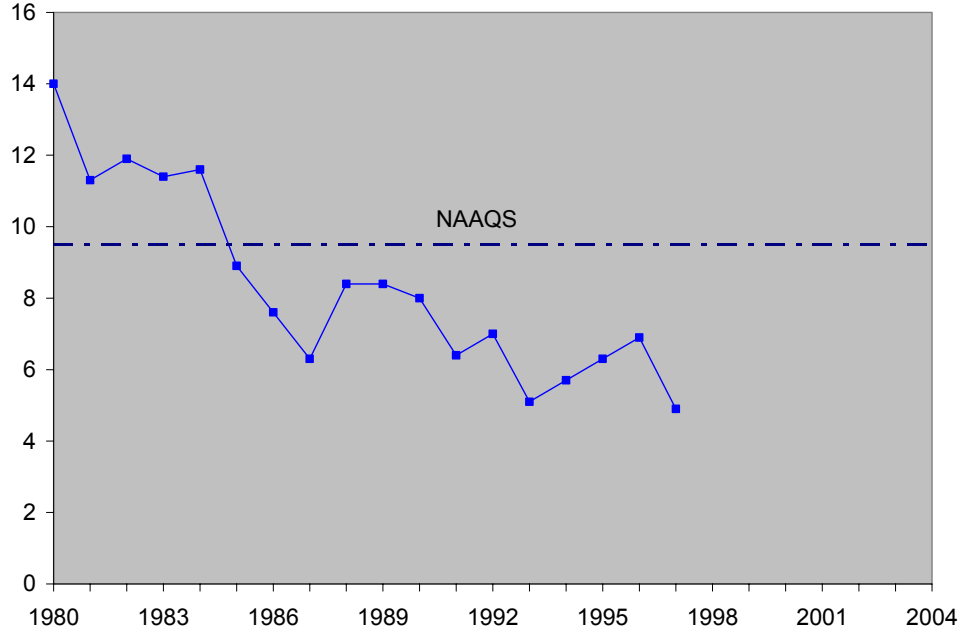
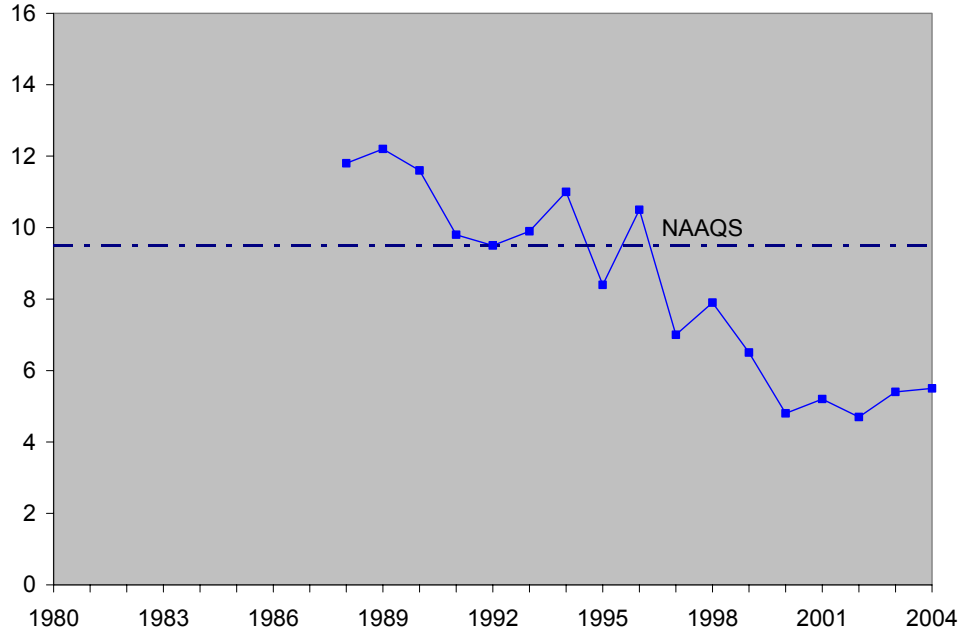


Figure 2-3(d)
Trend in 2nd Maximum 8-hour CO Concentration at Seward Highway Station (1987- 2004)



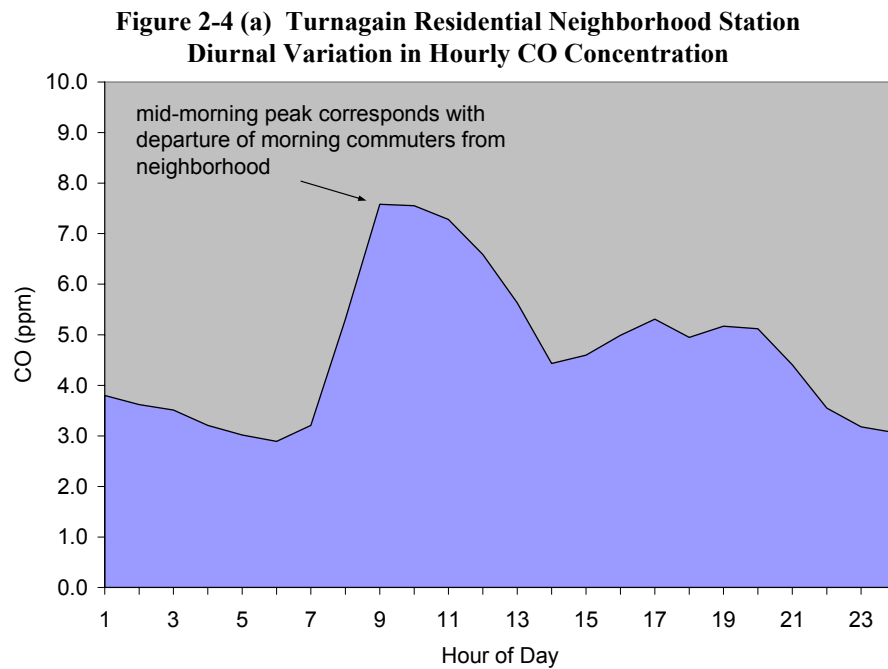
Diurnal Pattern in CO Concentrations

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.

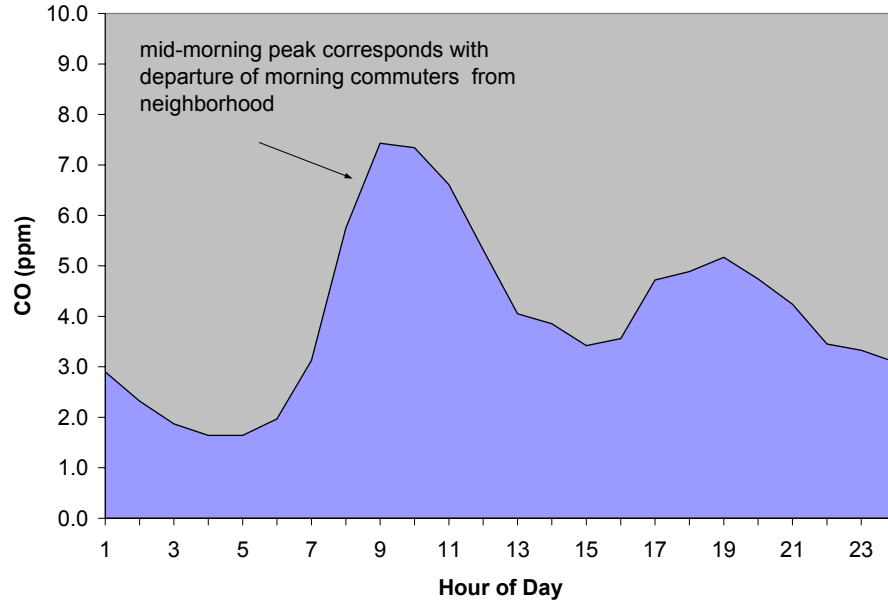
Diurnal patterns at the Turnagain, Garden and Seward Highway stations are illustrated in Figures 2-4(a-c). The hourly averages shown are composites of the hourly averages measured on the 10 days when the highest 8-hour CO concentrations were observed at each site between 1998 and 2004. The distinctive diurnal patterns observed at all three sites implicate cold start emissions a significant source of emissions at all three sites.

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. They 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.

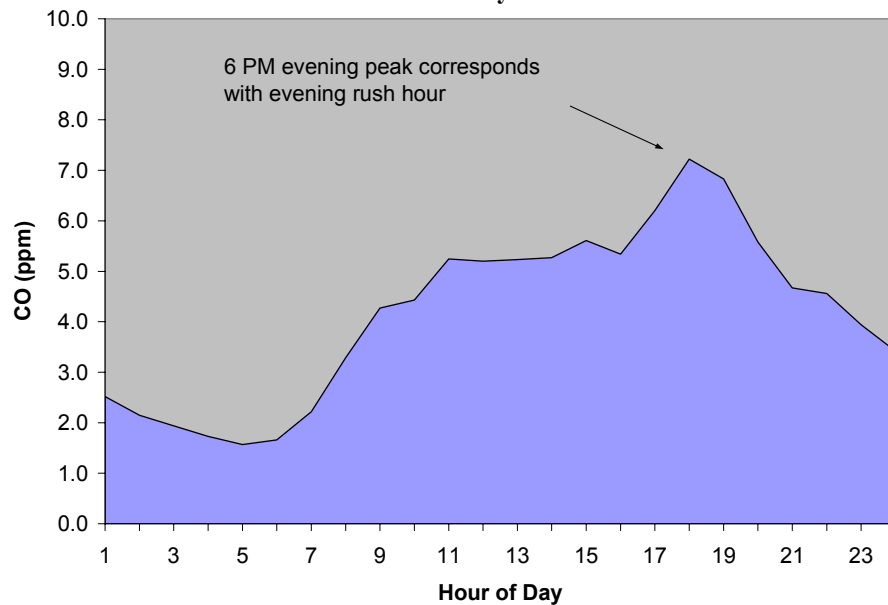
At the Seward Highway station, located at the busy intersection of the Seward Highway and Benson Boulevard, hourly concentrations build slowly from 7 a.m. through 1 p.m., hold steady through the mid-afternoon hours, and then rise rapidly during the evening rush hour. CO concentrations peak in the early evening about 6 p.m. and decline in the later evening hours. Cold start emissions from evening commuters leaving from downtown and mid-town employment centers likely contribute to this evening peak.



**Figure 2-4 (b) Garden Residential Neighborhood Station
Diurnal Variation in Hourly CO Concentration**



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



Influence of Meteorology on Ambient CO Concentrations

In Anchorage, CO concentrations are highest during the months November through February. As a high-latitude community, with long winter nights and weak daytime solar insolation, 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.

