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Puget Sound Clean Air Agency

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2008
Air Quality Data Summary

October 2009

Working Together for Clean Air

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The 2008 Air Quality Data Summary is available
for viewing or download on the internet at:

www.pscleanair.org/

Links to additional documents for download are also available at the web site.

This material is available in alternate formats for people with disabilities. Please call Carol Pogers at (206) 689-4080 (1-800-552-3565, ext. 4080).

INTRODUCTION

BACKGROUND

The Puget Sound Clean Air Agency (the agency) has issued an air quality data summary report almost every year for over 30 years. The purpose of this report has been to summarize regional air quality by presenting air monitoring results for six criteria air pollutants. The U.S. Environmental Protection Agency (EPA) sets national ambient air quality standards (NAAQS) for these pollutants. These criteria air pollutants are:

- Particulate Matter (10 micrometers and 2.5 micrometers in diameter)
- Ozone
- Nitrogen Dioxide
- Carbon Monoxide
- Sulfur Dioxide
- Lead

Beginning in 2004, the agency added additional information on air toxics to the Air Quality Data Summary. Air toxics are pollutants broadly defined by Washington State and the agency to include over 400 chemicals and compounds that are associated with a broad range of adverse health effects, including cancer. Many air toxics are a component of either particulate matter or volatile organic compounds (a precursor to ozone), so there are overlaps between the criteria pollutants and toxics.

The agency and Washington State Department of Ecology work together to monitor air quality within the Puget Sound region.[1] Real-time air monitoring data are available for some pollutants on the Internet at http://www.pscleanair.org/airq/aqi.aspx. Visit the agency's website at http://www.pscleanair.org/default.aspx to find more extensive air quality data, educational materials and discussions of current topics. Monthly air quality summaries, wind roses, air quality graphing tools, and historical data summaries are available at http://www.pscleanair.org/airq/reports.aspx. To receive the agency's monthly electronic newsletter, Clean Air Newsline, and stay current on air quality issues in King, Kitsap, Pierce, and Snohomish counties, visit http://www.pscleanair.org/news/agencynews.aspx and select Clean Air Newsline. Subscribers receive the latest on air quality news and updates on projects that affect local communities in the Puget Sound region. The Newsline also provides timely and important messages about burn bans, smog forecasts, and early calls to action when air quality deteriorates.

The agency is expanding and refining our internet site to better serve the residents of the Puget Sound region. We encourage feedback on our air quality data and program via e-mail to Mary Hoffman at maryh@pscleanair.org or at 206-689-4006.

[1]The Agency's jurisdiction covers King, Kitsap, Pierce, and Snohomish Counties in Washington State.

REPORT ORGANIZATION

A brief overview of this report is provided in the executive summary. The executive summary is followed by background on the Air Quality Index (AQI) and the agency's monitoring program and network and the 2008 agency-issued burn bans and smog forecasts.

The primary focus of this report is to present information on criteria air pollutants. Graphs, statistical summaries, and health effects information are provided for each pollutant monitored in 2008 in our four-county area, as well as comparisons to ambient air quality standards and health goals. Information about visibility based on fine particulates is included as part of our particulate matter presentation.

In addition to the information on criteria air pollutants, a summary of air toxics data based on monitoring by the Washington State Department of Ecology is also presented, along with links to more comprehensive reports describing air toxics concentrations and health effects information.

EXECUTIVE SUMMARY

The agency, along with partners, continued to monitor the region's air quality in 2008. Over the last decade, criteria air pollutant concentrations for some pollutants have fallen well below levels of concern in our jurisdiction. For example, levels of carbon monoxide, a pollutant that the region was formerly in nonattainment for, have fallen to levels so low that the Washington State Department of Ecology discontinued many of the monitors in 2006 in order to focus its monitoring resources on higher priority pollutants.

While the area enjoys improving air quality, we are facing new challenges. After more than a decade of attaining all federal standards, the agency faces nonattainment for $PM_{2.5}$ and ozone levels continue to be a concern for the region due to recent revisions to the national fine particulate and ozone standards to better protect public health.

Elevated fine particle levels present the greatest challenge in our jurisdiction. Fine particulate matter concentrations at the South L Tacoma monitoring site, located in the south end of Tacoma, violate EPA's revised daily fine particulate matter federal standard. EPA has designated the Wapato Hills-Puyallup River Valley area, including much of Tacoma and surrounding areas, as nonattainment for fine particles.

Monitoring sites in Snohomish County are close to the daily fine particle federal standard. Sites in all four counties - Snohomish, King, Kitsap, and Pierce - continue to exceed the agency's local $PM_{2.5}$ health goal, set at 25 $\mu g/m^3$ to adequately protect health.

Ozone levels remain a concern in our region, as ozone concentrations have not decreased as significantly as its precursor pollutants. EPA strengthened its 8-hour ozone standard from 0.08 parts per million to 0.075 parts per million in March 2008. Meeting a stricter ozone standard presents a challenge for the Puget Sound region. Ozone levels at the Enumclaw Mud Mountain monitor violated the new standard for the period 2006 through 2008. As of the publication of this report, the Puget Sound area is unlikely to be designated nonattainment under the 0.075 ppm standard, as preliminary data for 2007 - 2009 did not indicate violations of the standard. However, EPA expressed its intent in September 2009 to further strengthen the ozone standard in 2010. It is highly likely that the region would violate a future further strengthened standard.

Air toxics are also present in our airshed at levels that pose adverse health effects.[2] These health effects include, but are not limited to, increased cancer risk and respiratory effects.

Many of the same sources that produce criteria and toxic air pollutants also generate greenhouse gases. The agency collaborates with public and private partners to reduce greenhouse gases.[3] Unlike the criteria pollutants and air toxics included in this summary, we do not monitor their levels in the

[2]Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.
[3]Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound; http://www.pscleanair.org/programs/climate/rptfin.pdf.

atmosphere. The agency focuses on local emission inventories and reduction strategies. For more information, refer to http://www.pscleanair.org/programs/climate/default.aspx.

The agency is taking action with many partners to face these air quality challenges. These actions include exploring new methods to better characterize fine particulate and air toxics, estimating greenhouse gas emissions, developing reduction strategies, working with planning agencies, and implementing voluntary incentive programs that achieve reductions. Visit our website at www.pscleanair.org for more information about emission reduction programs.

AIR QUALITY INDEX (AQI)

The AQI is a nationwide reporting standard developed by the EPA for the criteria pollutants. The AQI is used to report daily air quality. "Good" AQI days continued to dominate our air quality in 2008. However, air quality degraded into "moderate" approximately one fifth of the time and to "unhealthy for sensitive groups" and "unhealthy" for brief periods.

Table 1 shows the AQI breakdown by percentage in each category for 2008. King County registered the highest AQI value of 140 on June 29. Ozone determined the AQI on June 29. $PM_{2.5}$ typically determines the AQI in the Puget Sound area on days considered unhealthy for sensitive groups. EPA has not yet updated the AQI breakpoints to reflect the new $PM_{2.5}$ standard. When the AQI is updated, it is likely that monitors will register more frequently in the "unhealthy for sensitive groups" and "unhealthy" range.

Table 1: AQI Ratings for 2008

	AQI Rating (% of year)				
County	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Highest AQI
Snohomish	80%	20%	0%	0%	96
King	78%	21%	1%	0%	140
Pierce	81%	17%	2%	0%	129
Kitsap	93%	7%	0%	0%	78

IMPAIRED AIR QUALITY -- BURN BANS AND SMOG FORECASTS

The Puget Sound Clean Air Agency issues temporary bans on indoor and outdoor burning when air inversions trap fine particle pollution emitted from our chimneys, cars, trucks, and other activities close to ground level. These burn bans are mandatory. There are two stages of the burn bans. Stage 1 prohibits burning from fireplaces and uncertified wood stoves except when the wood burning device is the only adequate source of heat. Stage 2 prohibits burning in fireplaces, uncertified wood stoves, EPA certified wood stoves, and pellet stoves unless the wood burning device is the only adequate source of heat.

The agency issued one stage one burn ban in 2008 for Pierce and Snohomish Counties. The burn ban occurred January 23-26.

The agency also may issue a smog forecast when predicted ozone levels are expected to persist for several days. During a smog forecast, the agency works with media and other partners to let the public know that ozone levels are unhealthy. We encourage people to work with our health partners to take steps to protect themselves and their families. The agency announced two smog forecasts in 2008: from August 4 through August 7, and from August 14 through August 17.

CRITERIA AIR POLLUTANTS AND VISIBILITY

The Puget Sound airshed is currently in attainment for carbon monoxide, ozone, and PM_{10}, and has maintenance plans in place for these pollutants.

The Tacoma South L monitor and surrounding is expected to be designated nonattainment for fine particles effective as of November 2009. Levels at the Marysville and Darrington monitors, both in Snohomish County, remain relatively close to the standard. Concentrations at monitors in all four counties continue to exceed our more stringent, local health goal.

A more protective 8-hour ozone federal standard may result in nonattainment at the Enumclaw Mud Mountain monitor in the future. This monitor typically has the highest regional ozone concentrations during high-ozone episodes.

Monitoring shows that visibility associated with fine particulate matter in the Puget Sound area has continued to improve over the last decade.

AIR TOXICS

The Department of Ecology began monitoring air toxics at the Seattle Beacon Hill site in 2008, as part of EPA's national air toxics trend network.

Carbon tetrachloride, a chemically persistent air toxic banned in 1996, presented the highest potential cancer risk from air toxics monitored in 2008 at the Seattle Beacon Hill site. Benzene, an air toxic from gasoline and other combustion, ranked second. It is important to note that this ranking does not include diesel and wood smoke particulate matter. A comprehensive 2003 evaluation showed that diesel particulate matter presents the majority of potential air toxics cancer health risk in our area.[4] Unfortunately, there is no direct monitoring method to measure diesel particulate matter.

[4] Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

AIR QUALITY INDEX

The air quality index (AQI) is reported according to a 500-point scale for five of the six major criteria air pollutants: ozone, particulate matter (both $PM_{2.5}$ and PM_{10}), carbon monoxide, nitrogen dioxide, and sulfur dioxide. The highest pollutant determines the daily ranking. For example, if an area has a carbon monoxide value of 132 on a given day and all other pollutants are below 50, the AQI for that day would be 132. The scale breaks down into six categories, listed below. Each category has a corresponding color, shown with pollution concentration breakpoints for each category, shown in Table 5 in the Definitions section of this document.

- **0 - 50: Good.** Satisfactory air quality; little or no risk from pollution.
- **51 - 100: Moderate.** Acceptable air quality; potential moderate health concerns for a very small number of people.
- **101 - 150: Unhealthy for Sensitive Groups.** Air quality is acceptable for the general public, but people with health conditions that make them sensitive to a particular pollutant are at greater risk of health problems.
- **151 - 200: Unhealthy.** Everyone may experience some health effects, more serious for members of sensitive groups.
- **201 - 300: Very Unhealthy.** Everyone may experience more serious health effects.
- **301 - 500: Hazardous.** Health risk is at emergency levels. Everyone is likely to be affected.

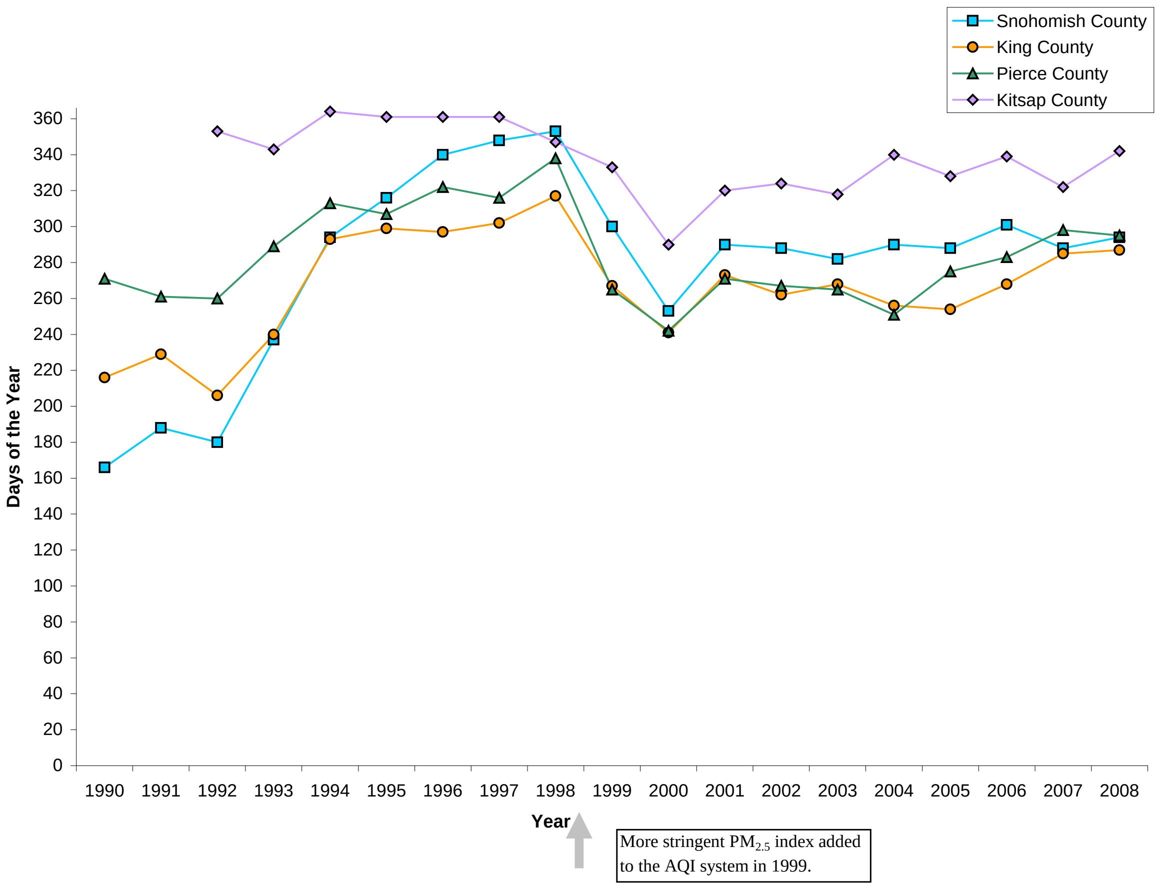
The AQI is a national index, so the reported values and colors used to show local air quality and the associated level of health concern will be the same throughout the United States. Current and archived AQI values for Puget Sound can be found on our website at www.pscleanair.org.

The number of “good” air quality days continues to dominate our air quality in the Puget Sound area. However, air quality degraded into “moderate”, “unhealthy for sensitive groups”, and “unhealthy” for brief periods. Table 1, presented in the executive summary, shows the AQI breakdown by percentage in each category for the year.

In 2008 EPA revised the AQI breakpoints for ozone in order to be consistent with the new ozone standard. EPA has not yet revised the AQI breakpoints to reflect the revised $PM_{2.5}$ daily standard. When EPA updates the AQI to reflect the new standard, it is possible that the Puget Sound Clean Air Agency could see more days in “moderate”, “unhealthy for sensitive groups”, and “unhealthy” categories.