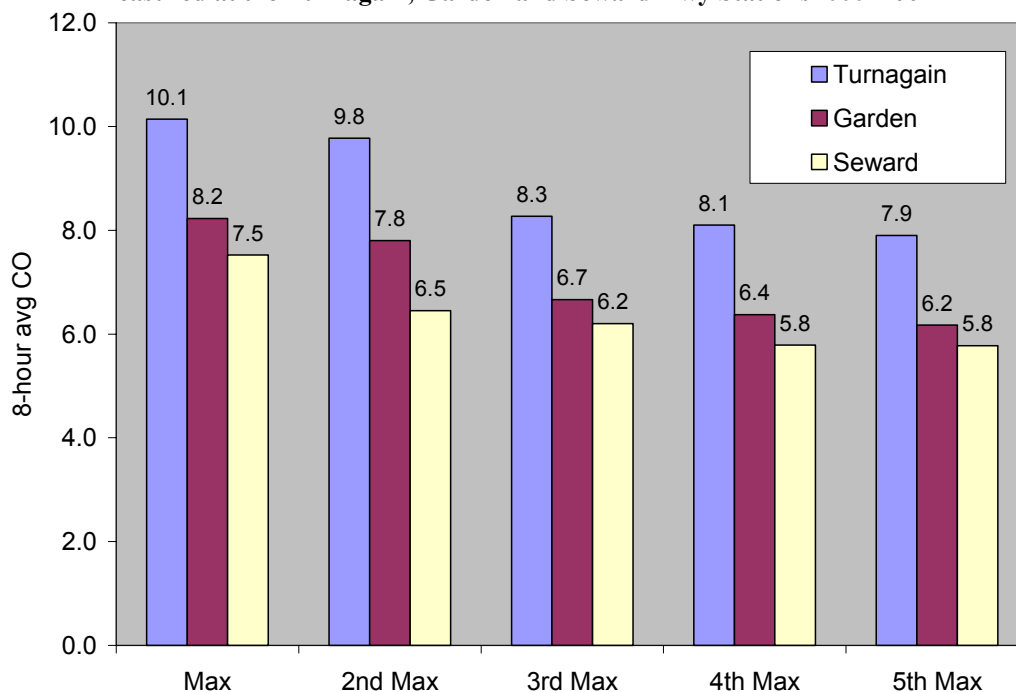
Exceedances of the NAAQS tend to occur on days with low wind speeds, clear or partly cloudy skies, and cold temperatures. About one-fourth of the exceedances since 1990 have occurred at temperatures above 15 °F, however. Exceedances are rare on weekends, presumably because traffic volumes are lower than weekdays. Weather conditions on the 28 days when Anchorage exceeded the standard since 1990 are summarized in Table 2-4. Local climatological data from the National Weather Service observatory at Point Campbell on Stevens Anchorage International Airport were used to prepare the following table. It should be noted that Point Campbell is in the extreme western part of Anchorage, adjacent to Cook Inlet. Temperatures here are often moderated by the surrounding water body. Temperatures in east Anchorage, away from the inlet, can sometimes be 10 to 20 °F lower. 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.

Date	Day	8-Hour Avg CO (ppm)	Site	Exceedance Time Period	Temp (°F)	Wind Spd (knots)	Cloud Cover (tenths)
1/5/90	Fri	11.4	Seward	3pm – 11pm	8	2.7	2
1/9/90	Tue	9.6	Seward	10am - 6pm	-7	4.7	5
1/29/90	Mon	9.8	Seward	4pm – 12am	-11	3.3	3
2/14/90	Wed	10.2	Seward	5pm – 1am	5	4.3	0
11/16/90	Fri	9.9	Seward	2pm – 10pm	21	3.0	8
11/21/90	Wed	9.9	Seward	4pm – 12am	-3	0.0	2
11/26/90	Mon	11.6	Seward	4pm – 12am	4	4.7	0
11/27/90	Tue	10.7	Seward	3pm – 11pm	-10	1.3	5
11/28/90	Wed	13.0	Seward	3pm – 11pm	-2	5.7	0
12/6/90	Thur	11.4	Seward	11am - 7pm	27	4.3	10
12/31/90	Mon	9.6	Seward	11am - 7pm	5	5.3	0
1/4/91	Fri	9.8	Seward	4pm – 12am	7	0.0	4
1/5/91	Sat	9.7	Seward	5pm – 1am	6	2.7	0
12/20/91	Fri	11.5	Seward	11am - 7pm	9	4.0	0
1/1/92	Wed	10.8	Garden	4pm – 12am	16	1.0	6
1/2/92	Thur	10.8	Garden	7am – 3pm	19	1.3	10
12/7/93	Tue	9.7	Garden	7am – 3pm	19	5.0	0
12/10/93	Fri	10.4	Seward	12pm - 8pm	22	4.0	10
12/13/93	Mon	10.0	Garden	7am – 3pm	12	3.0	6
12/30/93	Thur	9.9	Seward	3pm – 11pm	16	2.3	0
11/30/94	Wed	11.3	Seward	11am - 7pm	6	10.3	0
12/7/94	Wed	11.0	Seward	3pm – 11pm	-9	0.0	10
1/22/96	Mon	11.0	Benson	5pm – 1am	-2	0.0	1
12/27/96	Fri	10.0	Seward	2pm – 10pm	8	2.4	0
12/31/96	Tues	10.8	Seward	11am - 7pm	-7	2.7	0
1/5/98	Mon	9.5	Garden	8am – 4pm	-1	4.8	0
1/6/99	Wed	10.1	Turnagain	11am – 7pm	2	1.0	5
12/16/01	Sun	9.8	Turnagain	12 pm – 8 pm	-8	3.5	1
Average	--	--	--	--	5.4 °F	3.1 knots	3.1 tenths

The Role of Mechanical Mixing in Determining Peak CO Concentrations

During the past five years, the highest CO concentrations measured in Anchorage have been at residential neighborhood monitoring stations. Indeed, all of the exceedances recorded since 1996 have occurred at either the Turnagain or Garden stations, both of which are located in residential areas with relatively low vehicle traffic. Figure 2-5 shows that the highest 8-hour average concentrations at the Turnagain and Garden have been higher than those measured at the Seward Highway station area even though traffic volumes in the vicinity of the Seward Highway station are an order of magnitude greater. Moreover, CO emissions in the area surrounding the Seward Highway monitor are estimated to be four times greater than either of the residential areas surrounding the Turnagain or Garden stations. If the CO concentration were solely a function of the emissions generated in the vicinity of a particular monitor, one would expect that concentrations at the Seward Highway site to be consistently higher than either of these two residential monitoring sites. Some other factor must account for the high CO concentrations at these neighborhood sites.

Figure 2-5
Comparison of Five Highest 8-hour Average CO Concentrations
Measured at the Turnagain, Garden and Seward Hwy Stations 1999-2004



The volume and speed of vehicle traffic near the Seward Highway site is much greater than in the residential areas surrounding either the Turnagain or Garden sites. Traffic volumes are almost ten times greater near the Seward site and vehicle speeds are approximately 50% higher, on average. Because the mechanical turbulence created by a vehicle is a function of velocity cubed, the higher speeds experienced near the Seward result in substantially more turbulence. When both speed and traffic volume are considered, the amount of turbulence generated by vehicle traffic near the Seward Highway station is estimated to be roughly 20 times greater than experienced at the Turnagain or Garden stations. The added turbulence generated by vehicles traveling in and around the Seward Highway site helps to mix and dilute CO emissions. This is an important factor especially during strong temperature inversions when natural atmospheric mixing is minimal.

Monitoring data support the MOA hypothesis. When natural mixing is good (i.e. the mixing provided by wind and/or convection), the turbulent mixing provided by passing vehicles is a

relatively unimportant factor in determining overall concentrations. Under these circumstances, one would expect the CO concentration at Seward to be higher than those at Turnagain or Garden because the amount of CO emitted is significantly higher there. This is in fact the case. When natural mixing is good, CO concentrations at the Seward Highway station are roughly double those measured at Turnagain or Garden. However, when natural mixing is poor, the opposite is true. Indeed, under poor natural atmospheric mixing conditions, concentrations measured at Turnagain and Garden are consistently higher than those at Seward. It is precisely these days when Anchorage is likely to experience its highest CO concentrations and these almost always occur at either the Turnagain or Garden residential stations. On these poor mixing days, concentrations at Seward seem to be moderated by the turbulent mixing provided by the 80,000 vehicles that pass by the site every day, and as a consequence concentrations are lower there.

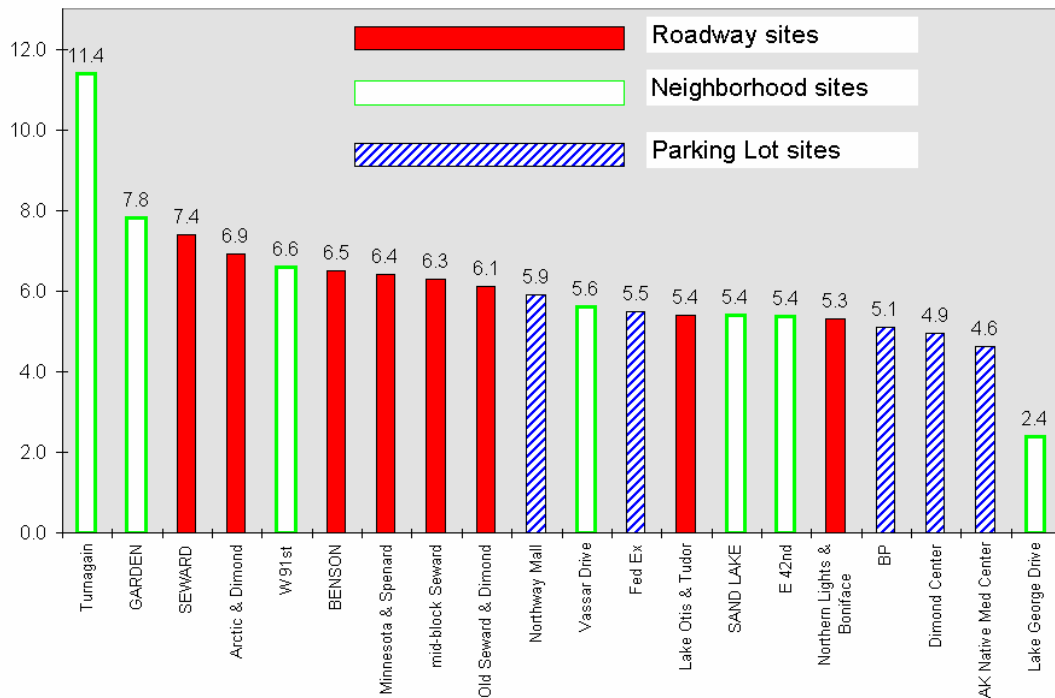
Summary of Recent Local Research

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. Six sites were located near major roadway intersections, five 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 (at Turnagain Street and 31st Avenue) 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 six roadway intersection sites. The study concluded that the permanent station at Seward Highway adequately characterizes 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 including shopping centers, restaurants, and schools.

Transportation planning models typically categorize trips into three categories as follows:

- Home-based work (HBW) trips – Commute trips that involve travel directly from home to work or from work to home.
- Home-based other (HBO) trips – Trips that originate from home to some location other than work (e.g. shopping center, school, health club, doctor office, etc.) or the return trip from the “other” location if it returns directly home.
- Non home-based (NHB) trips – Trips that originate from some location other than home (e.g. work, shopping, etc.) and are not a HBW or HBO trip.

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 HBW trips. The average idle duration for these trips was over 7 minutes³. The average idle duration for evening HBW trips beginning at the workplace was 3.4 minutes. The shortest idle durations were associated with morning and midday NHB 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. Results of the driver idling behavior study are shown in Table 2-5.

³ About 35% of morning HBW 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 for all morning HBW trips was about 7 minutes.

Time of Day	Trip Purpose	Soak Time (hours)		Idle Duration (minutes)	
		Average	Median	Average	Median
Morning 6:00 AM – 9:00 AM	HBW	11.9	12.8	7.3	5.7
	HBO	10.7	12.0	5.9	4.8
	NHB	1.1	0.1	0.8	0.6
Midday 9:00 AM – 3:00 PM	HBW	6.3	3.7	3.5	2.0
	HBO	6.6	1.7	2.0	1.2
	NHB	1.6	0.6	1.6	0.6
Evening 3:00 PM – 6:00 PM	HBW	6.8	8.2	3.4	1.2
	HBO	2.6	0.8	2.1	0.9
	NHB	3.0	0.8	3.1	0.8
Night 6:00 PM – 6:00 AM	HBW	5.8	4.5	3.0	1.2
	HBO	2.0	1.2	2.6	2.7
	NHB	2.0	1.0	1.5	1.3

The longest soak times and idle durations are associated with morning home based work trips and home based other 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, NHB trips, because they typically involve short soak times and idle durations, likely have relatively low start up and idle CO 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 exceedances of the CO NAAQS are most likely to occur in Anchorage and Fairbanks. Sierra Research equipped a large van with a modified Horiba IMVETS emissions test system that provided measurements of CO and HC 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.

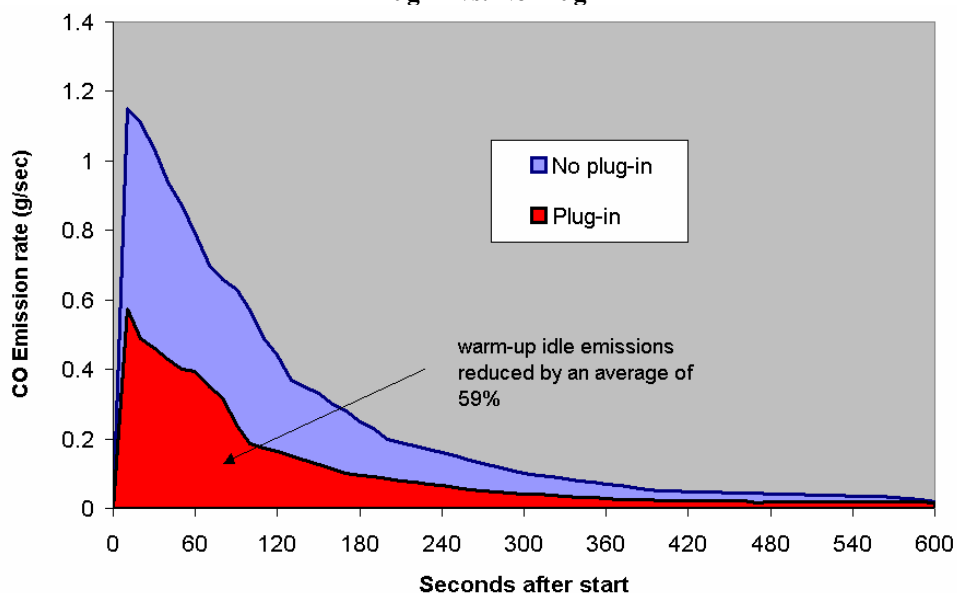
After an initial cold soak of four hours or more at ambient temperature, test vehicles were cold-started and mass emissions were measured for a period of 20 minutes subsequent to start-up. Testing was conducted at ambient temperatures that ranged from -6 °F to +23 °F in Anchorage and -36 °F to +14 °F 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 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, etc.). Key findings from the 1998-99 and 2000 –2001 studies are summarized below:

- *A large portion of CO emissions occurs during cold start and warm-up idle.*
In order to simulate a typical morning commute in Anchorage⁴, 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, CO emissions actually increase when idle times are cut shorter than 10 minutes. When the idle time is cut to 5 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 (10-minute warm-up followed by a 7.3-mile drive) 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.

Figure 2-7

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



⁴ 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.

CO Concentrations in Anchorage Compared with Other Areas

Concentrations from a number of selected metropolitan areas in the western U.S. are compared to Anchorage in Table 2-6 for calendar year 2004. These data were compiled from the EPA Aerometric Information and Retrieval System (AIRS). 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, etc.) and may not necessarily be representative of area-wide air quality.

Metropolitan Area	Highest 8-hour Concentration	2nd Highest 8-hour Concentration	Number of Exceedances of the NAAQS
Calexico, CA	10.3	8.3	1
Anchorage, AK	8.1	7.9	0
El Paso, TX	6.5	6.4	0
Las Vegas, NV	5.8	5.1	0
Fairbanks, AK	5.4	5.4	0
Phoenix, AZ	5.2	5.1	0
Tacoma, WA	5.0	4.0	0
Lake Tahoe (Stateline), CA	4.4	4.4	0
Denver, CO	4.4	4.1	0
Spokane, WA	4.5	4.0	0
Portland, OR	4.5	3.9	0
Medford, OR	4.0	4.0	0
Reno, NV	4.0	3.9	0
San Francisco, CA	2.7	2.6	0

References

1. "Anchorage Carbon Monoxide Maintenance Plan," Environmental Quality Program, Department of Health and Human Services, Municipality of Anchorage, October 2003.
2. "Anchorage Carbon Monoxide Emission Inventory and Attainment Projections," Air Quality Program, Department of Health and Human Services, Municipality of Anchorage, October 2003."
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. In 1987 EPA established a particulate standard for particles with an aerodynamic diameter of less than 10 microns. These particles, called PM₁₀, can be inhaled into the thoracic or lower regions of the respiratory tract where they can do the most harm. Epidemiological studies indicate that adverse health impacts can result from exposure to PM₁₀ 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 PM₁₀ levels are high. In Anchorage, evidence suggests an association between elevated PM₁₀ and increases in out-patient visits for asthma and upper respiratory illness (Gordian, 1996). The 24-hour NAAQS for PM₁₀ is 150 µg/m³. The annual average NAAQS is 50 µg/m³.

In July of 1997 EPA established a new NAAQS for particulate. The standard now includes limits on fine particulate matter less than 2.5 microns in diameter, called PM_{2.5}. It supplements the long standing standard for PM₁₀, sometimes referred to as coarse particulate. Recent epidemiological studies suggest that adverse health impacts are strongly related to exposure to fine particulate, and that these PM_{2.5} particles may cause health impacts at concentrations well below the 150 µg/m³ standard set for PM₁₀. A growing body of epidemiological evidence suggests that these sub-2.5 µm particles may 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_{2.5} is 15 µg/m³. The 24-hour standard, established for the 98th percentile of monitored values is 65 µg/m³. This means that a community may exceed 65 µg/m³ 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.

Sources of PM₁₀ in Anchorage

Dust from paved and unpaved roads accounts for almost all of the airborne particulate in Anchorage and Eagle River. Sources of particulate in Anchorage and Eagle River have been quantified by a technique known as chemical mass balance receptor modeling. Over 90% of the particulate 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 particulate 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.

PM₁₀ Monitoring in Anchorage and Eagle River

The DHHS uses Andersen-head PM₁₀ samplers to collect PM₁₀ samples for gravimetric analysis. The Andersen-head sampler has been designated by EPA as a reference method for PM₁₀ 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 PM₁₀ mass is calculated by subtracting the weight of the filter before sampling. Once the PM₁₀ mass is known, the PM₁₀ 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.

PM₁₀ is also monitored using a Graseby Andersen beta attenuation monitor (BAM). 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 is capable of accurately estimating the particulate mass from attenuation measurements. The instrument then calculates the PM₁₀ concentration from mass and the flow data. DHHS also uses a Rupprecht & Patashnick tapered element oscillating microbalance (TEOM) to collect PM₁₀ 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. PM₁₀ data from the BAM and TEOM are transmitted via modem to the DHHS central computer.

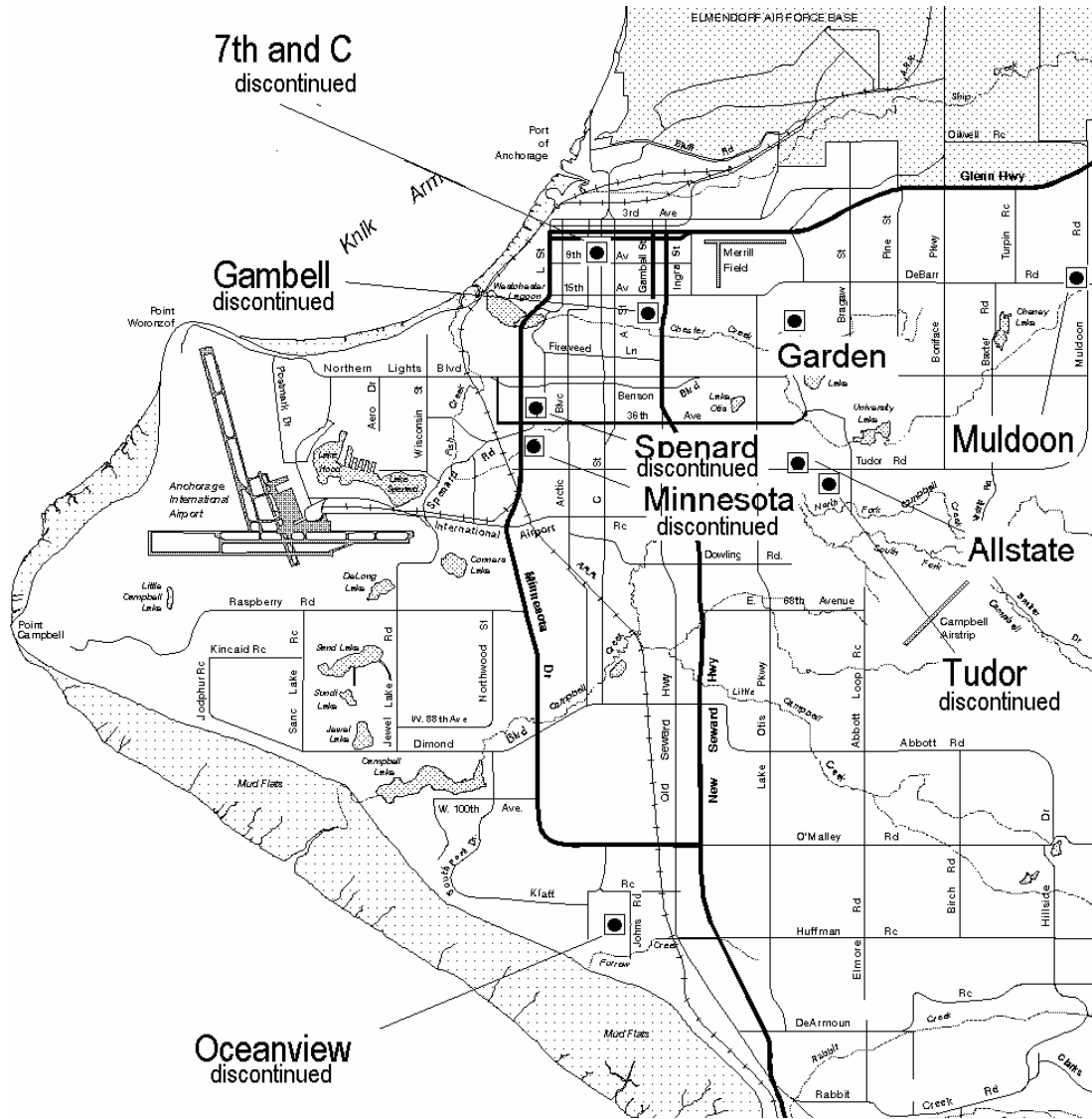
Figure 3-1
Allstate Building PM₁₀ and PM_{2.5} Monitoring Station



The Allstate Building PM₁₀ monitoring station, located off Tudor Road near Bragaw Street is shown in Figure 3-1. PM monitors are typically placed on roof tops as shown below. 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.