Figure 1 presents the annual number of “good” AQI days for each of the four counties. The number of “good” days has been relatively constant over the last few years for each county. Lower numbers of “good” days now can not be directly compared with the numbers before 1999, when $PM_{2.5}$ was added to the index and the “unhealthy” category was divided into “unhealthy” and “unhealthy for sensitive groups.”

Figure 1: Number of Days Air Quality Rated As "Good" Per AQI



Figures 2 through 5 present AQI days for King, Kitsap, Pierce, and Snohomish Counties. Graphs include numbers adjacent to the "unhealthy for sensitive groups" and "unhealthy" lines for clarification of the number of days with these designations. Pages A-1 through A-4 of the Appendix present summaries for each county. Summaries include "good", "moderate", "unhealthy for sensitive groups", and "unhealthy" days from 1980 to 2008 (from 1990 to 2008 for Kitsap County).

Figure 2: Air Quality for King County

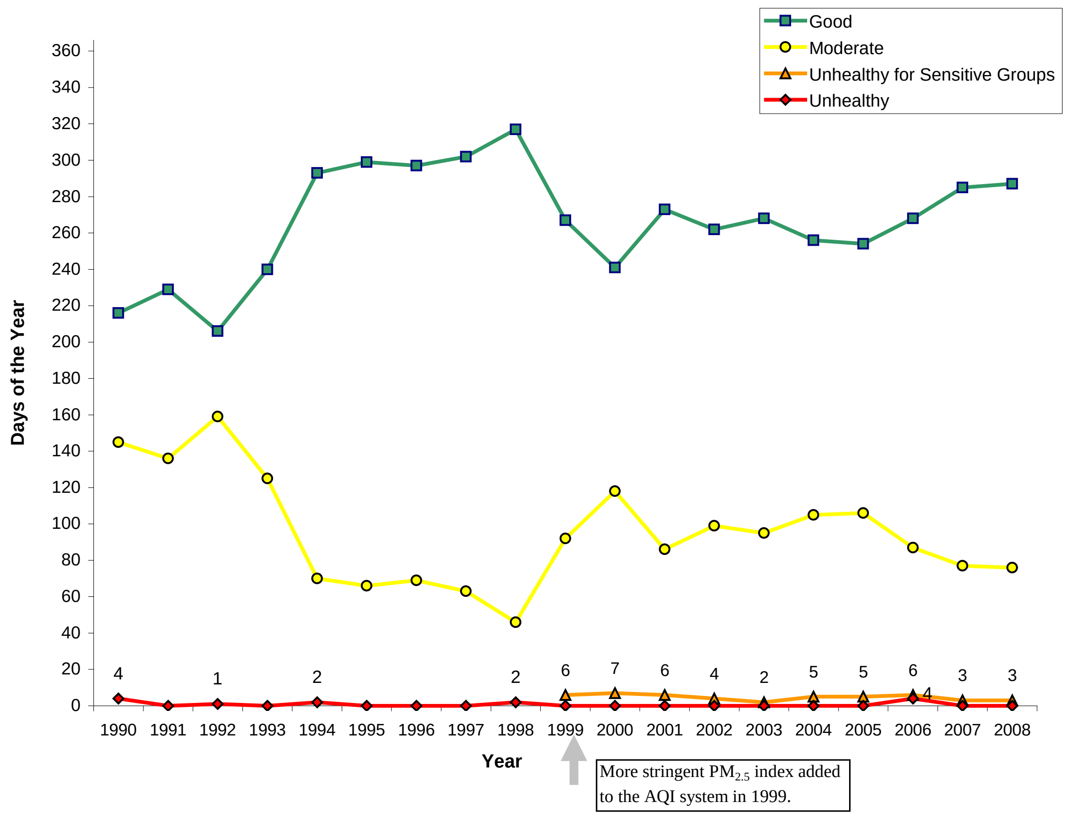


Figure 3: Air Quality for Kitsap County

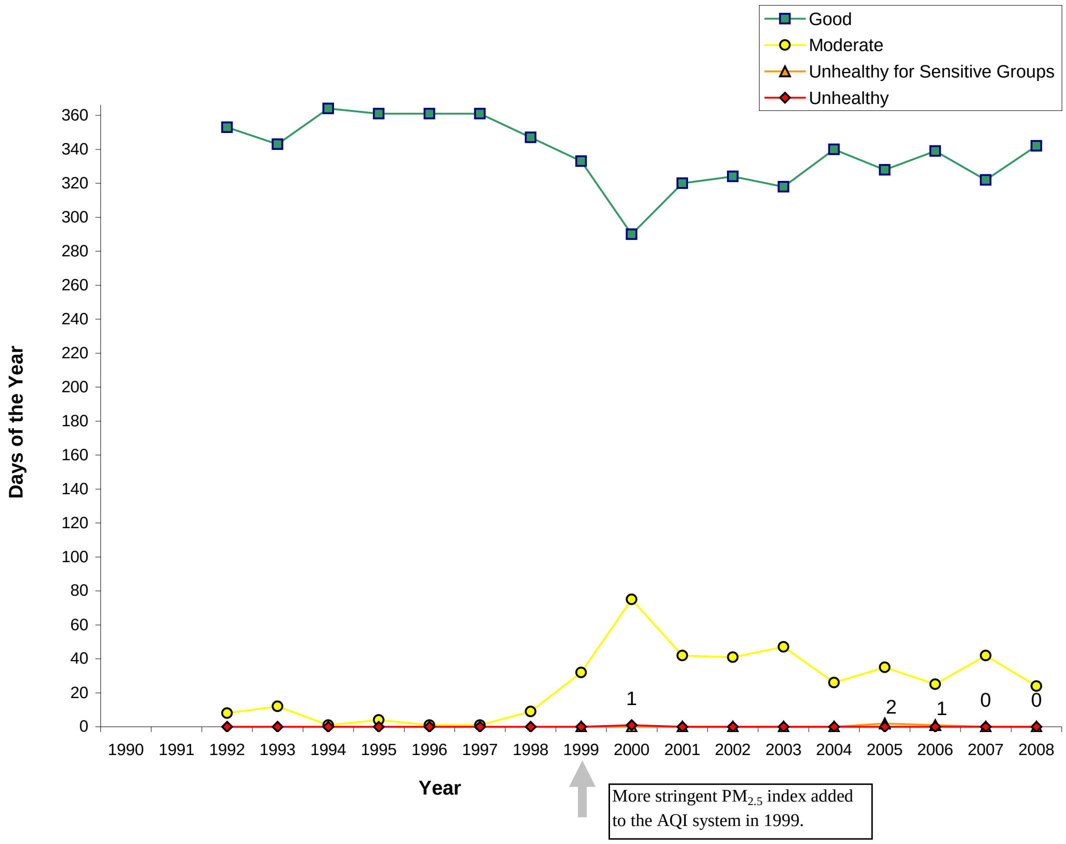


Figure 4: Air Quality for Pierce County

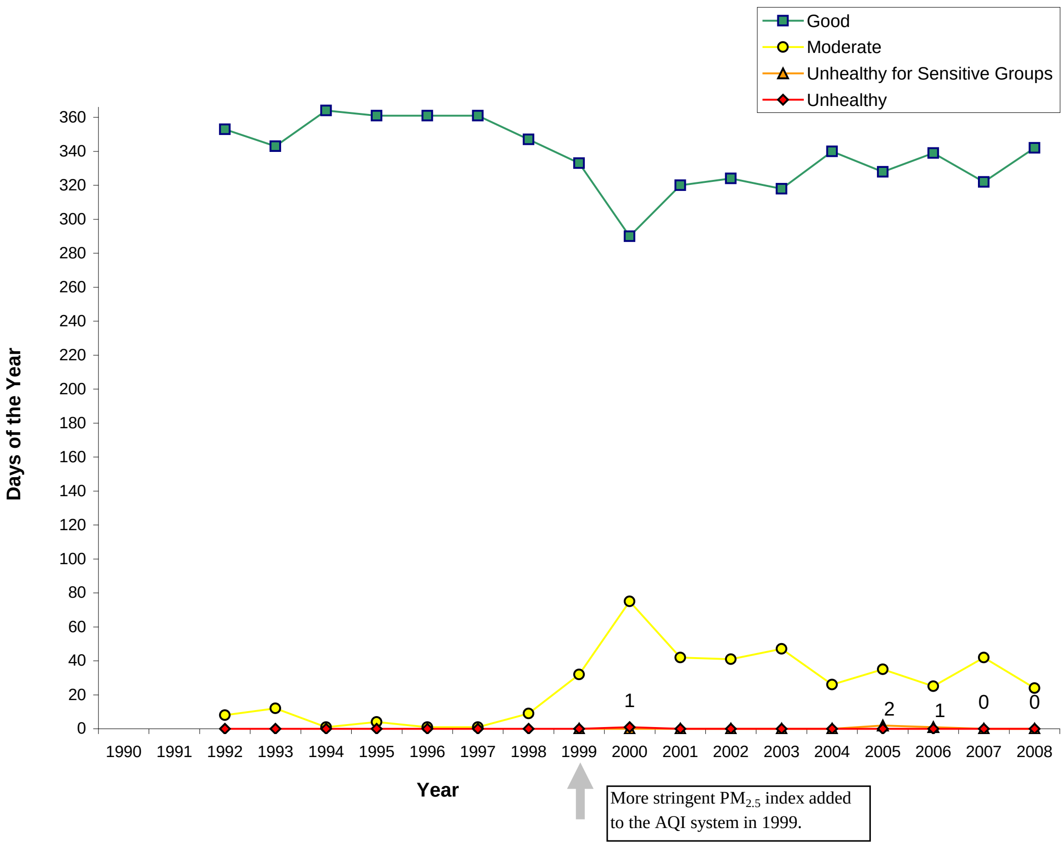
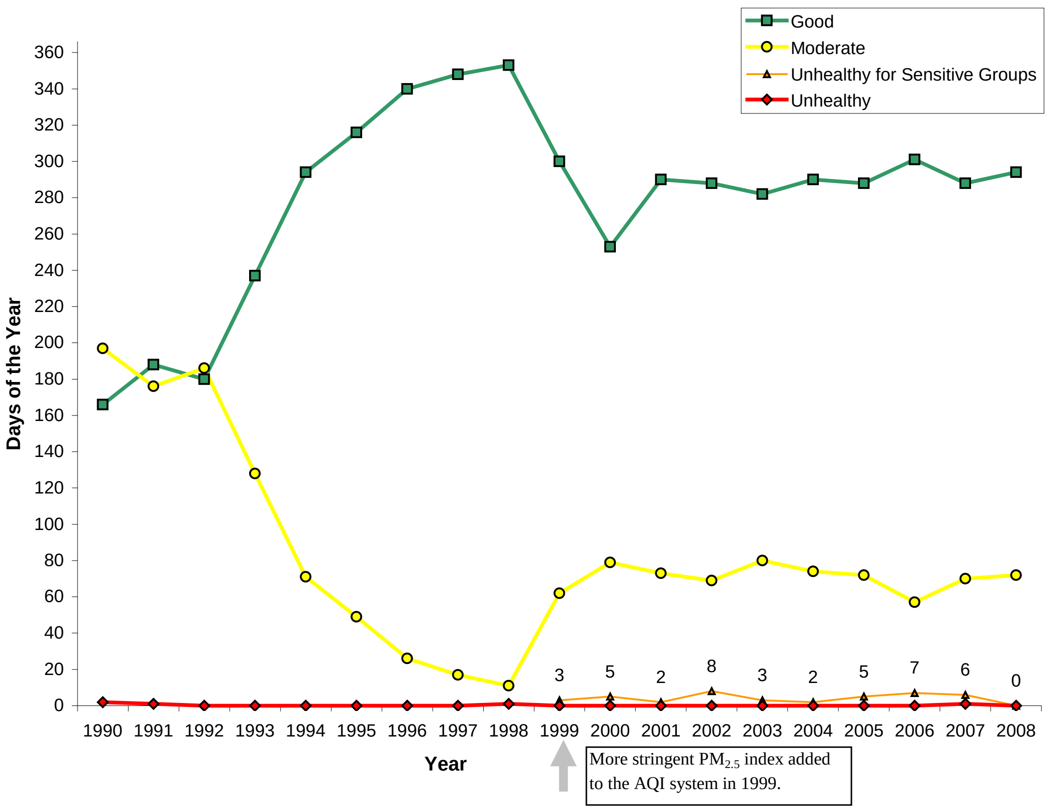


Figure 5: Air Quality for Snohomish County



MONITORING NETWORK

The agency and the Washington State Department of Ecology operate the Puget Sound region's monitoring network, comprised of both meteorological and pollutant-specific equipment. Data from the network are either collected manually by field staff or sent directly to engineers and scientists through a telemetry network.

The agency conducted monitoring as early as 1965; however, this report will focus on post-1999 monitoring. Table 2 presents a summary of the monitoring stations and parameters monitored from 1999 through 2008. Some parameters were monitored for only part of this time frame. Shaded stations in the table operated in 2008. Similarly, a filled circle denotes a pollutant that was monitored in 2008. An "x" denotes a pollutant that was no longer monitored in 2008. The network changes because the agency and the Department of Ecology regularly re-evaluate monitoring resources to measure and report on the pollutants that are most relevant to public health. Additionally, sometimes logistical issues (such as loss or gain of real estate) cause changes in the network.

Monitoring stations are located in a variety of geographic locations in the Puget Sound region. Most are located in highly populated areas. Monitors are sited according to EPA criteria to ensure a consistent and representative picture of air quality. Map 1 on page 18 shows monitoring stations that were active in 2008.

The station IDs shown on the map correspond with table identification letters. These same identification letters are used throughout this data summary. General location descriptors are also provided for each station in the last column of the monitoring network table. These descriptors make broad distinctions between urban center, suburban, and rural, and also provide information as to whether areas are more commercial, industrial, or residential. Sites that have more than two descriptors have varied land use; for example, both residential and commercial. In addition, some sites are selected to focus on the emissions of a specific pollutant or source (for example, near a busy roadway or residential areas where wood is used for home heating). Pollutant-specific sections of this report highlight these monitoring locations and objectives.

The agency and the Washington State Department of Ecology measure criteria air pollutants using federal reference methods (FRM) that are approved by the Environmental Protection Agency (EPA). In addition to the federal reference method, the agency measures particulate matter using alternate methods. These methods help engineers and scientists better understand the presence and behavior of these pollutants. For example, as shown in the monitoring network table, fine particulate ($PM_{2.5}$) is monitored according to the EPA reference method ("ref" in the table), as well as several other methods that provide real-time values.

A list of the methods used for monitoring the criteria pollutants can be found on page A-5 of the Appendix. Additional information on these methods is available at EPA's website at http://www.epa.gov/ttn/amtic/. Information on air toxics monitoring methods is available at http://www.epa.gov/ttn/amtic/airtox.html.