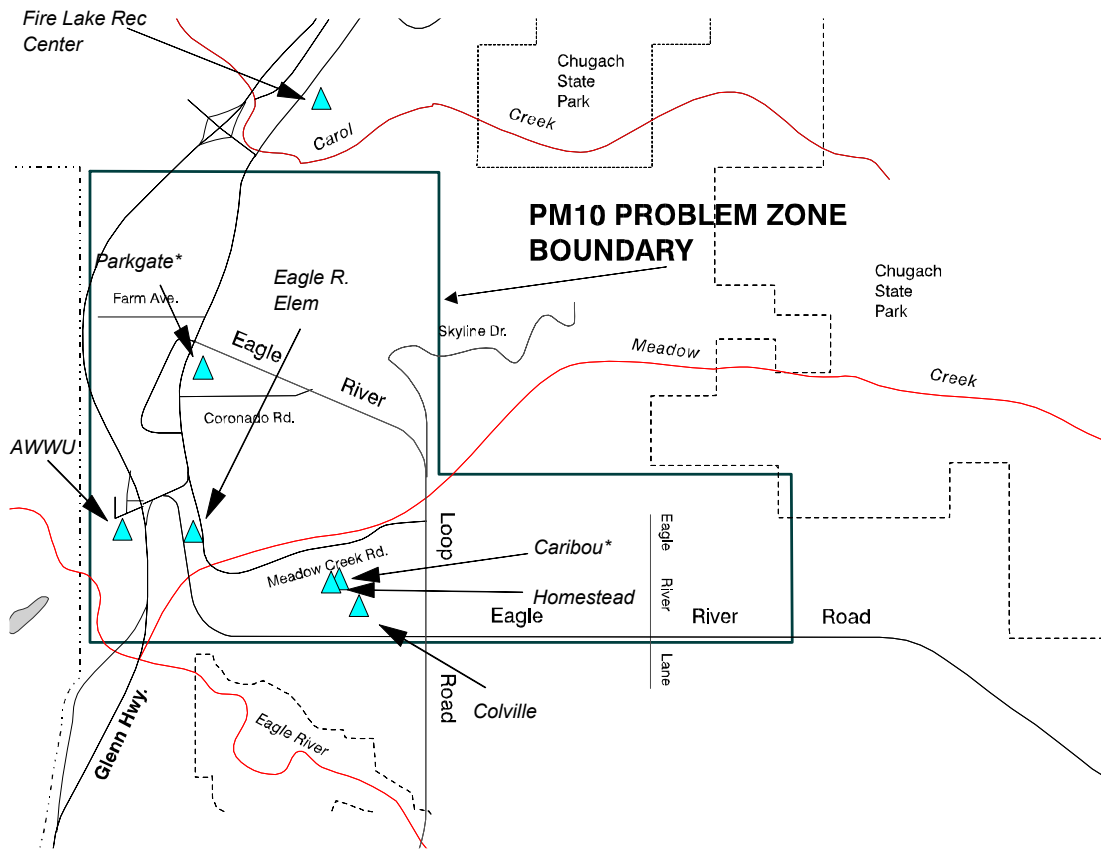
Over the years, PM₁₀ monitoring has been conducted at 16 different locations in Anchorage and Eagle River. Most were discontinued when sufficient data were collected to characterize PM₁₀ levels at those locations. In 2004 three stations were operated in the Anchorage bowl and one in Eagle River. Monitoring locations are identified in Figures 3-2 and 3-3.

Figure 3-2
Location of Active and Discontinued PM₁₀ Monitoring Stations in Anchorage



	Status (2004)	Location
Muldoon	Active	Roof top 1100 Muldoon Road
Allstate	Active	Roof top, 3335 East Tudor Road
Garden	Active	Roof top, 3000 E 16 th Street
Gambell	Discontinued	Roof top Worthington Ford, 1950 Gambell Street
7th & C Street	Discontinued	Roof top, Downtown Fire Station, 625 C Street
Oceanview	Discontinued	Roof top Oceanview School, 11911 Johns Road
Tudor	Discontinued	Roof top, Public Works Complex, 3500 E Tudor Road
Spenard	Discontinued	Roof top, 3309 Spenard Road
Minnesota	Discontinued	Roof top, 3443 Minnesota Blvd.

Figure 3-3
Location of Active and Discontinued PM₁₀ Monitoring Stations
in Eagle River



Site	Status (1999)	Location
Parkgate	Active	Roof top Parkgate Bldg., near Old Glenn Hwy & Easy Street
Caribou	Discontinued	Roof top Homestead School, approx 15 meters north of Baranof Drive
AWWU	Discontinued	Ground level, AWWU Wastewater facility, Artillery Road
Fire Lake Rec Center	Discontinued	Roof top of Recreation Center, Mile 2.2, Old Glenn Hwy
Homestead	Discontinued	Roof top Homestead School, approx 50 meters north of Baranof Drive
Colville	Discontinued	Roof top, AWWU well house, southeast of intersection, Baranoff & Colville Streets
Eagle River Elementary	Discontinued	Roof top, Eagle River Elementary School

PM₁₀ Data Summary

Data from the four active and twelve discontinued PM₁₀ 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 the eruption of Mt. Spurr in August of 1992 were responsible for numerous exceedances of the 24-hour NAAQS observed in 1990 and 1992. In March of 2003, Anchorage experienced a dust storm from gale force winds clocked as high as 100 mph. This storm was responsible for a number of exceedances at several monitoring stations during the period March 7 – 13. EPA has flagged these exceedances as "natural events" and they are not considered violations of the NAAQS.

Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1996 ^a	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 ^b	127	0
2002	1 in 2	31.2	105	104	0
2003	1 in 2	26.8	421 ^c	179 ^d	2
2004	1 in 2	21.9	97	97	0

^a Sampling began mid-October 1996

^b Values below 155 µg/m³ are not considered an exceedance.

^c Exceedance measured on March 12, 2003 was attributed to high winds. .

^d Exceedance measured on March 7, 2003 was attributed to high winds

Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1995 ^a	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 ^b	--	89	78	0
2001	1 in 2 ^b	--	180 ^c	82	1
2002	1 in 2 ^b	--	63	58	0
2003	1 in 2 ^b	--	277 ^d	187 ^e	3 ^f
2004	1 in 2 ^b	--	83	55	0

^a Sampling began mid-April 1995

^b Sampling only conducted during peak PM₁₀ period in spring and fall

^c Exceedance measured on March 18, 2001 was attributed to high winds.

^d Exceedance measured on March 12, 2003 was attributed to high winds.

^e Exceedance measured on April 19, 2003 was attributed to parking lot sweeping activity.

^f 3rd exceedance measured on March 13, 2003 attributed to high winds.

Table 3-1(c) Garden PM ₁₀ Station 3000 E 16 th Street, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1999 ^a	1 in 6	16.2	73 ^a	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 ^b	57	1
2004	1 in 6	16.7	70	43	0

^a This value attributed to July 4th fireworks.

^b This value attributed to high winds on March 12, 2003.

Table 3-1(d) Parkgate PM ₁₀ Station Parkgate Building, Old Glenn Hwy & Easy Street, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1985 ^a	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 ^b	26.8	143	106	0
1991	1 in 6	28.2	78	72	0
1992	1 in 6	31.5	165 ^c	128	1 ^c
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 ^d	590 ^d	92	1
2004	1 in 6	16.7	70	43	0

^a Incomplete data for year, sampling began early October 1985

^b Sampling frequency switched from every day sampling to once every six days in July 1990

^c Exceedances in 1992 attributed to resuspended ash from Mt. Spurr

^d Exceedance on March 12, 2003 attributed to high winds. This value and 92 µg/m³ value measured on March 10, 2003 contributed disproportionately to high annual average for 2003.

Table 3-1(e) Gambell PM ₁₀ Station 1950 Gambell Street, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	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 ^a	39.6	260 ^b	188 ^b	2 ^b
1991	every day	36.6	144	141	0
1992	every day	49.4	565 ^c	446 ^c	11 ^c
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 ^d	158 ^e	2 ^{d,e}
1997	every day	32.0	128	127	0
1998	every day	26.4	115	98	0
1999 ^f	every day	--	87	73	0

^a Sampling frequency changed from once every two days to every day sampling in July 1990

^b Exceedances in 1990 attributed to resuspended volcanic ash from Mt. Redoubt

^c Exceedances in 1992 attributed to resuspended volcanic ash from Mt. Spurr

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

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

^f Sampling discontinued April 30, 1999.

Table 3-1(f) Oceanview School PM ₁₀ Station 11911 Johns Road, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1990 ^a	1 in 2	--	81	77	0
1991	1 in 2	24.1	130	99	0
1992	1 in 2	29.9	549 ^b	331 ^b	5 ^b
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 ^c	1 in 2	15.0	90	41	0

^a Incomplete data for year, sampling began early October 1990

^b Exceedances in 1992 attributed to resuspended volcanic ash from Mt. Spurr

^c Sampling discontinued in February 2000

Table 3-1(g) Minnesota PM₁₀ Station 3443 Minnesota Blvd., Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1997 ^a	1 in 2	--	95	91	0
1998	1 in 2	--	59	48	0

^a Sampling began March 1997 and ended May 1998

Table 3-1(h) Spenard PM₁₀ Station 3309 Spenard Road, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1997 ^a	1 in 2	--	139	116	0
1998	1 in 2	--	72	65	0

^a Sampling began February 1997 and ended May 1998

Table 3-1(i) Caribou PM₁₀ Station Homestead Elementary School, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1992 ^a	every day	--	304 ^b	170 ^b	3 ^b
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 ^c	every day ^c	--	81	68	0

^a Incomplete data for year, sampling began late May 1992

^b Exceedances in 1992 attributed to resuspended volcanic ash from Mt. Spurr

^c Incomplete data, sampling discontinued after October 1, 1996

Table 3-1(j) Colville PM ₁₀ Station AWWU well house, northeast of intersection of Baronoff & Colville Streets, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1988 ^a	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 ^b	every day	--	147	116	0

^a Incomplete data available for year, sampling began late August 1988

^b Sampling discontinued May 1992

Table 3-1(k) 7th & C Street PM ₁₀ Station Downtown Fire Station, Anchorage Fire Department, 625 C Street, Anchorage					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1985 ^a	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 ^b	1 in 6	--	108	94	0

^a Only one quarter of data available for year, sampling began early October 1985

^b Sampling discontinued late September 1990

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

^a Only one quarter of data available for year, sampling began early October 1985

^b Sampling discontinued late December 1987

Table 3-1(m) Homestead Elementary School PM₁₀ Station 18001 Baronoff Avenue, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1987 ^a	1 in 2	--	40	39	0
1988 ^b	1 in 2	--	55	48	0

^a Sampling conducted from early May 1987 through late November 1987

^b Sampling conducted from early April 1988 through late October 1988

Table 3-1(n) Anchorage Wastewater Treatment Facility PM₁₀ Station Artillery Road, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1987 ^a	1 in 2	--	24	19	0

^a Sampling conducted from early May 1987 through early December 1987

Table 3-1(o) Eagle River Elementary School PM₁₀ Station Old Eagle River Road, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1987 ^a	1 in 2	--	40	40	0

^a Sampling conducted from early May 1987 through early December 1987

Table 3-1(p) Fire Lake Recreation Center PM₁₀ Station East of Old Glenn Highway, Eagle River					
Calendar Year	Sampling Frequency	Annual Avg (µg/m ³)	Highest 24-Hour Avg (µg/m ³)	2nd Highest 24-Hour Avg (µg/m ³)	No of Days Exceeding NAAQS
1987 ^a	1 in 2	--	21	19	0

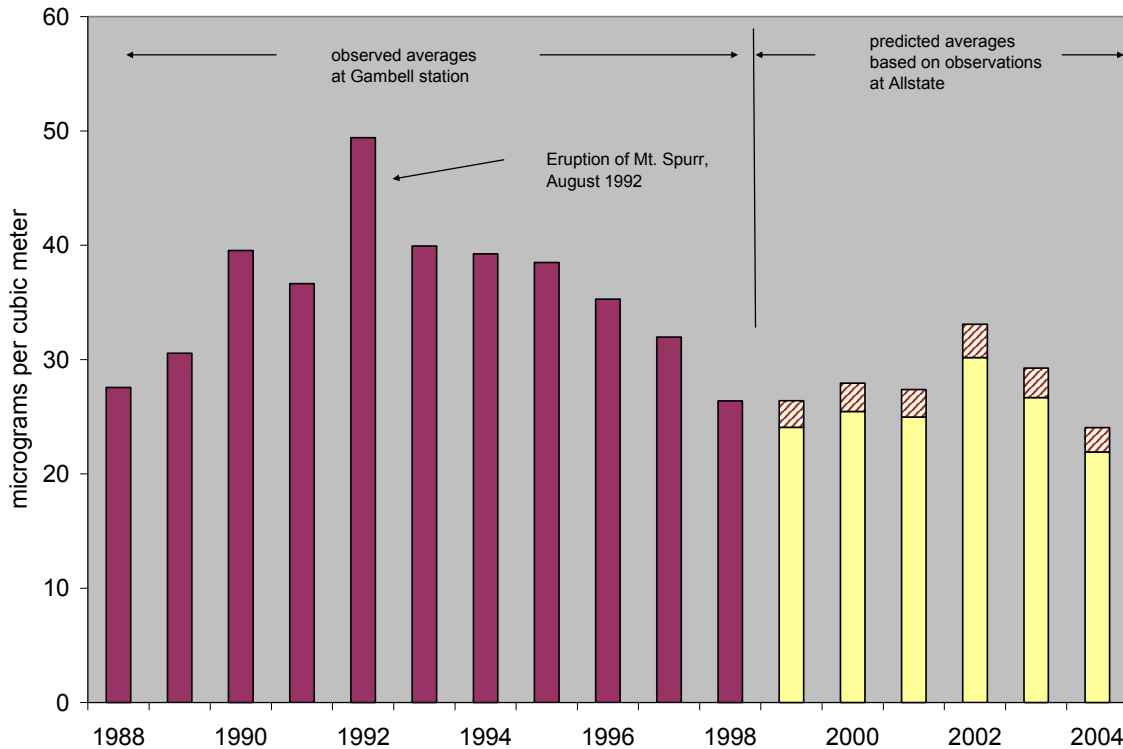
^a Sampling conducted from early May 1987 through early December 1987

PM₁₀ Trends in Anchorage

It is difficult to construct a long term PM₁₀ trend for Anchorage because no single monitoring station has been operating for the entire period of interest (1980 – 2004). 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. PM₁₀ data has been collected at the Allstate building from 1996 through 2004. Both

of these stations were or are located adjacent to major roadways and operated concurrently between October 1996 and April 1999 allowing a mathematical relationship between the two sites to be constructed. During this period, on coincident sampling days, the average concentration at Gambell site was just 9.7% higher than Allstate ($29.4 \mu\text{g}/\text{m}^3$ vs. $26.6 \mu\text{g}/\text{m}^3$). A long term trend plot (1986 – 2004) was constructed using the data from these two sites. Figure 3-4 shows average annual concentrations measured at Gambell from 1986-1998. For the period 1998-2004, the predicted average Gambell concentration was estimated from data collected at Allstate by simply increasing the observed average value at Allstate by 9.7%.

Figure 3-4
Trend in Annual PM₁₀ Concentrations in Anchorage
Based on Data from Gambell and Allstate PM₁₀ Stations 1986 – 2004



Elevated PM₁₀ 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; PM₁₀ impacts persisted for a number of years following the eruption. Microscopic techniques were used to quantify the impact of Mt. Spurr ash on PM₁₀ levels in Anchorage following the eruption in August 1992. Mt. Spurr ash accounted for about 90% of the PM₁₀ on days immediately following the eruption. Microscopic analysis of PM₁₀ samples collected in 1994 indicated that 20 to 30% of the PM₁₀ mass was composed of volcanic ash suggesting that it was a significant contributor to PM₁₀ two years after the eruption.

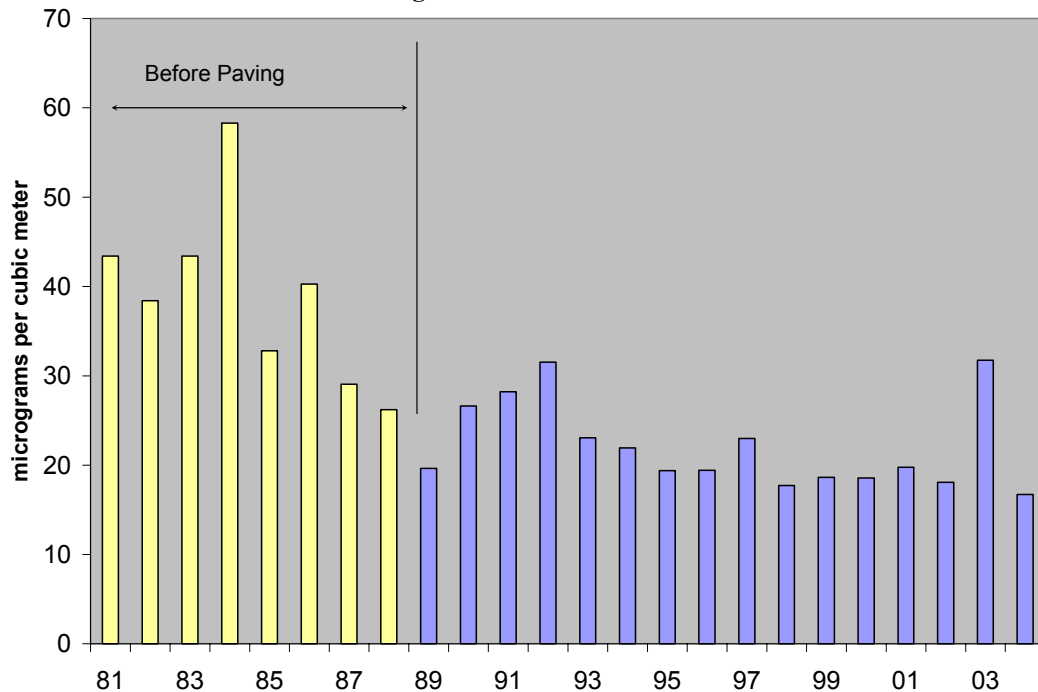
Annual average PM₁₀ levels in 2002 were the highest since 1996. This was largely the consistently elevated levels of PM₁₀ in the second quarter (April – June). The annual concentration in 2003 was also higher than most other recent years. This value is largely the result of very high PM₁₀ concentrations experienced during an intense, week-long wind storm in early March 2003. Gusts as high as 100 mph were measured during the storm causing blowing dust. Record high PM₁₀ concentrations were measured at several monitoring stations during this period.

Significant changes in road sanding and clean-up methods were made beginning in 1996. 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 and State are now using magnesium chloride deicer in lieu of road sand when appropriate and this has helped to reduce the amount sand applied to roadways over the course of the winter. Although year-to-year variability in PM₁₀ 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 PM₁₀ concentrations, there appears to be some evidence that PM₁₀ concentrations have been reduced. Annual average PM₁₀ concentrations in 2004 were the lowest on record. During the past 17 years, six of the seven lowest annual average PM₁₀ years have occurred since changes in road sanding and clean-up practices were implemented.

PM₁₀ 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. PM₁₀ monitoring was initiated in October of 1985 and continues to present. Concurrent TSP and PM₁₀ monitoring between October 1985 and December 1986 enabled a mathematical relationship between PM₁₀ and TSP to be developed through linear regression procedures that allows PM₁₀ concentrations to be predicted from TSP measurements. There is good agreement between TSP and PM₁₀. Thus, average annual PM₁₀ concentrations could be extrapolated from TSP data during calendar years 1981-1985 when PM₁₀ data were not collected. Observed and extrapolated annual average PM₁₀ concentrations are plotted in Figure 3-5.

Figure 3-5
Trend in Average Annual PM₁₀ Concentrations in Eagle River
Parkgate Station 1981 - 2004



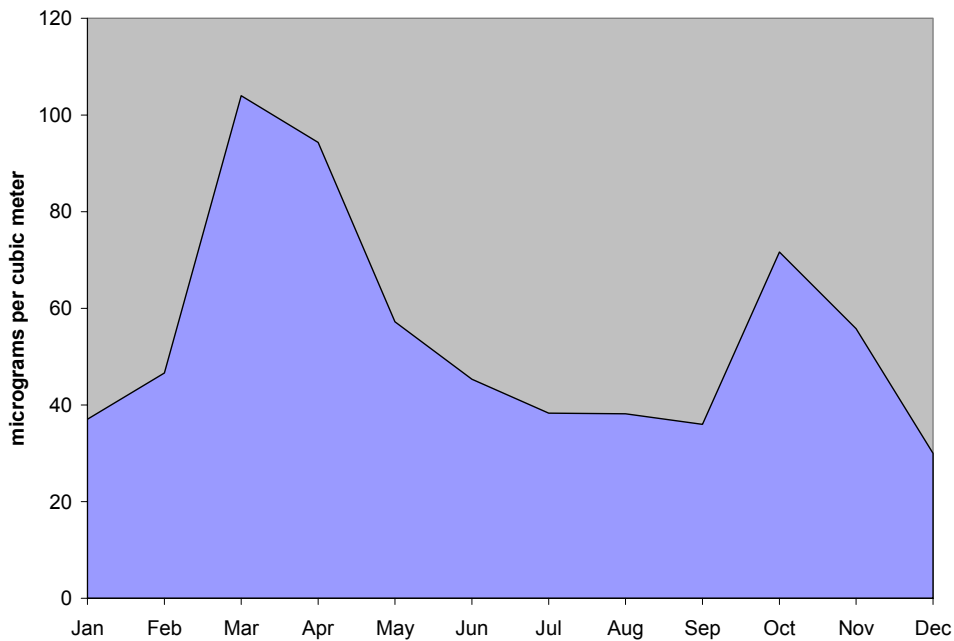
A dramatic reduction in PM₁₀ concentrations is evident at the Parkgate station beginning in 1989. In September of 1988, many of the roads surrounding this site were paved or surface with recycled asphalt. As one might expect, PM₁₀ concentrations declined. On average, PM₁₀ levels at Parkgate

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 the week long wind storm in March 2003 discussed earlier.