FINE PARTICULATE MONITORING – FEDERAL REFERENCE METHOD AND CONTINUOUS METHODS

Fine particulate matter ($PM_{2.5}$) is measured using a variety of methods because it is the main pollutant of concern in our area. The EPA considers the federal reference method (FRM) to be the most accurate way to determine $PM_{2.5}$ concentrations. This method involves pulling in air (at a given flow rate) for a 24-hour period and collecting particles of a certain size (in this case $PM_{2.5}$) on a filter. The filter is weighed and the mass is divided by air volume (determined from flow rate and amount of time) to provide concentration. Particles on the filter can be later analyzed and modeled for more information about the types of particulate matter. Unfortunately, the FRM does not provide continuous or rapid turnaround information.

The agency uses the FRM as well as two continuous methods to provide more time-relevant data. Our agency has been a national leader in this type of continuous monitoring.

These methods determine fine particulate matter concentration differently:

- the nephelometer uses scattering of light
- the tapered element oscillating microbalance (TEOM) measures mass

The agency also uses instruments to measure organic components of fine particulate matter, called aethalometers. These instruments measure light absorption.

In this report, continuous method data are compared, where possible, to the reference method values and calculations are made to determine the degree of difference from the reference method. The differences are then applied to the current continuous values in an attempt to make them “FRM-like.” Continuous concentrations from Kitsap County are not adjusted to make them “FRM-like”, as there is no site-specific FRM data at the Meadowdale and Silverdale monitoring sites.

Table 2: Air Quality Monitoring Network

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
AO◉	Northgate, 310 NE Northgate Way, Seattle (ended 3/31/03)												X						b, d, f
AQ	Queen Anne Hill, 400 W Garfield St, Seattle (photo/visibility included)							●						●	●	●		●	a, d, f
AR◉	4th Ave & Pike St, 1424 4th Ave, Seattle (ended Jun 30, 2006)												X						a, d
AS◉	5th Ave & James St, Seattle (ended Feb 28, 2001)												X						a, d
AU◉	622 Bellevue Way NE, Bellevue (ended Jul 30, 1999)												X						a, d
AZ	Olive Way & Boren Ave, 1624 Boren Ave, Seattle SPECIATION SITE							●	●					●	●	●		●	a, d
BF◉	University District, 1307 NE 45th St, Seattle (ended Jun 30, 2006)												X						b, d
BU◉	Highway 410, 2 miles E of Enumclaw (ended Sep 30, 2000)									X									c, e
BV◉	Sand Point, 7600 Sand Pt Way NE, Seattle (ended Aug 31, 2006 in the process of restarting)							●						●	X	X			b, d
BW◉ BZ◉	Beacon Hill, 15th S & Charlestown, Seattle SPECIATION SITE				●		●	●	●	●	●	●	●	●	●	●	●	●	b, d, f
CE	Duwamish, 4752 E Marginal Way S, Seattle SPECIATION SITE	X		X	●		●	●	●		X			●	●	●		●	a, e
CG◉	Woodinville, 17401 133rd Av NE, Woodinville							●						●					b,d,f
CW	James St & Central Ave, Kent	X		X	X		●	●						●	●	●		●	b, d
CX	17711 Ballinger Way NE, Lake Forest Park (ended Jun 4, 1999)	X	X											X	X			X	b, d, f

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
CZ	Aquatic Center, 601 143rd Ave NE, Bellevue (ended May 31, 2006)						X	X						X				X	b, f
DA	South Park, 8025 10th Ave S, Seattle (ended Dec 31, 2002)	X			X			X						X	X			X	b, e, f
DB	17171 Bothell Way NE, Lake Forest Park SPECIATION SITE	X	X		●		●	●	●					●	●	●		●	b, d, f
DC⦿	305 Bellevue Way NE, Bellevue				X			●						●				●	a, d
DD	South Park, 8201 10th Ave S, Seattle							●						●				●	b, e, f
DE⦿	City Hall, 15670 NE 85th St, Redmond (ended Dec 14, 2005)				X			X						X				X	a, d
DF⦿	30525 SE Mud Mountain Road, Enumclaw				X			●		●				●	●	●		●	c
DG⦿	42404 SE North Bend Way, North Bend				X		X	●		●				●	●	●		●	c, d, f
DH⦿	2421 148th Ave NE, Bellevue												●						b, d
DK⦿	43407 212th Ave SE, 2 mi west of Enumclaw (ended Sep 6, 2006)														X	X			c
DL⦿	NE 8th St & 108th Ave NE, Bellevue (ended March 4, 2003)												X						a, d
DN⦿	20050 SE 56th, Lake Sammamish State Park, Issaquah									●					●	●			b, d
DP⦿	504 Bellevue Way NE, Bellevue (ended Sep 30, 1999)	X			X														a, d
DZ⦿	Georgetown, 6431 Corson Ave S, Seattle (ended August 31, 2002)											X	X		X				a, d, e, f
EA	Fire Station #12, 2316 E 11th St, Tacoma (ended Dec 31, 2000)	X	X												X				a, e
EP	27th St NE & 54th Ave NE, Tacoma (ended Feb 29, 2000)	X									X				X				b, e, f
EQ	Tacoma Tideflats, 2301 Alexander Ave, Tacoma[11]	X	X	X	X		X	●			X			●	●	●		●	a, e

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
ER	South Hill, 9616 128th St E, Puyallup	X	X		X	X		●						●	●	●		●	b, f
ES	7802 South L St, Tacoma (began Oct 3, 1999)				●		●	●	●					●	●	●		●	b, f
FF⦿	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma														●	●			b, f
FG⦿	Mt Rainier National Park, Jackson Visitor Center									●									c
FH⦿	Charles L Pack Forest, La Grande									●									c, f
FL⦿	1101 Pacific Ave, Tacoma (ended Jun30, 2006)												X						a, d
ID	Hoyt Ave & 26th St, Everett (ended Feb 29, 2000)										x				X				a, e, d
IG	Marysville JHS, 1605 7th St, Marysville	X	X		●		●	●	●					●	●	●		●	b, d
IH	20935 59th Place West, Lynnwood (ended Jun 8, 1999)	X		X										X	X			X	a, d
II	6120 212th St SW, Lynnwood				X	X	●	●						●	●	●		●	b, d
JN⦿	5810 196th Street, Lynwood (ended Jun 30, 2006)												X						a,d
JO	Darrington High School, Darrington 1085 Fir St				●			●	●					●	●	●		●	d, f
JP⦿	2939 Broadway Ave, Everett (ended March 31, 2003)												X						a, d
JQ⦿	44th Ave W & 196th St SW, Lynnwood (ended May 3, 2004)												X						a, d
JS⦿	Broadway & Hewitt Ave, Everett (ended May 21, 2000)												X						a, d
QE	Meadowdale, 7252 Blackbird Dr NE, Bremerton	X				X		●						●	●	●		●	b, f
QF	Lions Park, 6th Ave NE & Fjord Dr, Poulsbo (ended Feb 29, 2000)														X				b, f

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
QG	Fire Station #51, 10955 Silverdale Way, Silverdale (began Jun 2, 2000)					X		●						●	●	●		●	a, d
RV⦿	Yelm N Pacific Road, 931 Northern Pacific Rd SE, Yelm (began May 2005)									●									c,f
UB⦿	71 E Campus Dr, Belfair (ended September 30, 2004)									X									c
VK⦿	Fire Station, 709 Mill Road SE, Yelm (began May 1, 2000 - ended in October 2005)									X									c,f

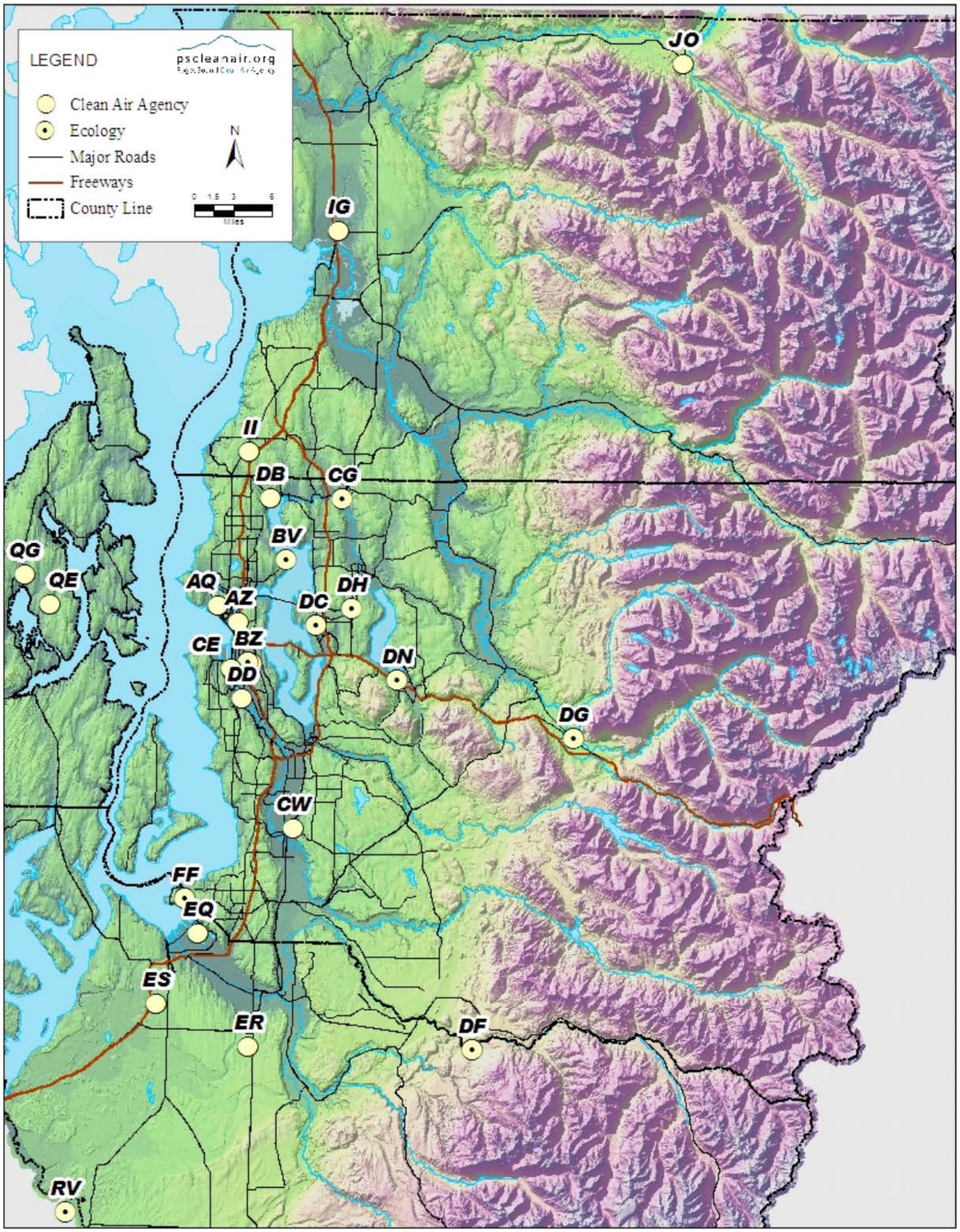
⦿	Station operated by Washington State Department of Ecology
RV⦿	Shading indicates station currently functioning
●	Indicates parameter currently monitored
X	Indicates parameter previously monitored
PM_{10} ref	Particulate Matter 10 micrometers (reference)
PM_{10} bam	Particulate Matter 10 micrometers (beta attenuation continuous)
PM_{10} teom	Particulate Matter 10 micrometers (teom continuous)
$PM_{2.5}$ ref	Particulate Matter 2.5 micrometers (reference)
$PM_{2.5}$ bam	Particulate Matter 2.5 micrometers (beta attenuation continuous)
$PM_{2.5}$ teom	Particulate Matter 2.5 micrometers (teom continuous)
$PM_{2.5}$ ls	Particulate Matter 2.5 micrometers (light scattering nephelometer continuous)
$PM_{2.5}$ bc	Particulate Matter 2.5 micrometers black carbon (light absorption aethalometer)

SO_2	Sulfur Dioxide
NO_x	Nitrogen Oxide
CO	Carbon Monoxide
b_{sp}	Light scattering by atmospheric particles (nephelometer)
Wind	Wind direction & speed
Temp	Air temperature (relative humidity also measured at BW)
AT	Air Toxics
VSBY	Visual range (light scattering by atmospheric particles)
PHOTO	Visibility (camera)
O_3	Ozone (May through September)

Location

- a Urban Center
- b Suburban
- c Rural
- d Commercial
- e Industrial
- f Residential

Map 1: Active Air Monitoring Network for 2008



IMPAIRED AIR QUALITY—BURN BANS AND SMOG WATCH

BURN BANS

Washington State has a winter impaired air quality program focusing on particulate matter from wood stoves and fireplaces. The agency enforces this program by working with local media and partners to issue temporary bans on indoor burning (in wood stoves and fireplaces) when air inversions trap fine particle pollution and air quality degrades. Outdoor burning of yard waste, in areas where such burning is normally allowed, is also prohibited during burn bans on indoor burning. These burn bans are mandatory and are enforced by agency inspectors.

There are two stages of the indoor burn bans. For a first-stage burn ban, residential burning in fireplaces or uncertified wood stoves is prohibited (unless a wood burning device is the only adequate source of heat).[5] For a second-stage burn ban, the use of any kind of wood-burning device (including certified wood stoves and pellet stoves) is prohibited unless a wood burning device is the only adequate source of heat.