Seasonality of PM₁₀ Concentrations in Anchorage and Eagle River

The highest PM₁₀ 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 95th percentile concentrations from the Allstate Building station near Tudor Road are plotted by month in Figure 3-6.

Figure 3-6
95th Percentile PM₁₀ Concentration by Month
at the Allstate Building Station, Anchorage (1996 – 2004)



Influence of Weather on PM₁₀ Concentrations

Weather strongly influences PM₁₀ concentrations in Anchorage and Eagle River. Because road dust emissions are the largest source of PM₁₀, 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 PM₁₀. During the spring break-up period the highest PM₁₀ concentrations 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 PM₁₀ concentrations occur during the period when temperatures fall below freezing, particularly during the morning commute when traffic is heavy.

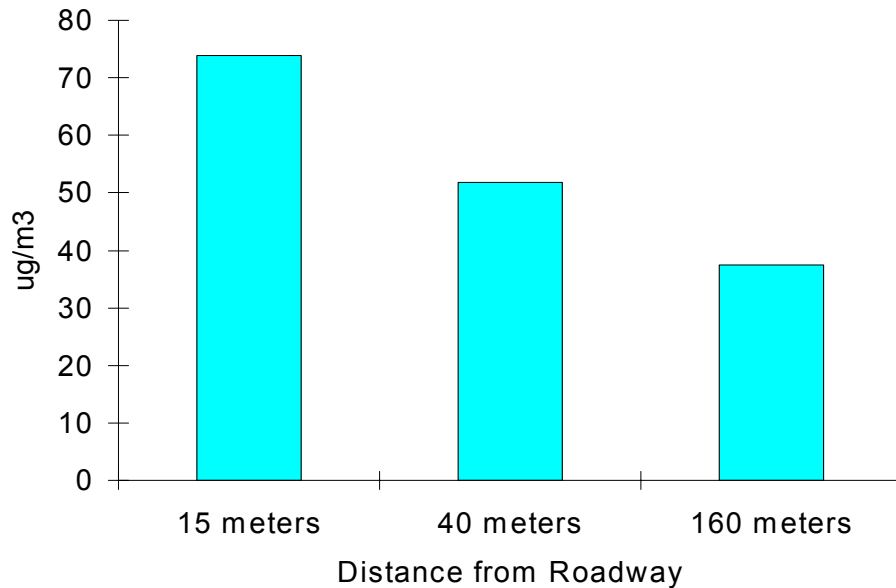
It should be noted that the highest PM₁₀ levels normally occur on days with low wind speeds. When wind speeds are low, atmospheric mixing is often poor and PM₁₀ emissions are trapped close to the ground. Moderately windy days, with improved atmospheric mixing, normally have lower PM₁₀ levels. However, during periods of extreme winds, (i.e. sustained winds of more than 25 mph) PM₁₀ levels can be very high because of an increase in wind blown dust.

Effect of Proximity to Roadways on PM₁₀ Concentrations

PM₁₀ monitoring in Anchorage implicates major roadways as the source of PM₁₀ emissions and the data suggest that except for natural events like volcanic eruptions or wind storms, PM₁₀ exceedances occur only near major roadways. PM₁₀ drops dramatically as the distance from the roadway increases. In 1997, during the spring break-up period, PM₁₀ 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.

Figure 3-7

Average PM₁₀ Concentration vs. Roadway Setback
Gambell Street, Spring 1997



PM₁₀ Concentrations in Anchorage Compared with Other Areas

PM₁₀ concentrations from a number of other western cities are compared to Anchorage in Table 3-2. The highest and second highest 24-hour average concentrations measured in calendar year 2004 are tabulated along with the average annual average concentration for each city during the year.

Comparison of data from different cities should be done with caution. PM₁₀ 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 PM₁₀ (µg/m³)	Highest 24-Hour Avg (µg/m³)	2nd Highest 24-Hour Avg (µg/m³)
Mono Lake, CA	63	987	913
Butte, AK	29	605	97
El Paso, TX	45	397	281
Phoenix, AZ	64	251	145
Portland, OR	25	114	61
Anchorage, AK	22	97	97
Denver, CO	29	90	75
Boise, ID	23	70	57
Seattle, WA	25	57	47
Eugene, OR	14	36	35

PM_{2.5} Data Summary

Sampling with EPA-approved reference samplers began in Anchorage in November 1998. PM_{2.5} data from the Garden Station station are summarized in Table 3-3(a). Data from the Allstate Building are summarized in Table 3-3(b). Monitoring at this site was discontinued at the end of 2002. Annual average and 24-hour concentrations measured at these sites have been well below the NAAQS.

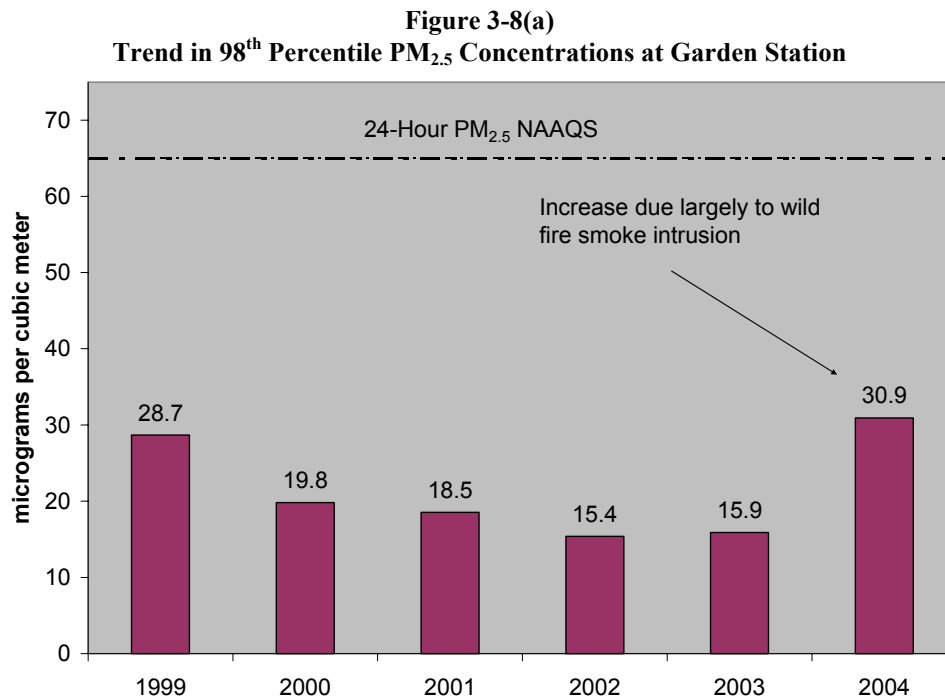
	Annual Average	Annual Max	98 th Percentile
1999	6.5	69.8 ^a	28.7
2000	5.4	38.9	19.8
2001	5.9	27.8	18.5
2002	5.8	16.9	15.4
2003	5.9	25.4	15.9
2004	7.0	43.7	30.9

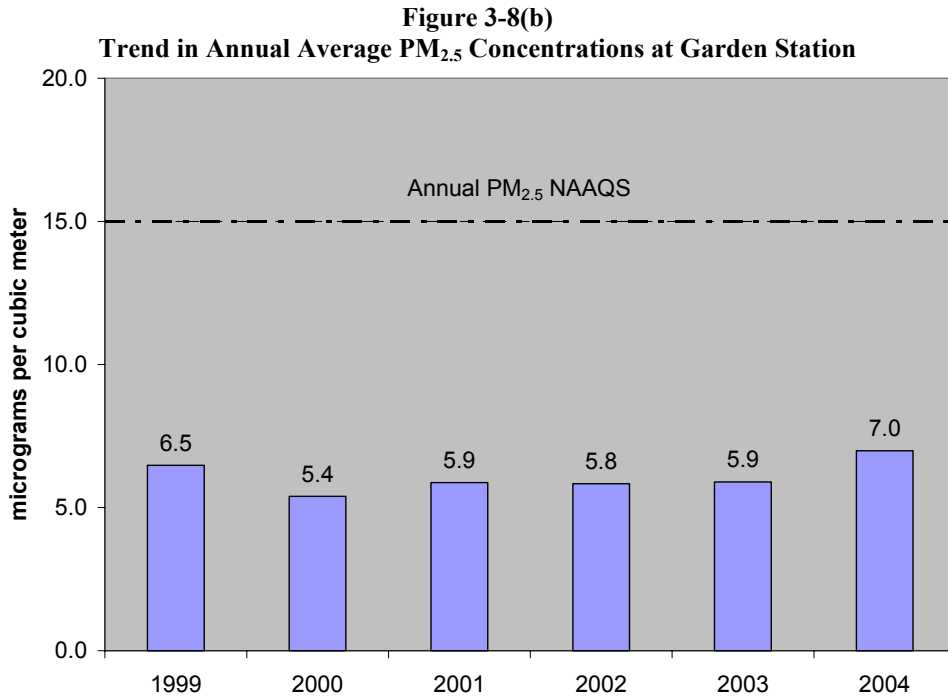
	Annual Average	Annual Max	98 th Percentile
1999	6.8	43.7	21.6
2000	6.1	32.8	16.3
2001	6.2	30.0	15.5
2002	6.9	20.8	17.4
2003	---	---	
2004	---	---	

^a 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_{2.5} Trends

Annual average and 98th percentile PM_{2.5} concentrations from 1999 through 2004 are plotted in Figures 3-8(a) and 3-8(b). No clear upward or downward trend is evident. Smoke from interior wild fires during the summer of 2004 is the cause of higher-than-normal PM_{2.5} levels in 2004.

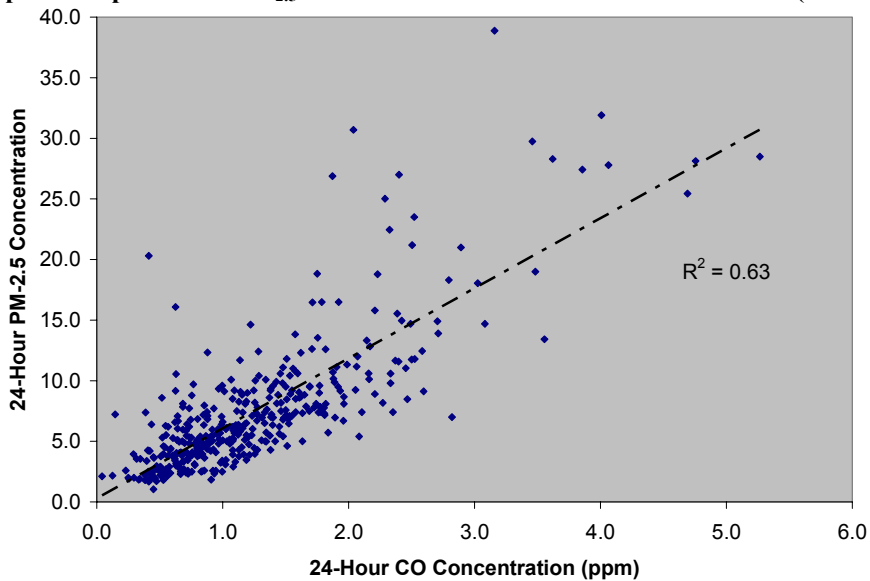




Sources of PM_{2.5} in Anchorage

Data collected thus far in Anchorage suggests that PM_{2.5} originates from different sources than PM₁₀. While the majority of PM₁₀ in Anchorage has been shown to be of geological origin, PM_{2.5} appears to have a different source. The highest PM_{2.5} concentrations usually occur on days when the CO concentrations are also high, suggesting that the same source that contributes the majority of CO emissions, motor vehicle exhaust, is also the main source of PM_{2.5}. Figure 3-9 shows a scatter plot comparison of PM_{2.5} and CO measured at the Garden Station. The strong association between PM_{2.5} and CO measurements ($R^2 = 0.63$) suggests that these two pollutants have a common source.

Figure 3-9
Scatterplot Comparison of PM_{2.5} and CO Concentrations at Garden Station (1999 – 2004)



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 PM₁₀ Filters, Anchorage, Alaska," Laboratory Report from Microlab Northwest for the Municipality of Anchorage, Report No. 1062-94, October 17, 1994
4. "Eagle River PM₁₀ 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 PM₁₀ 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 PM₁₀ 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 lead can occur through ingestion or inhalation. 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. 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. Recent studies have implicated lead as a factor in high blood pressure and heart disease. Exposure to lead has declined dramatically in the last ten years as a result of the reduction of lead in gasoline, paint, and the elimination of lead from soldered cans.

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.

Site Name	Monitoring Duration	Location
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

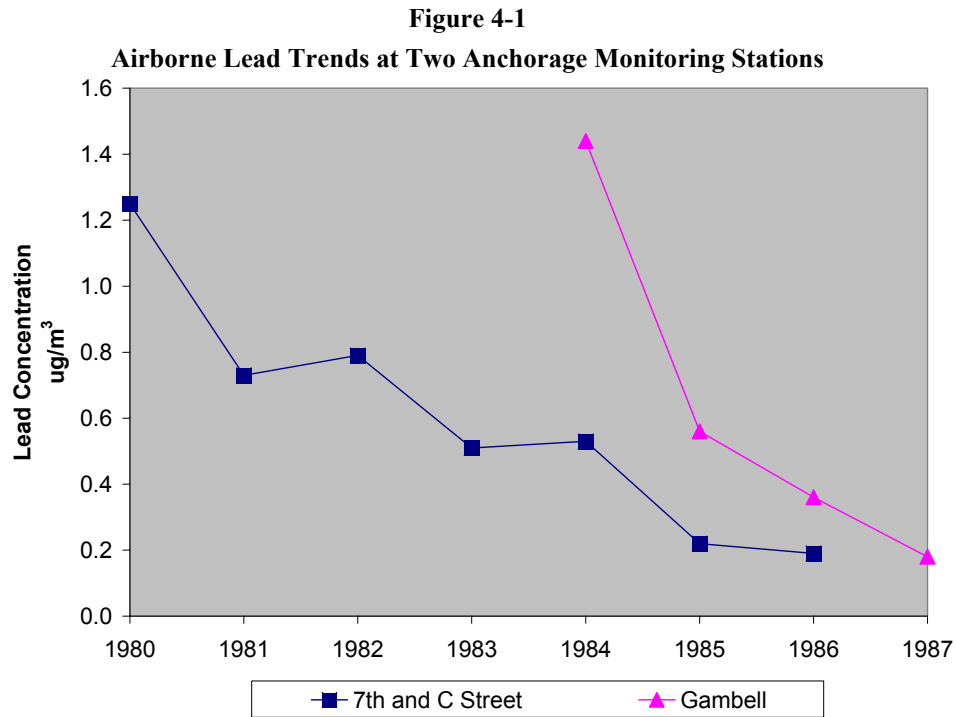
The NAAQS for airborne lead is set at 1.5 $\mu\text{g}/\text{m}^3$ for a maximum quarterly average. The average lead concentration measured in any single quarter cannot exceed 1.5 $\mu\text{g}/\text{m}^3$. In Anchorage, airborne lead concentrations were highest during the winter months, in the first and fourth quarters. Lead data are summarized in Table 4-2.

Year	7th & C Street	Gambell	8th & L Street	Jefferson Avenue	Cheechako Street
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.



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.

References

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

Section 5 - Sulfur Dioxide

Health Effects of Sulfur Dioxide

High concentrations of sulfur dioxide (SO₂) may aggravate existing respiratory and cardiovascular disease. Asthmatics, and those with emphysema or bronchitis are the most sensitive to SO₂ exposure. Children and the elderly may also be more sensitive. SO₂ 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 SO₂ in Anchorage

There are no significant sources of SO₂ in Anchorage. SO₂ 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.

SO₂ Monitoring in Anchorage

SO₂ was monitored in Anchorage from April 1983 through December 1984 at a site located downtown at 820 West 4th Avenue. The levels of SO₂ 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.

Table 5-1		
Anchorage SO₂ Concentrations Compared to the NAAQS		
Data from 1983-84 Monitoring		
Averaging Period	Highest Concentration Measured in Anchorage	NAAQS* for Averaging Period
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.

SO₂ Concentrations in Anchorage Compared with Other Areas

In 1983 and 1984, SO₂ levels in Anchorage were lower than 95% or more of the SO₂ monitoring 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 6 - Ozone

Health Effects of Ozone

Ozone 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 O₃ 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_x) and oxygen (O₂). 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.

O₃ Monitoring in Anchorage

O₃ has been monitored in 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. 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 O₃ were found to be about one-half of the NAAQS in effect at that time. O₃ measurements at these two sites are compared to the NAAQS in Table 6-1.

Monitoring Site	Period When Monitoring was Performed	Highest 8-Hour O₃ Measurement
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.

O₃ Concentrations in Anchorage Compared with Other Areas

In 1985, the last year data was collected in Anchorage, peak hourly O₃ 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 (NO₂) 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 NO₂ may cause acute respiratory disease in children.

NO₂ is an important precursor in the formation of ozone or smog. Consequently, control of NO₂ emissions is an important component of overall pollution reduction strategies in areas with ozone problems.

NO₂ is also a precursor in the formation nitric acid and other acid aerosols that may affect aquatic and terrestrial ecosystems.

Sources of NO₂ in Anchorage

Nationwide, the two main sources of NO₂ are fuel combustion and transportation. In Anchorage, a comprehensive NO₂ inventory has not been prepared. However, the main sources of NO₂ in Anchorage are probably similar to the U.S. as a whole. Mobile sources, natural gas combustion for electrical power, and aircraft are likely the major sources of NO₂ in Anchorage.

NO₂ Monitoring in Anchorage

The DHHS has not monitored for NO₂. No data are presented here.

NO₂ Concentrations in Anchorage Compared with Other Areas

Since 1992, all areas of the country, including Los Angeles, which regularly experiences the highest concentrations of NO₂, 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 nonlymphotic 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, PM₁₀, lead, SO₂, O₃, and NO₂), EPA has not established ambient air quality standards for VOCs.

VOC Monitoring in Anchorage

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 th 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

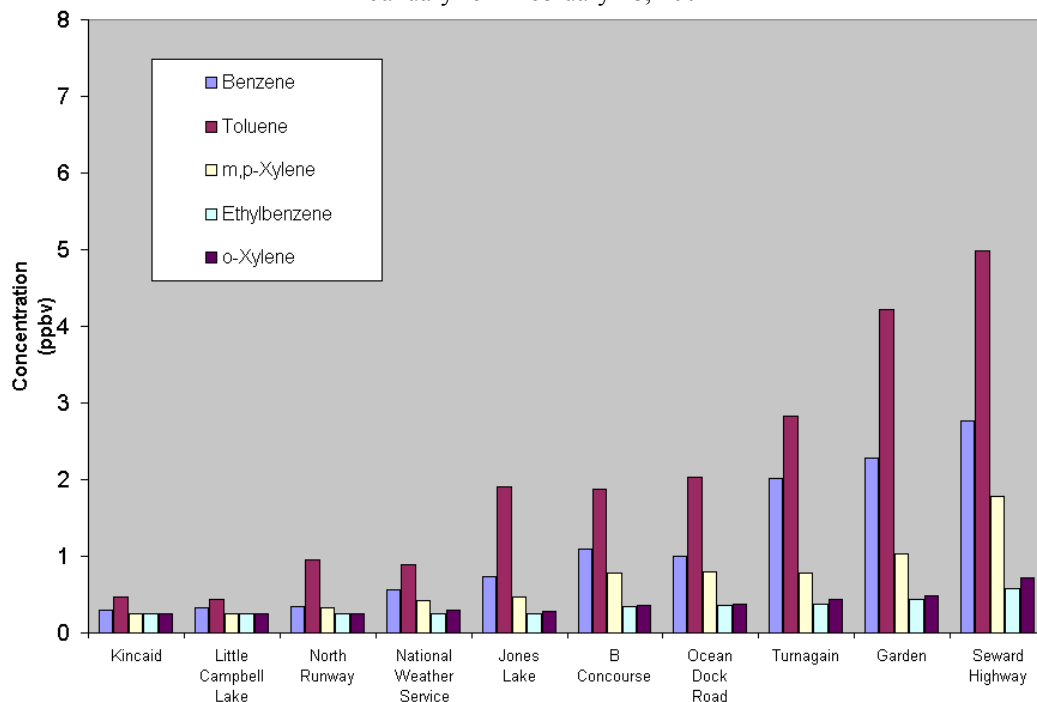


Figure 8-3 shows that BETX concentrations at the six sites nearest the airport were lower than the four “non-airport” sites. This was not surprising. Each of the BETX compounds are a significant component of gasoline and motor vehicle emissions are the predominant source of these compounds in ambient 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