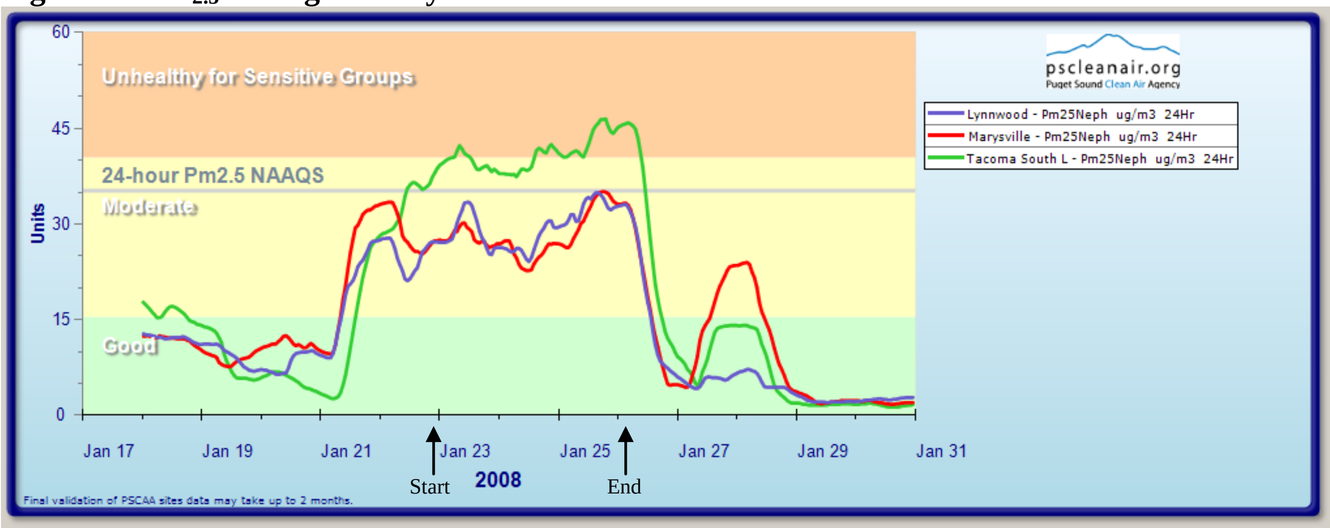
Before 2008 a first-stage burn ban could be declared by the agency when $PM_{2.5}$ levels reached 35 $\mu g/m^3$ (24-hour average). A second-stage burn ban could be declared when $PM_{2.5}$ levels reached 60 $\mu g/m^3$ (24-hour average). In 2008, the Washington State Legislature revised the burn ban triggers to be consistent with the new, stricter $PM_{2.5}$ standard. Under the revised statute, a first-stage burn ban is triggered when meteorological conditions are predicted to cause fine particulate levels to exceed 35 $\mu g/m^3$ (based on a 24-hour average) within 48 hours. A second-stage burn ban is generally triggered when the following three things have happened: 1) a first-stage burn ban has been enforced and has not been sufficient to reduce the increasing fine particulate pollution trend, 2) $PM_{2.5}$ levels are recorded at or above 25 $\mu g/m^3$ (based on a 24-hour average), and 3) forecasted meteorological conditions are not expected to allow $PM_{2.5}$ concentrations to decline. In the past, second-stage burn bans have been very rare; however, with the new burn ban thresholds it is likely that there will be more second-stage burn bans in the future.

The agency called one first-stage burn ban in 2008 for Snohomish and Pierce counties. The burn ban occurred January 23-26.

Fine particulate levels at three monitoring sites during the January burn ban are shown in Figure 6. These three sites (Lynnwood and Marysville in Snohomish County, and Tacoma South L in Pierce County) are shown because they registered the highest fine particulate levels in their counties during the burn ban period. Figure 6 shows the 24-hour average $PM_{2.5}$ concentrations with Air Quality Index (AQI) shading and a line representing the 35 $\mu g/m^3$ federal daily standard. Concentrations are based on $PM_{2.5}$ nephelometer measurements. Each point represents a 24-hour average based on the 12 hours before and after.

[5] Uncertified wood stoves emit more pollution than ones certified by the EPA. To determine if your wood stove is certified, visit our website for more information at http://www.pscleanair.org/actions/woodstoves/basics.aspx.

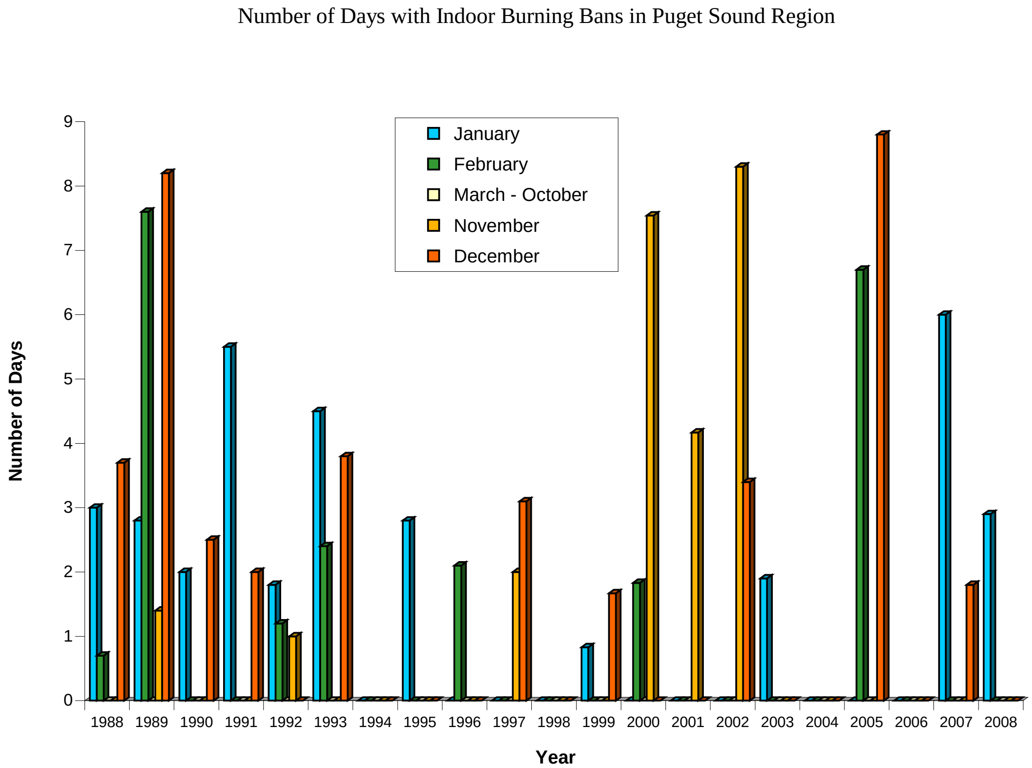
Figure 6: $PM_{2.5}$ during January. 23-26 2008 Burn Ban



Even with the burn ban, air quality reached the “unhealthy for sensitive groups” designation at the Tacoma South L monitoring site, and exceeded the federal daily standard of 35 µg/m^3. This is not necessarily a violation of the federal standard, because the daily standard is based on a 98th percentile over three years. It’s also noteworthy that all three sites exceeded the agency’s health goal of 25 µg/m^3 during the burn bans.

Burn bans typically occur in November through February. Figure 7 shows the number of days when burn bans have been declared since 1988. A detailed list of these burn bans is included on page A-6 of the Appendix.

Figure 7: Impaired Air Quality Resulting in Burn Bans



Smog Forecasts

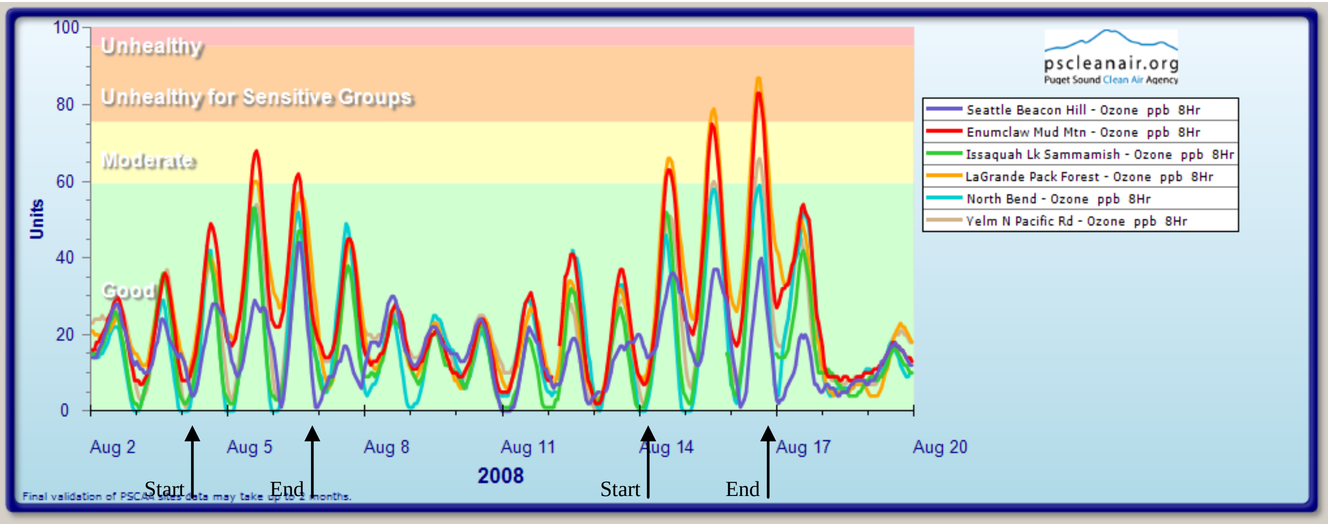
The agency maintains a voluntary air quality smog forecast program. During the summer, the agency notifies residents of potential unhealthy ozone levels. Summer ozone typically becomes a problem on hot stagnant summer days. Thus, advisories are driven more by meteorology than by monitored air quality data. The agency announces smog forecasts when weather forecasts predict temperatures in the upper 80s or higher, with little or no wind for at least a 48-hour period.

The agency communicates with meteorologists, traffic reporters, news media, and local businesses and agencies during smog forecast advisories. The agency and its health partners encourage people to take measures to reduce their exposure to unhealthy smog and protect their health.

The agency announced two smog forecasts during 2008. These occurred during August 4-7 and August 14-17. Figure 8 shows the 8-hour ozone concentrations at several ozone monitoring stations in the agency's jurisdiction with AQI shading. The stations included in Figure 8 are Beacon Hill, Enumclaw, Lake Sammamish, North Bend, Pack Forest, and Yelm. Ozone concentrations during the second smog forecast reached the “unhealthy for sensitive groups” level at Enumclaw and Pack Forest monitoring sites.

8-hour ozone concentrations are shown on page A-13 of the Appendix.

Figure 8: Smog Forecast Events



AIR QUALITY STANDARDS AND HEALTH GOALS

The national Clean Air Act (CAA), last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for criteria pollutants considered harmful to public health and the environment. These standards are designed to protect the public, including sensitive populations such as asthmatics, children, and the elderly. They are also intended to safeguard public welfare by reducing effects such as decreased visibility and damage to animals, crops, vegetation, and buildings. EPA has established standards for six criteria pollutants including carbon monoxide, nitrogen dioxide, sulfur dioxide, lead, and separate standards for the two size ranges of particulate matter. EPA is required to re-visit and update standards every five years, to incorporate the latest health and welfare information.

The state of Washington and the Puget Sound region have adopted these standards, and in the case of sulfur dioxide have also applied a stricter state standard. For more information, EPA air quality standards and supporting rationale are available at http://epa.gov/air/criteria.html. Washington State air quality regulations are available at http://www.ecy.wa.gov/laws-rules/ecywac.html#air.[6] The air quality standards that apply to the Puget Sound airshed are summarized in Table 3.

In addition to air quality standards, the agency has developed an air quality health goal for daily $PM_{2.5}$ concentrations. The agency convened a Particulate Matter Health Committee, comprised of local health professionals, who examined the fine particulate health research.[7] The Health Committee did not consider the federal standard at the time to be protective of human health. In 1999, the agency adopted a health goal of 25 $\mu g/m^3$ for a daily average, more protective than the current federal standard of 35 $\mu g/m^3$. This level is consistent with the American Lung Association's goal and the EPA Clean Air Science Advisory Committee's recommended lower range for the EPA's 2006 ambient air quality standard revision.[8,9] The form of the agency's health goal is "never-to-be-exceeded." The agency did not adopt a separate health goal for the annual $PM_{2.5}$ average.

EPA revised its 8-hour ozone standard on March 27, 2008 from 0.08 ppm to 0.075 ppm after determining that the former standard was not protective of human health.[10]

Similarly, EPA revised the quarterly lead standard on October 15, 2008 from 1.5$\mu g/m^3$ to 0.15$\mu g/m^3$.[11]

[6] Washington Administrative Code chapters 173-470, 173-474, and 173-475.
[7] Puget Sound Clean Air Agency. Final Report of the Puget Sound Clean Air Agency $PM_{2.5}$ Stakeholder Group; http://www.pscleanair.org/news/library/reports/pm2_5_report.pdf.
[8] American Lung Association; http://lungaction.org/reports/sota06exec_summ.html.
[9] EPA Clean Air Scientific Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; http://www.epa.gov/sab/panels/casacpmpanel.html
[10] 2008 Revised Ground-Level Ozone Standards; http://www.epa.gov/air/ozonepollution/actions.html.
[11] EPA. National Ambient Air Quality Standards – Lead Standards; http://www.epa.gov/air/lead/actions.html

Table 3: Puget Sound Region Air Quality Standards for Criteria Pollutants for 2008

Pollutant	Standard	Level[a,b]
Ozone[c]	The 3-year average of the 4th highest daily maximum 8-hour average concentration must not exceed the level (round to the nearest 0.01)	0.075 ppm (0.075 ppm)
Particulate Matter (10 micrometers)	The 3 year average of the 99th percentile (based on the number of samples taken of the daily concentrations must not exceed the level (round to the nearest 10)	154 µg/m^3 (150 µg/m^3)
Particulate Matter (2.5 micrometers)	The 3-year annual average of the daily concentrations must not exceed the level (round to the nearest 0.1)	15.04 µg/m^3 (15.0 µg/m^3)
	The 3-year average of the 98th percentile (based on the number of samples taken) of the daily concentrations must not exceed the level (round to the nearest 1)	35 µg/m^3 (35.4 µg/m^3)
Carbon Monoxide	The 1-hour average must not exceed the level more than once per year	35.4 ppm (35 ppm)
	The 8-hour average must not exceed the level more than once per year (round to the nearest 1)	9.4 ppm (9 ppm)
Sulfur Dioxide[d]	Annual arithmetic mean of 1-hour averages must not exceed	0.02 ppm
	24-hour average must not exceed	0.10 ppm
	1-hour average must not exceed	0.40 ppm
	AND no more than twice in 7 consecutive days can the 1-hour average exceed	0.25 ppm
Lead[e]	The quarterly average (by calendar) must not exceed the level (round to the nearest 0.01)	0.15 µg/m^3 (0.15 µg/m^3)
Nitrogen Dioxide	The annual mean of 1-hour averages must not exceed the level (round to the nearest 0.0001)	0.0534 ppm (0.053 ppm)

[a]Daily concentration is the 24-hour average, measured from midnight to midnight.

[b]EPA adopts rounding conventions. Numbers with no parentheses represent highest values that will meet standards using EPA's rounding convention. Numbers in parentheses represent the rounded standards.

[c]EPA changed the 8-hour ozone standard from 0.08 to 0.075 in March of 2008.

[d]Washington's Ambient Air Standards for SO_2 are more stringent than EPA's standards. These standards can be found at http://apps.leg.wa.gov/WAC/default.aspx?cite=173-474-100.

[e]EPA changed the quarterly standard for lead from 1.5 µg/m^3 to 0.15 µg/m^3 in October 2008.

Pollutants typically have multiple standards with different averaging times; for example, daily and annual standards. Multiple standards are created and enforced to address health impacts as a result of a shorter, high-level exposure versus longer, low-level exposures. These differences are addressed pollutant-by-pollutant in the following sections. Additional information is on EPA's website at http://epa.gov/air/criteria.html.

PARTICULATE MATTER

Particulate matter (PM) includes both solid matter and liquid droplets suspended in the air. Particles smaller than 2.5 micrometers in diameter are called "fine" particles, or $PM_{2.5}$. Particles between 2.5 and 10 micrometers in diameter are called "coarse" particles. PM_{10} includes both fine and coarse particles.

PM_{10}

In 2006, EPA revoked the annual PM_{10} standard due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution.[12] The agency ceased all PM_{10} monitoring in 2006 and has focused its efforts on $PM_{2.5}$ monitoring. Fine particles have a greater impact than coarse particles at locations far from the emitting source because they remain suspended in the atmosphere longer, and travel farther. For a historic look at Puget Sound area PM_{10} levels, please see pages 32-35 of the 2007 data summary at http://www.pscleanair.org/news/library/reports/2007AQDSFinal.pdf

$PM_{2.5}$ HEALTH AND ENVIRONMENTAL EFFECTS

$PM_{2.5}$ is one of the major air pollution concerns affecting our region. $PM_{2.5}$ primarily comes from wood burning and vehicle exhaust including cars, diesel trucks, and buses. Fine particulate can also be formed in the atmosphere through chemical reactions of pollutant gases.

Exposure to $PM_{2.5}$ can have serious health effects. Fine particles are most closely associated with increased respiratory disease, decreased lung function, and even premature death.[13,14,15,16] Children, older adults, and people with some illnesses are more sensitive and more likely to develop heart or lung problems associated with $PM_{2.5}$.[17,18] People with respiratory or heart disease, older adults, and children should avoid outdoor exertion if $PM_{2.5}$ levels are elevated. $PM_{2.5}$ can also significantly affect visibility.

$PM_{2.5}$ DAILY FEDERAL STANDARD AND HEALTH GOAL

On September 21, 2006, EPA adopted a new daily standard of 35 $\mu g/m^3$.[19] The Puget Sound area had one violation of the National Ambient Air Quality Standards (NAAQS) in 2008, at the South L Tacoma monitor located at the south end of Tacoma, in Pierce County. Concentrations at the Marysville and

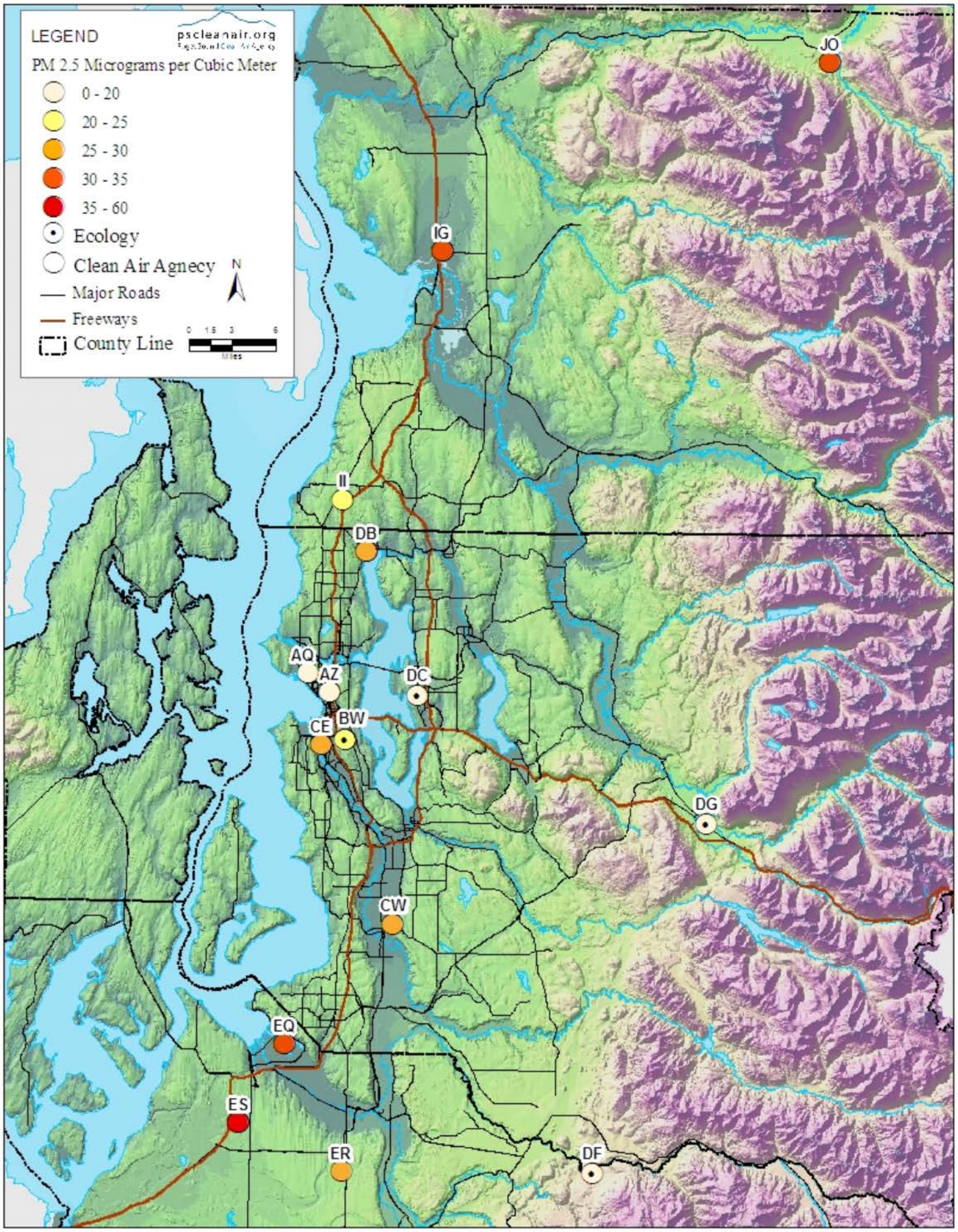
[12] U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; http://www.epa.gov/particles/actions.html.
[13] Pope et al. Lung Cancer, Cardiopulmonary Mortality, and Long–Term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association.* 287: pp 1132-1141, March 6, 2002.
[14] Gauderman et al. The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. *The New England Journal of Medicine.* Volume 351: pp 1057–1067, Number 11, September 9, 2004.
[15] Kunzli et al. Ambient Air Pollution and Atherosclerosis in Los Angeles. *Environmental Health Perspectives.* Volume 113, 2: pp 201-206, February 2005; http://ehp.niehs.nih.gov/members/2004/7523/7523.pdf.
[16] US Environmental Protection Agency (US EPA). Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information. EPA-452/R-05-005, June 2005; http://www.epa.gov/ttn/naaqs/standards/pm/data/pmstaffpaper_20050630.pdf.
[17] Park et al. Effects of Air Pollution on Heart Rate Variability: The VA Normative Aging Study. *Environmental Health Perspectives.* Volume 113, 3. pp 304-309, March 2005; http://ehp.niehs.nih.gov/members/2004/7447/7447.pdf.
[18] Goss et al. Effect of Ambient Air Pollution on Pulmonary Exacerbations and Lung Function in Cystic Fibrosis. *American Journal of Respiratory Critical Care Medicine.* Volume 169: pp 816-821. January 12, 2004.
[19] U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; http://www.epa.gov/particles/actions.html.

Darrington monitors, both located in Snohomish County, remain close to violating the new daily standard.

In addition to the federal standard, our Board of Directors adopted a more stringent goal based on recommendations from our Particulate Matter Health Committee. Monitors in all four counties of our jurisdiction exceed this local health goal of 25 $\mu g/m^3$ during the winter season.

Map 2 shows the 98^{th} percentile of the 3-year average of daily $PM_{2.5}$ concentrations. The map includes only those monitoring sites with three years of complete data from 2006 to 2008.

Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2008*



*Seattle Beacon Hill was down most of 2006 and has fewer data points to calculate the 98th percentile 3-year average. Kitsap monitors did not have a full year of data for 2008 and were omitted from this map. The Woodinville monitor was started in February 2009 and therefore does not have three years of complete data.

Figures 9 through 12 show daily 98th percentile 3-year averages at each monitoring station in King, Kitsap, Pierce, and Snohomish Counties compared to the current daily federal standard. Points on the graphs represent averages for three consecutive years. For example, the value for 2008 is the average of the 98th percentile daily concentration for 2006, 2007, and 2008. Concentrations for King, Pierce, and Snohomish Counties were measured using the FRM, except where noted.[20] Concentrations for Kitsap County were measured using continuous methods.[21]

Figure 10 does not include 2008 data for Kitsap County. This is because monitoring at the Silverdale site was discontinued, and the Bremerton site had equipment problems for part of the year, resulting in an incomplete dataset. Historical data for the county is well below the federal standard.

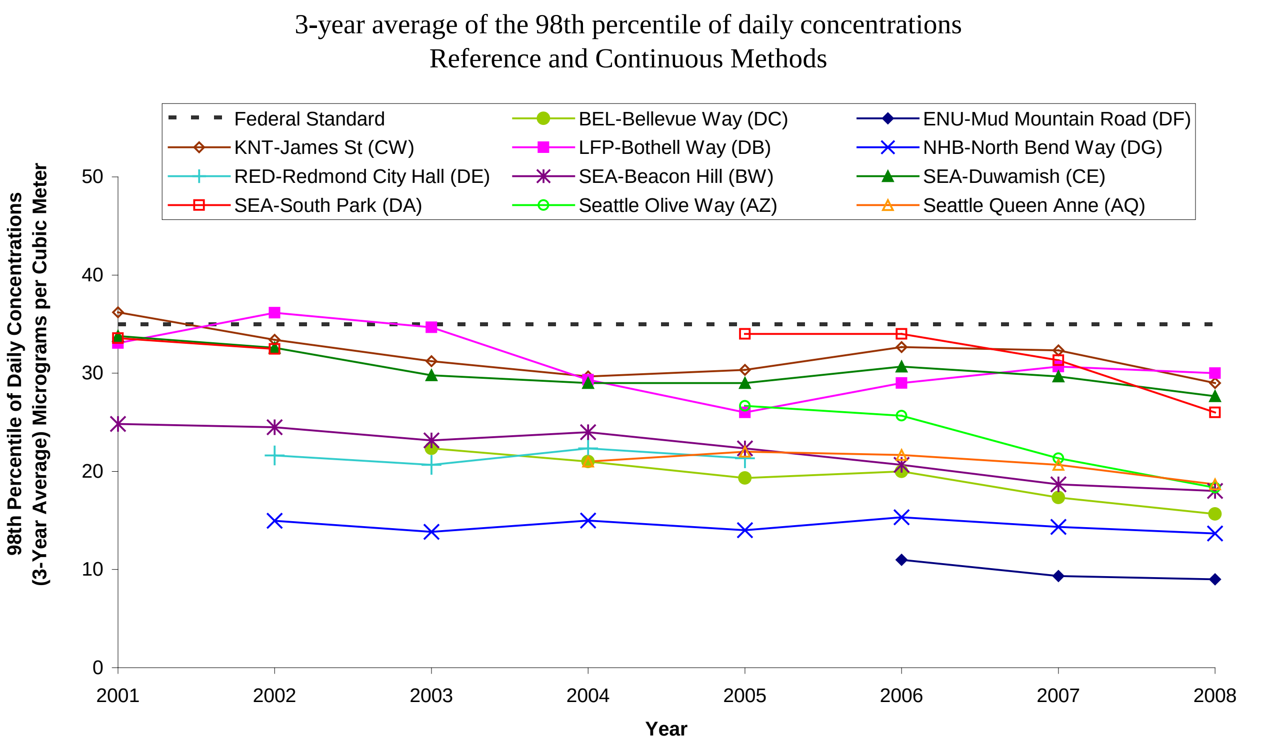
Figure 11 shows that the Tacoma South L Site, located at the south end of Tacoma, violates the new federal standard of 35 $\mu g/m^3$. Concentrations at the Darrington and Marysville monitors in Snohomish County, and the Tacoma Tideflats monitor in Pierce County and are the next highest range of concentrations between 30 to 35 $\mu g/m^3$.

Statistical summaries for 98th percentile daily concentrations for 2008 data are provided on page A-7 through A-10 of the Appendix.

[20] Where possible, continuous method data are compared to the reference method values and calculations are made to determine the degree of difference from the reference method. The differences are then applied to the current continuous values in an attempt to make them "FRM-like."

[21] Continuous concentrations in Kitsap are not adjusted to make them "FRM-like", as there is no site-specific FRM data at the Meadowdale and Silverdale monitoring sites.

Figure 9: Daily $PM_{2.5}$ for King County



Note: Duwamish (CE) and Beacon Hill (BW) data are FRM from 1999-2008. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2008. Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-08. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2008. Olive Way (AZ) data are neph from 2003-2008. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2008. Kent (CW) data are FRM from 1999-2004, neph in 2005-2008. Enumclaw (DF) data are from neph in 2000-2008.