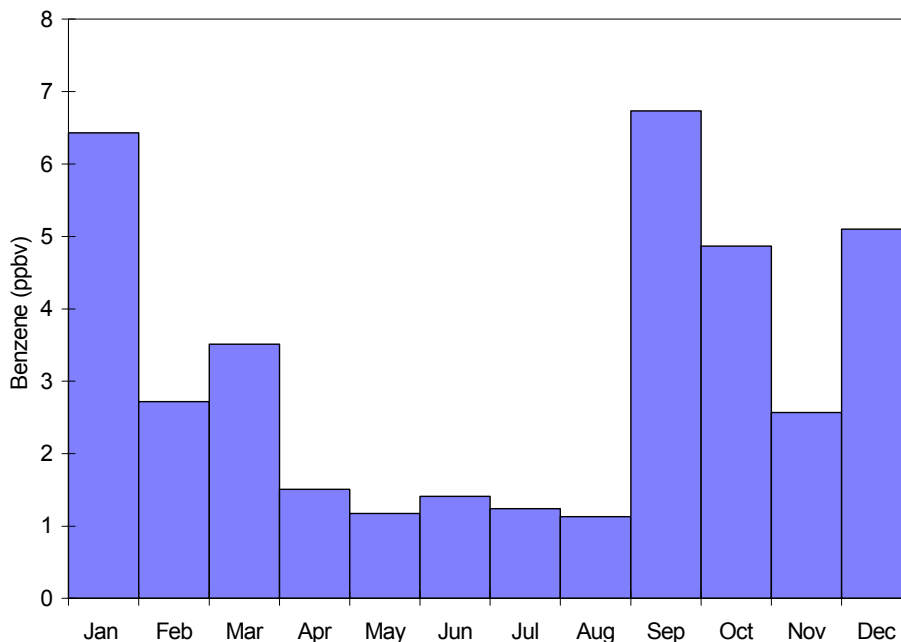
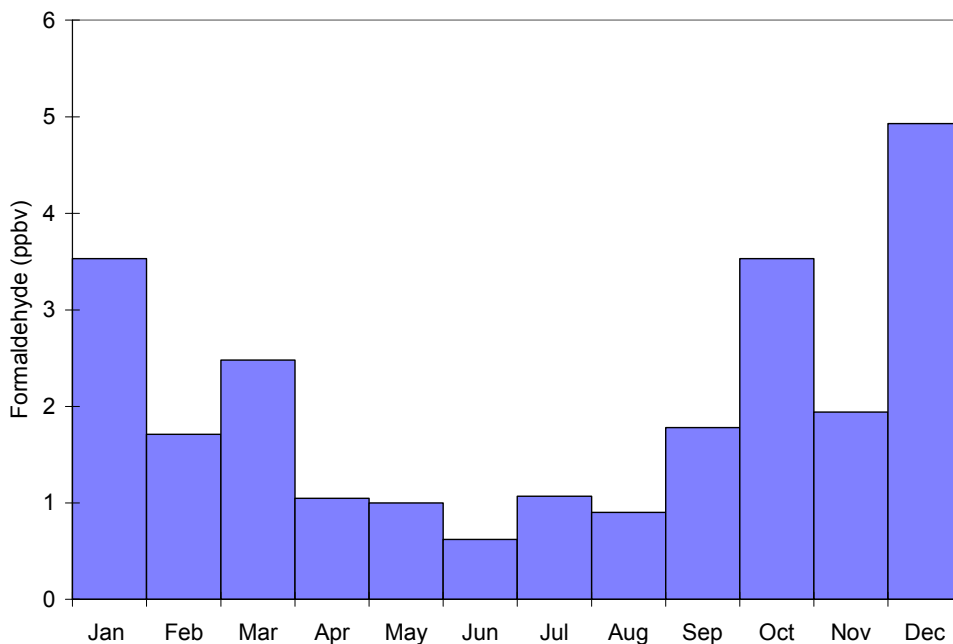


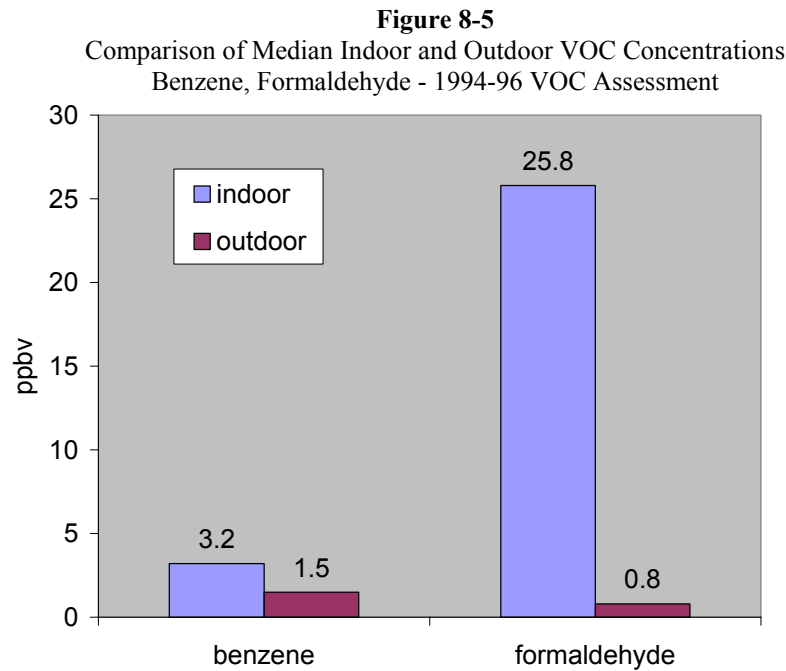
Figure 8-4(b)
 Mean Formaldehyde Concentrations by Month at Benson Site
 1994-96 VOC Assessment



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.

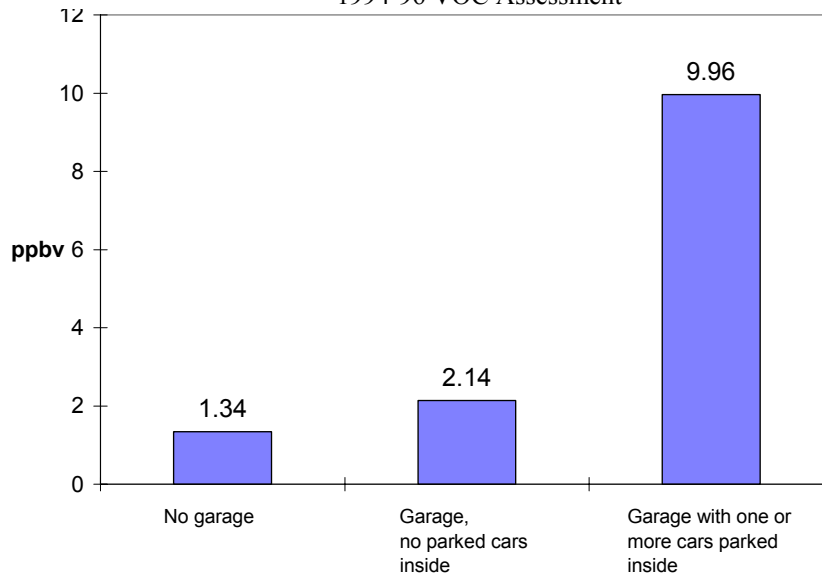
Results of Indoor Monitoring

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

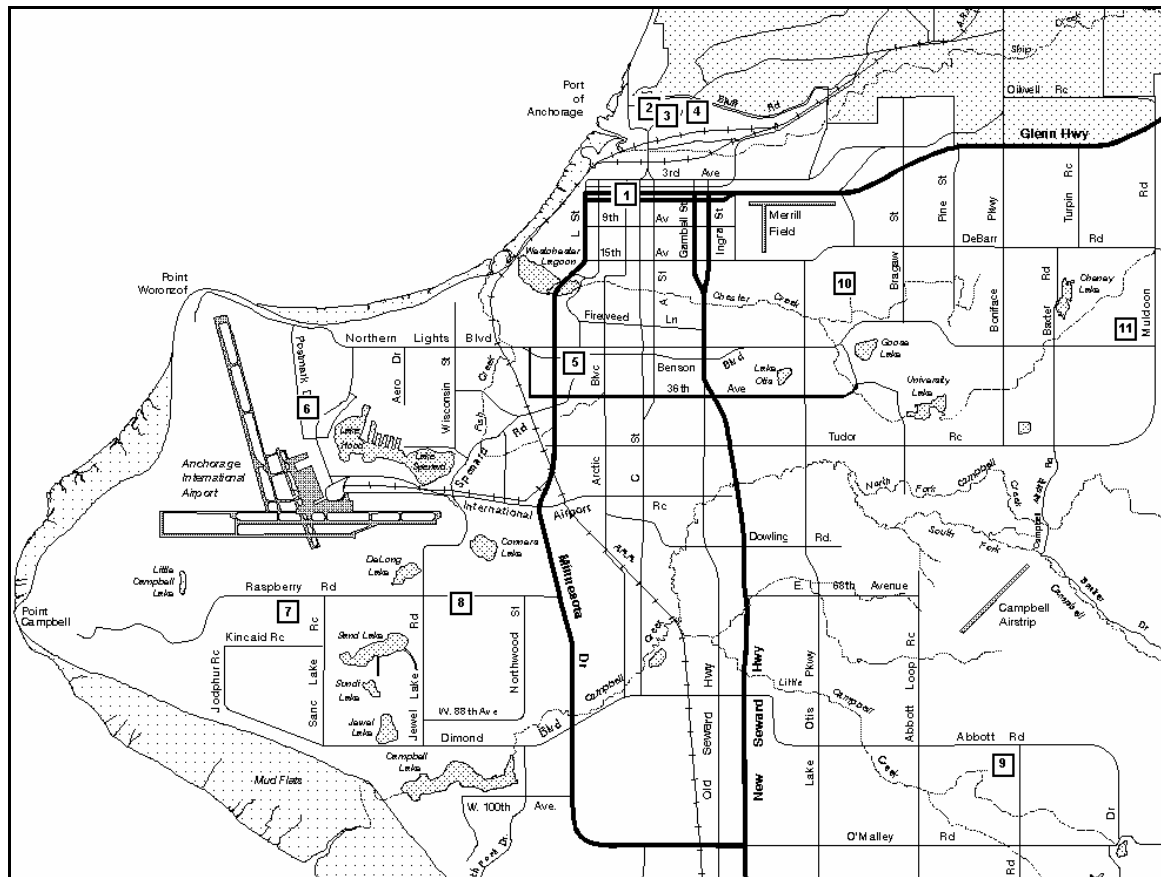


The data suggested that motor vehicle and/or gasoline-related emissions were not a significant source of indoor formaldehyde or acetaldehyde, however. These compounds were not correlated with the indoor BETX measurements indicating that they have a different source than the BETX compounds.

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. 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



Site No	Land Use	Location
Site 1	commercial	Downtown, 6 th and E Street
Site 2	industrial/residential boundary	Government Hill bluff, Delaney St. & W. Cook
Site 3	residential	Government Hill, Cunningham St. & E. Manor
Site 4	residential	Government Hill Elementary School
Site 5	commercial, heavy traffic	Collocated with Benson CO station
Site 6	commercial	Airport Post Office, Postmark Drive
Site 7	residential, low density	Raspberry Road near Tanaina Drive
Site 8	residential	Collocated with Sand Lake CO station
Site 9	residential, low density	Lower Hillside area
Site 10	residential	Collocated with Garden CO station
Site 11	residential	Muldoon area

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	Airport Hgts (Garden)	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^2) 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 identify trends in Anchorage VOC data because data have been collected sporadically. However, there is some evidence suggesting 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. There is some evidence this has occurred. Between the 1992-93 and 1994-96 studies, average benzene concentrations at the Garden site fell by approximately 30% (3.6 ppb to 2.5 ppb).

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 during the Ted Stevens Anchorage International Airport Study in January and February 2002 were limited to a six week period therefore 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. The 1995 data from this study are compared to 1995 data from other cities selected from the EPA's on-line AirData database in Table 8-2.⁵ This comparison suggests that ambient benzene concentrations in Anchorage were among the highest in the country in 1995.

Inter-city comparisons of data should be made with caution, however, measured concentrations are highly dependent on the local sampling conditions (i.e. proximity to major traffic arterials, industrial areas, etc.). Concentrations measured at any one site are not necessarily representative of the average concentration in each city. Also, 1995 VOC data were limited or unavailable for many cities. The Anchorage data presented in Table 8-2 were from the Garden station, located in an east Anchorage residential area.

City	Number of Samples	Max (ppb)	Mean (ppb)
Anchorage, AK	40	10.3	2.3
Los Angeles, CA	44	5.2	2.1
El Paso, TX	55	5.0	1.6
Houston, TX	46	3.6	1.5
Chicago, IL	139	3.3	1.2
Minneapolis, MN	53	2.2	0.8
Bellingham, WA	11	2.0	0.8
San Diego, CA	48	4.5	0.8
Sacramento, CA	109	4.3	0.7
Duluth, MN	39	1.4	0.6
Vancouver, WA	10	1.5	0.6

⁵ The benzene data presented in EPA AirData are expressed in units of ppbC. These data were converted to ppb for presentation in Table 8-2.

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