Figure 10: Daily $PM_{2.5}$ for Kitsap County

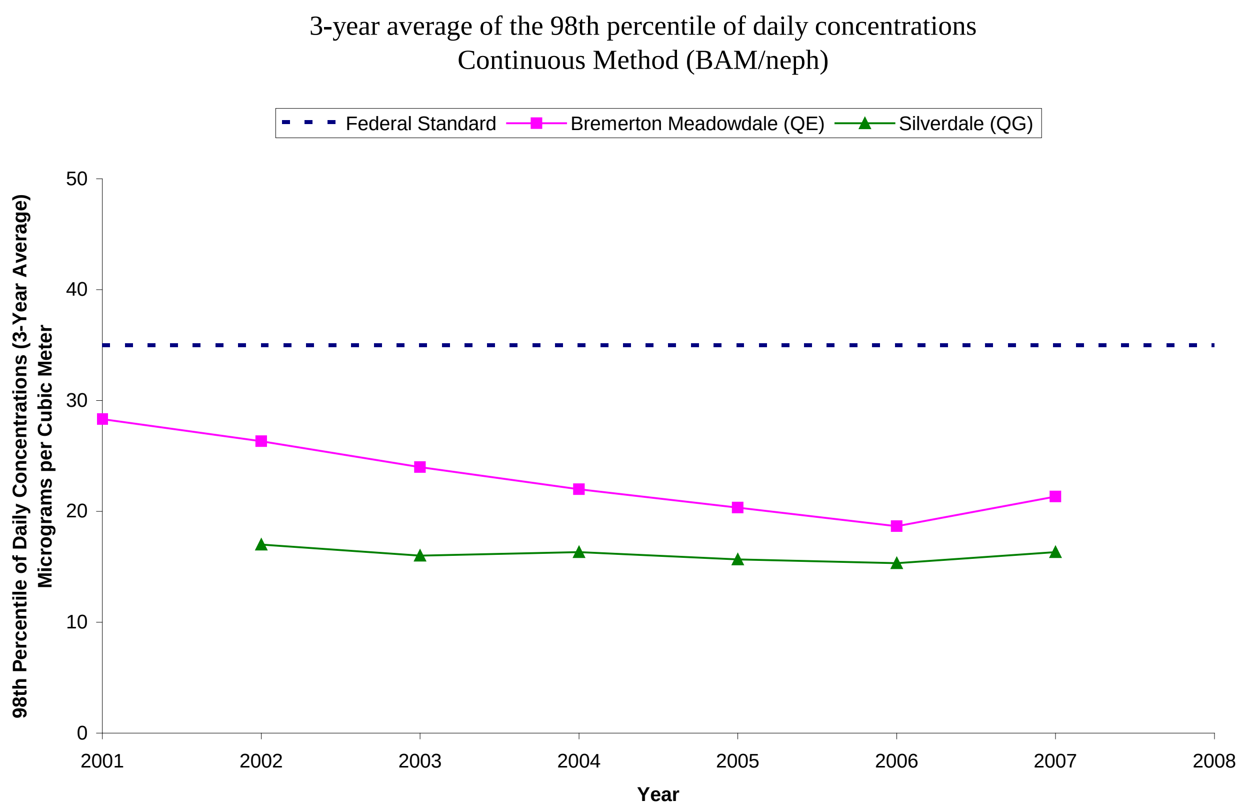
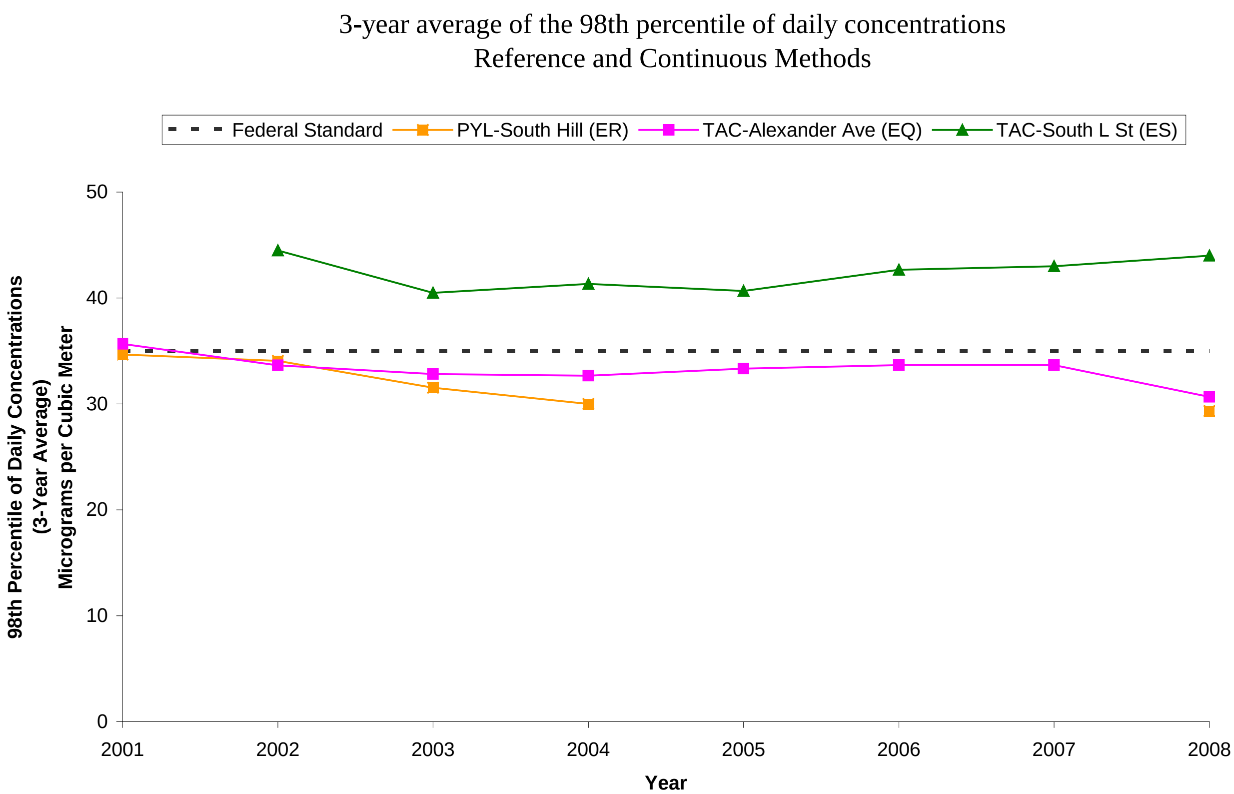
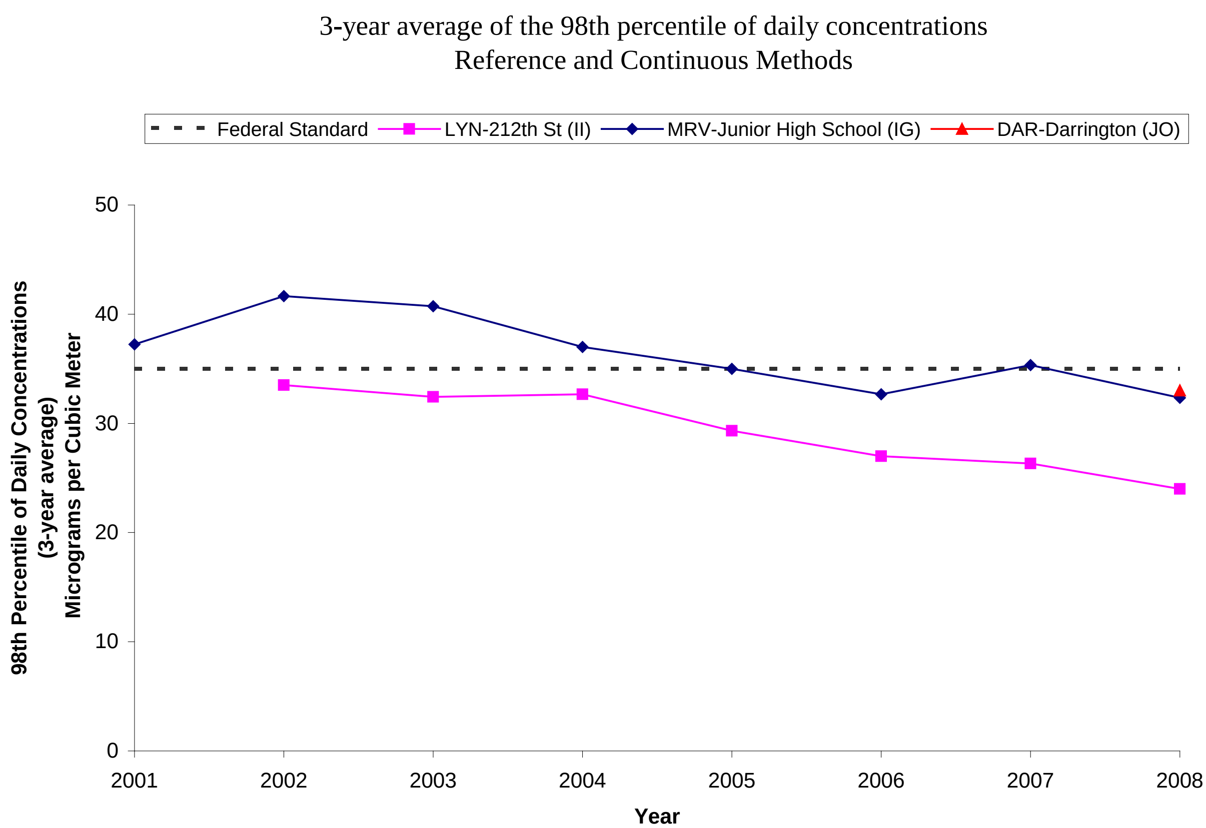


Figure 11: Daily $PM_{2.5}$ for Pierce County



Note: All South L data are FRM from 2000- 2008. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2008.
South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004; incomplete nephelometer data was collected from South Hill in 2005.

Figure 12: Daily $PM_{2.5}$ for Snohomish County

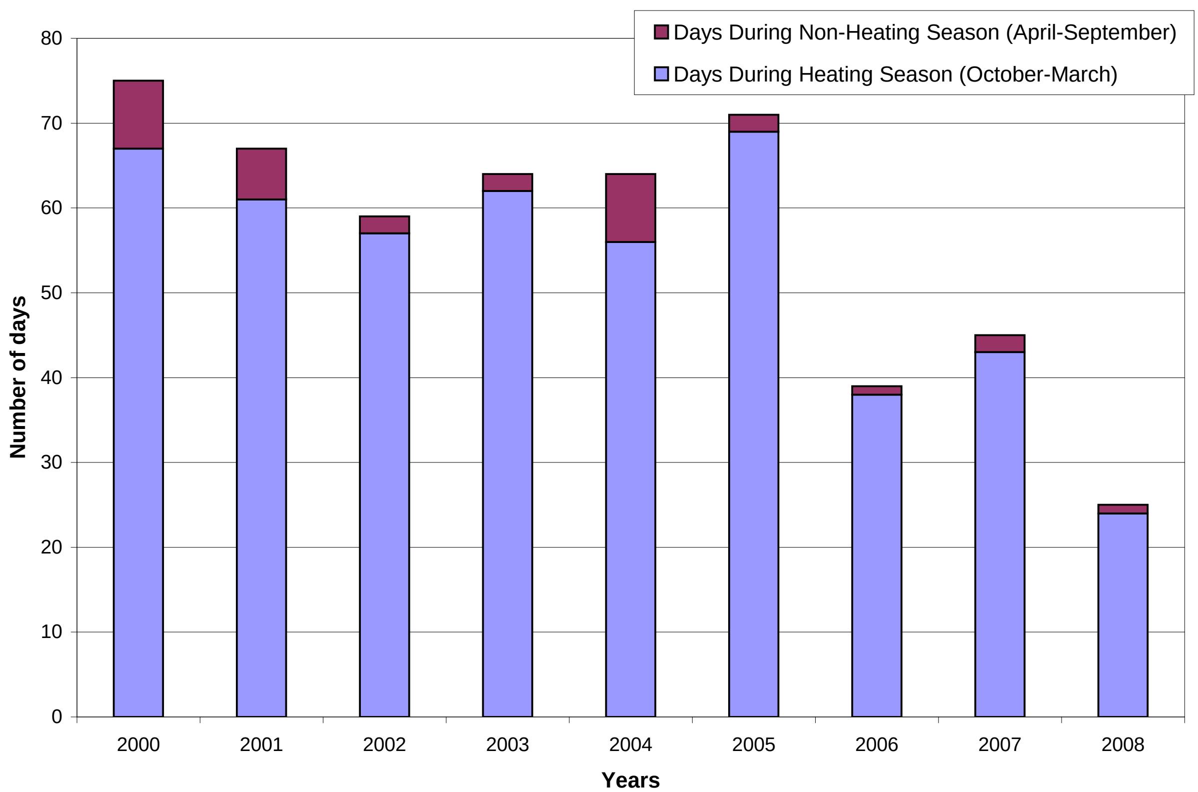


Note: Marysville data are FRM from 1999-2008. Lynnwood (II) data are FRM except 2004, 2007, and 2008 which were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2008.

As described in the Air Quality Standards and Health Goals section, the agency also has a daily fine particulate health goal. Many of the monitoring sites in King, Pierce, and Snohomish Counties exceed the agency's daily fine particulate health goal of 25 μg/m^3 for a 24-hour average. This health goal is intended to never be exceeded (unlike the federal standard that is based on the 98th percentile of a 3-year average).

Figure 13 shows the number of days the health goal is exceeded annually in the region, from 2000 to 2008. The shading demonstrates that our highest fine particulate days overwhelmingly take place during the winter wood heating months. While the graph indicates that we may be making slow progress reducing the number of days we exceed the health goal, it also shows that we are falling short of our goal of having zero days exceeding the health goal, especially during winter months.

Figure 13: Days Exceeding the $PM_{2.5}$ Health Goal at One or More Monitoring Sites



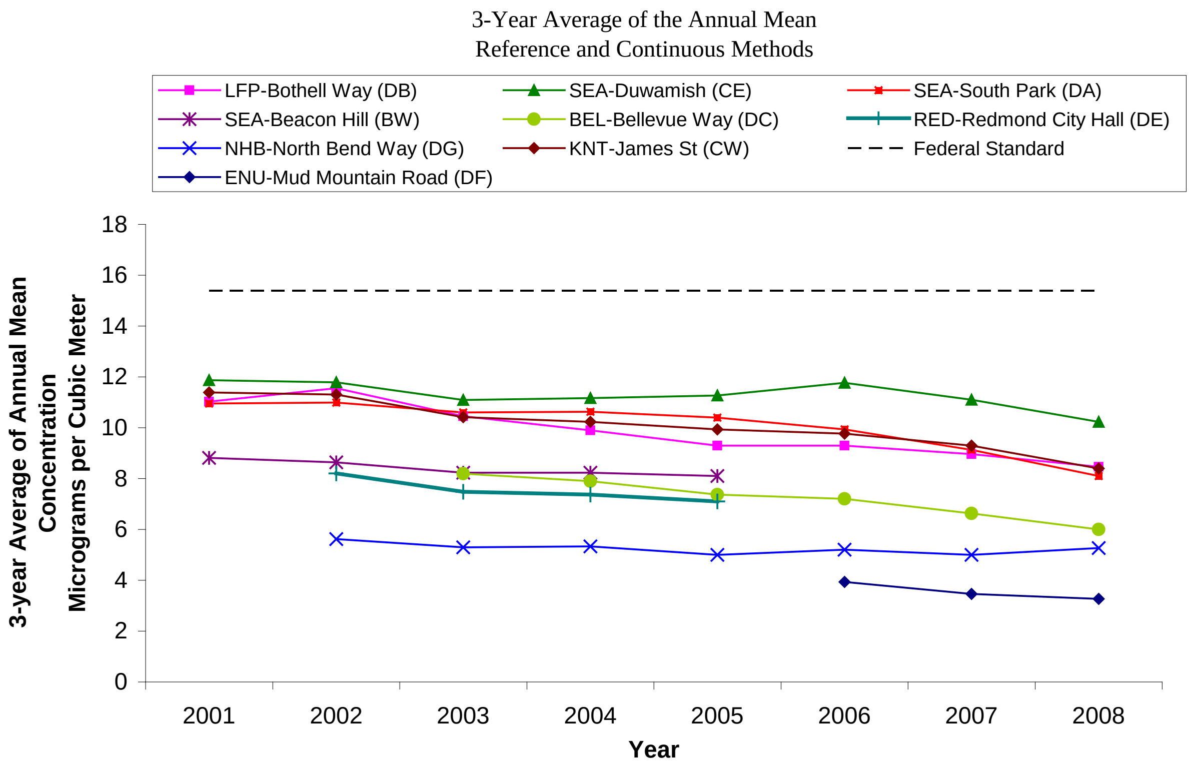
Includes data from all sites in King, Kitsap, Pierce, and Snohomish counties, both daily and continuous methods. The Darrington monitor was added in 2004.

$PM_{2.5}$ Annual Federal Standard

The Puget Sound airshed has been in compliance with the annual $PM_{2.5}$ standard since the EPA promulgated it in 1997. The annual standard was not updated when EPA revised the 24-hour standard in 2006. Figures 14 through 17 show annual averages at each monitoring station for King, Kitsap, Pierce, and Snohomish Counties and the federal annual standard. Figure 15 doesn't show any 2008 data for Kitsap County. This is because monitoring at the Silverdale site was discontinued, and the Bremerton site had equipment problems for part of the year, resulting in an incomplete dataset. Figures 14 through 17 show data from both the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, so each value on the graph is actually an average for three consecutive years. For example, the value shown for 2008 is the average of the annual averages for 2006, 2007, and 2008.

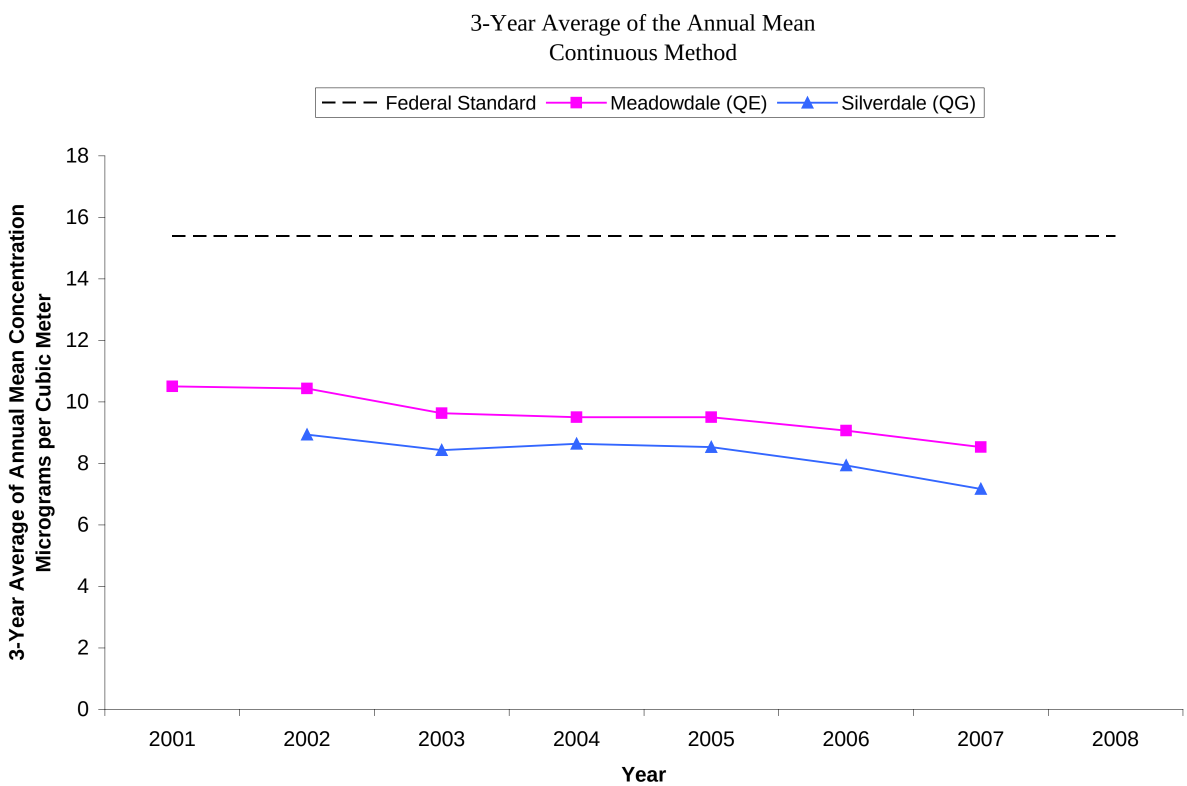
The agency's Health Committee did not recommend an annual $PM_{2.5}$ health goal lower than the federal annual standard (15 $\mu g/m^3$).

Figure 14: Annual $PM_{2.5}$ for King County



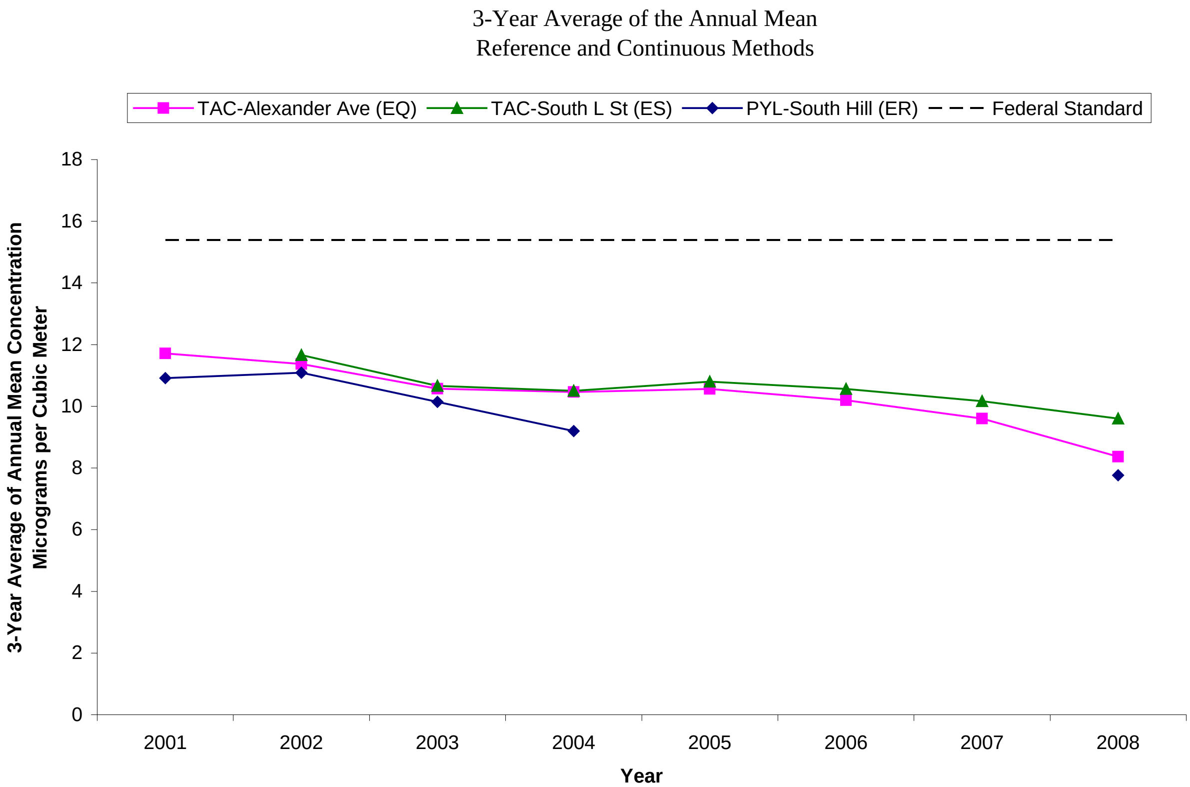
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008. Beacon Hill (BW), and Duwamish (CE) data are FRM from 1999-2008. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2008. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2008. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2008. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2008.

Figure 15: Annual $PM_{2.5}$ for Kitsap County



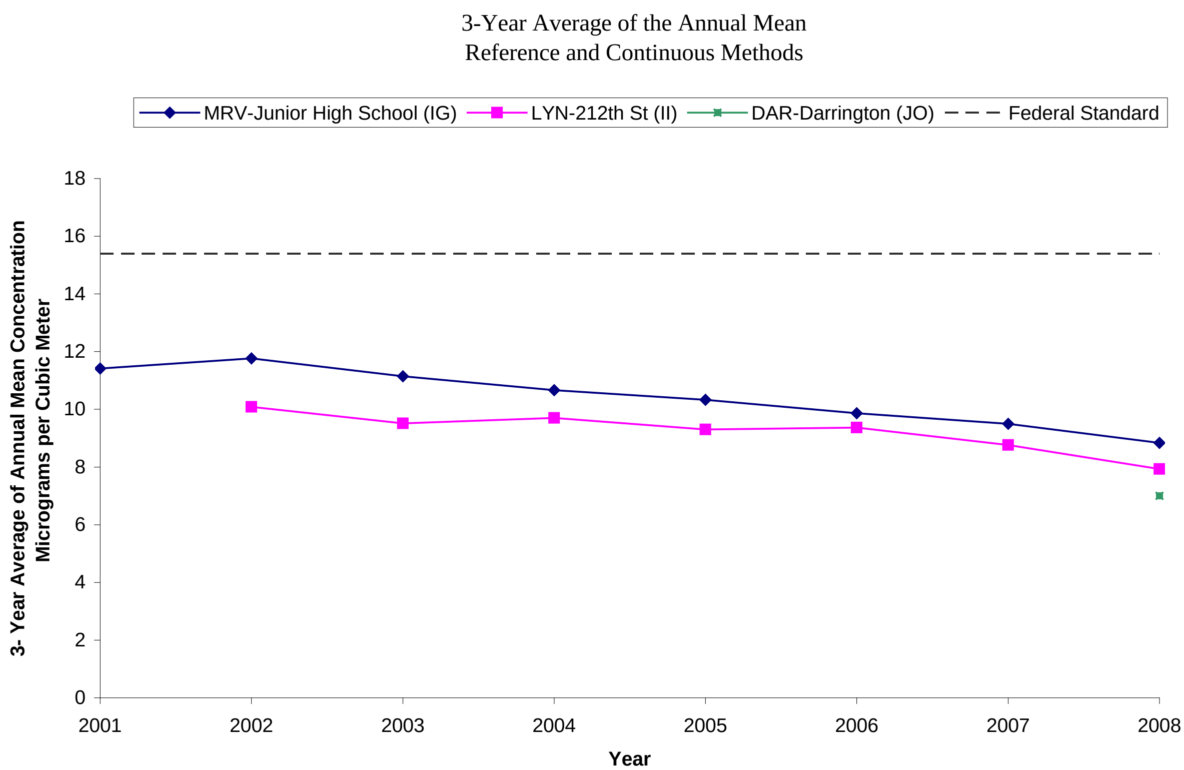
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2008.

Figure 16: Annual $PM_{2.5}$ for Pierce County



Note: South L St. (ES) data are FRM. South Hill (ER) data are FRM from 1999-2002. South Hill (ER) data 2003, 2004, 2008 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002. Alexander Ave (EQ) data 2003-2008 was measured with a nephelometer.

Figure 17: Annual $PM_{2.5}$ for Snohomish County



Note: Marysville (IG) data are FRM from 1999-2008. Lynnwood (II) data are FRM except 2004, 2007, and 2008. The 2004, 2007, and 2008 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2008

$PM_{2.5}$ Continuous Data and Seasonal Variability

Continuous monitoring data provide information on how concentration levels vary throughout the year. For example, many sites have elevated $PM_{2.5}$ levels during the winter when residential burning and air stagnations are at their peak, but have low levels of $PM_{2.5}$ during the summer. For more detailed information on continuous data, please see the Airgraphing tool at http://airgraphing.pscleanair.org/ to plot the sites and timeframes that you are interested in.

PARTICULATE MATTER - $PM_{2.5}$ SPECIATION AND AETHALOMETERS

The methods described above show the total amount of fine particulate matter, but do not tell us anything about chemical composition. Although there are no regulatory requirements to go beyond measuring the total mass of fine particulate matter, it is important to know the chemical makeup of particulate matter in addition to its mass. Knowledge about the composition of fine particulate can help to guide emission reduction strategies. Information on fine particulate composition helped guide the agency's commitment to reduce wood smoke and diesel particulate emissions.[22]

Two methods help to inform us about the type of fine particulate matter present in our area: source apportionment modeling of speciation data, and aethalometers.

SPECIATION MONITORING AND SOURCE APPORTIONMENT

Speciation monitoring involves determining the individual fractions of metals and organics in fine particulate matter on different types of filters. These filters are weighed and analyzed to determine the makeup of fine particulate at that site. Over 60 analytes are measured at speciation monitors in the area. Analytes and annual average concentrations are shown on page A-11 of the Appendix. These data can then be used in source apportionment models to estimate contributing sources to $PM_{2.5}$. Source apportionment models use statistical patterns in data to identify likely sources, and then estimates how much each source is contributing at each site.

The Washington Department of Ecology conducted speciation monitoring at two monitoring sites in the Puget Sound region in 2008:

- Seattle Beacon Hill site – typical urban impacts, mixture of sources (speciation samples collected every third day)

- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day)

Several researchers have used speciation data from these sites to better understand air quality. In addition to using speciation data for specific analytes or source apportionment modeling, the agency uses them to qualitatively look at the makeup of fine particulate at our monitoring sites. Using a mass reconstruction equation to simplify analytes into five broad categories, we can look at main contributors to mass when fine particle levels are highest, and compare sites.[23, 24] Major constituents of fine particulate matter in our region include:

- Organic and Elemental Carbon – These are largely from combustion sources.

[22]Puget Sound Air Toxics Evaluation, October 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.
[23]Brook, Dann, and Burnett. The Relationship Among TSP, PM_{10}, $PM_{2.5}$, and Inorganic Constituents of Atmospheric Particulate Matter at Multiple Canadian Locations. Journal of Air & Waste Management. Volume 47: pp 2-19. January 1997. Page 6 includes a mass reconstruction equation for soil components.
[24]Jeffrey Brook and Tom Dann. Contribution of Nitrate and Carbonaceous Species to $PM_{2.5}$ Observed in Canadian Cities. Journal of Air & Waste Management. Volume 49: pp 193-199. February 1999. Results demonstrate that organic carbon concentrations should be multiplied by a factor of roughly 1.4 to account for the molecular form.

- Sulfate and Nitrates – These are formed in the atmosphere from sulfur and nitrogen oxides, SO_X, and NO_X. The largest sources of SO_X and NO_X in our area are on-road and non-road mobile sources (gasoline and diesel fuels). Large industrial sources also contribute substantially to SO_X (about 20%). Voluntary and regulatory programs that have started reducing the sulfur content in fuels will begin to reduce the SO_X and sulfates in our area.
- A "soil" component comprised of analytes typically associated with crustal materials – The soil fraction includes aluminum, silicon, calcium, iron, titanium, and potassium.

Figures 18 through 21 show simplified, major contributors at the speciation sites for the all 2008 samples (annual average), as well as on the highest concentration days. Because speciation samples are collected on either every third or sixth day schedules, it's not possible to capture some of the most elevated concentration days. This schedule results in only a handful of samples (seven for Beacon Hill and three for South End Tacoma) represented in the 'highest concentration' pie charts below. Also, as $PM_{2.5}$ concentrations at Beacon Hill are typically lower than at Tacoma South L site, the threshold for a 'highest concentration day' is also lower (15 $\mu g/m^3$ at Beacon Hill vs. 20 $\mu g/m^3$ at the Tacoma South L site).

The Beacon Hill site, shown in figures 18 and 19 – shows that organic carbon is the largest contributor to $PM_{2.5}$ mass, and the contribution of elemental carbon increases most on elevated fine particle days.

The South L site, shown in figures 20 and 21, shows slightly more organic carbon as a main average contributor to $PM_{2.5}$ mass, with an increase in organic carbon on most elevated fine particle days. Organic carbon comes from combustion sources, and notably from wood smoke.

Figure 18: Seattle Beacon Hill Average Contributions 2008

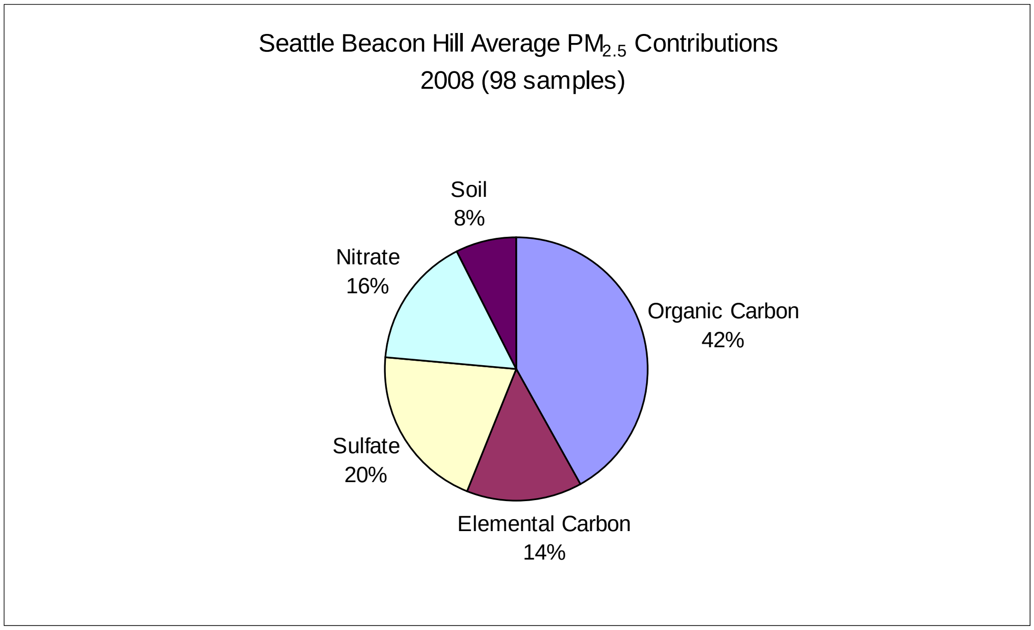


Figure 19: Seattle Beacon Hill Contributions on Highest Days 2008 (7 samples over 15 µg/m^3)

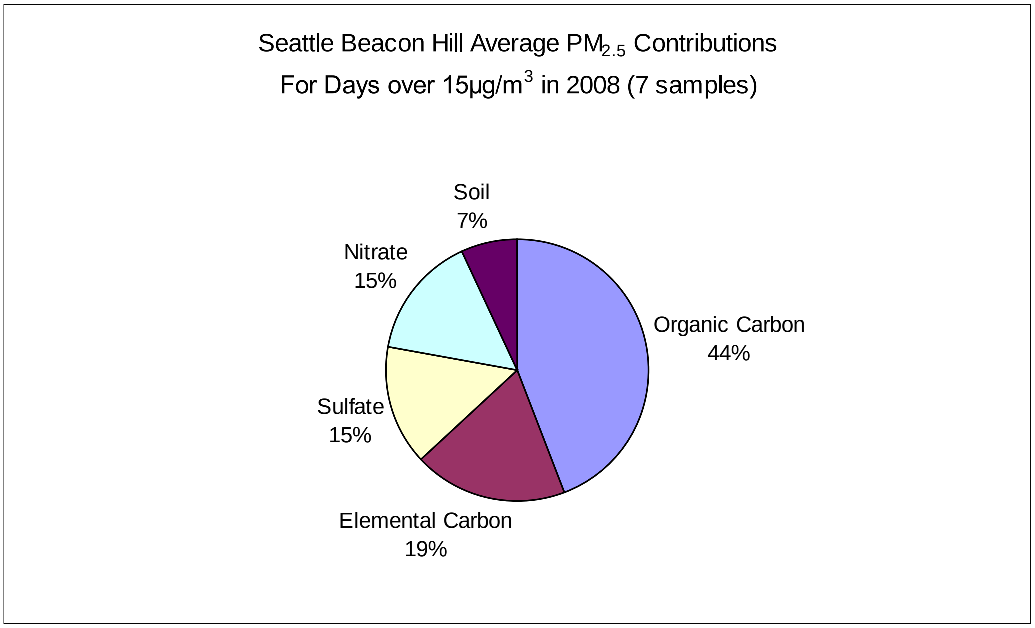


Figure 20: Tacoma South L Average Contributions 2008

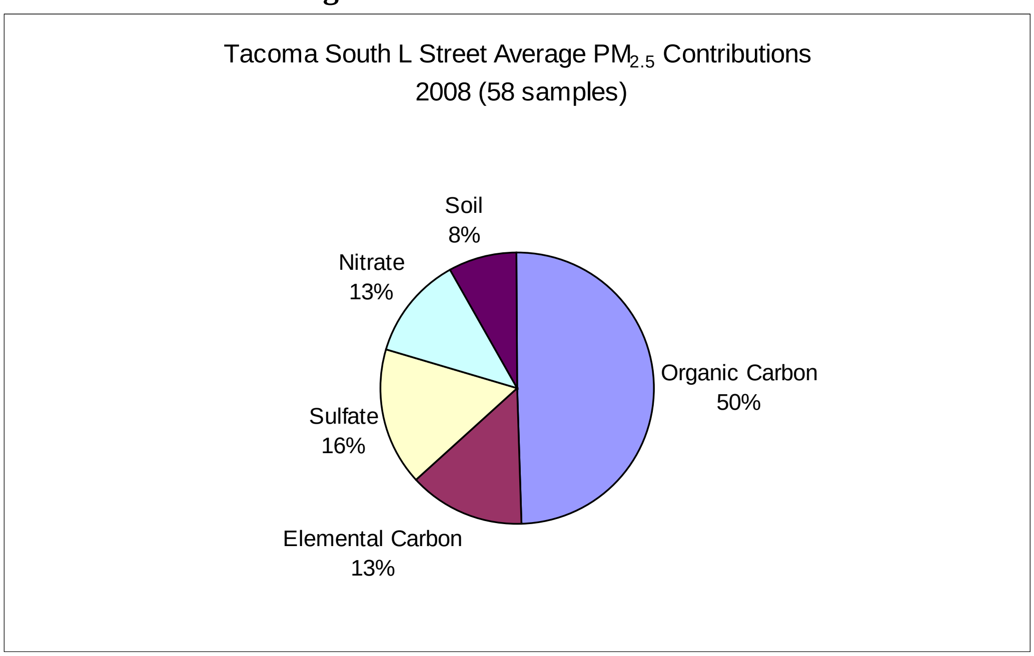
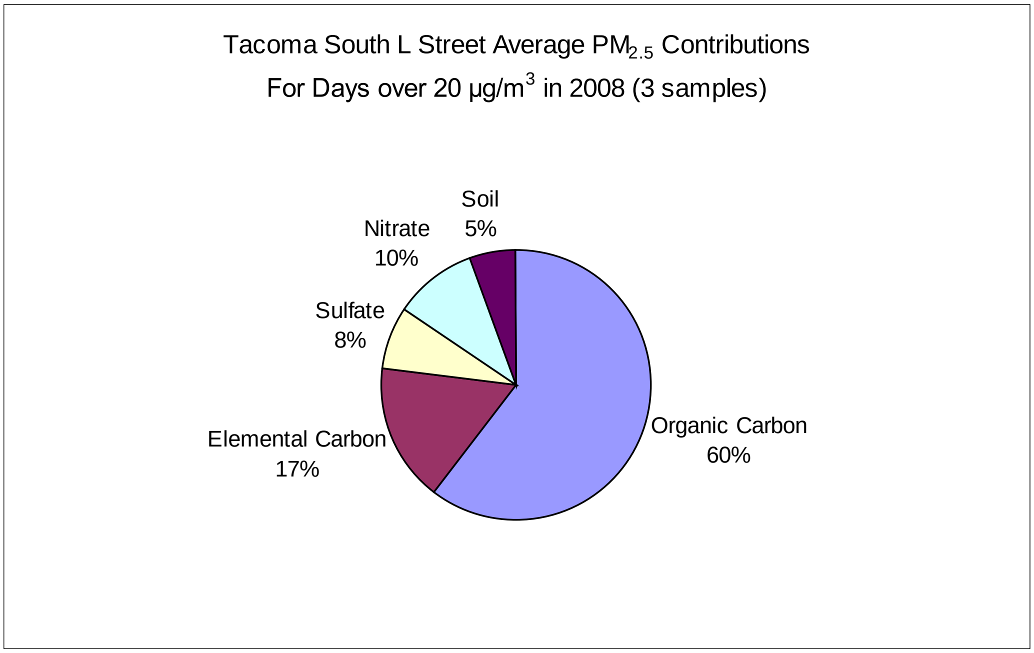


Figure 21: Tacoma South L Contributions on Highest Days 2008 (3 samples over 20 µg/m[3])



AETHALOMETER DATA

Aethalometers are monitoring instruments that provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption to estimate carbon concentrations. The aethalometer measures two channels, black carbon (BC) and ultraviolet (UV). The instrument translates information into concentrations; concentrations from the black carbon channel correlates well with elemental carbon (EC) speciation data. Qualitatively, the difference between the UV and BC channel (UV-BC) correlates well with organic carbon (OC) speciation data.

Elemental and organic carbon are related to diesel particulate, wood smoke particulate, and particulate from other combustion sources.[25] Unfortunately, neither are uniquely correlated to a particular combustion type – so the information gained from aethalometer data is largely qualitative.

The agency maintains aethalometers at monitoring sites with high particulate matter concentrations, as well as sites with speciation data, so that the different methods to measure carbon may be compared. For more information on aethalometers, refer to our aethalometer monitoring paper at http://www.pscleanair.org/airq/Aeth-Final.pdf.

A statistical summary of aethalometer black carbon data is presented on page A-12 of the Appendix.

[25] Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area; http://www.pscleanair.org/airq/Aeth-Final.pdf.

OZONE

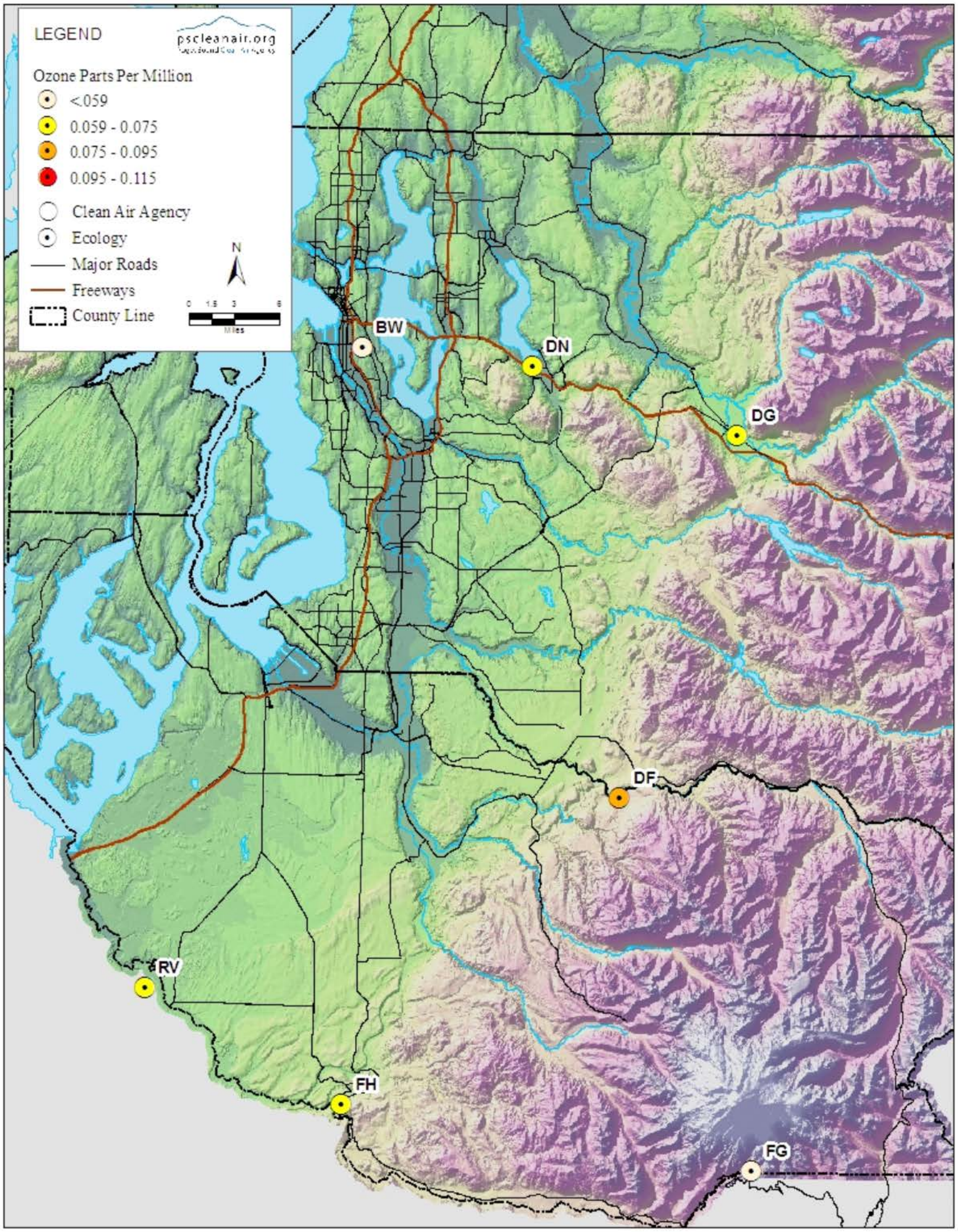
Ozone is a summertime air pollution problem and is not directly emitted by pollutant sources. Ozone forms when photochemical pollutants react with sunlight. These pollutants are called ozone precursors and include volatile organic compounds (VOC) and nitrogen oxides (NO_x), with some influence by carbon monoxide (CO). These precursors come from anthropogenic sources such as mobile sources and industrial and commercial solvent use, as well as natural sources (biogenics). Levels are usually highest in the afternoon because of the intense sunlight and the time required for ozone to form in the atmosphere. Ozone levels are highly affected by weather. The Washington State Department of Ecology currently monitors ozone from May through September, as this is the time period of concern for elevated ozone levels in the Pacific Northwest.

People sometimes confuse upper atmosphere ozone with ground-level ozone. Stratospheric ozone helps to protect the earth from the sun's rays. In contrast, ozone formed at ground level is unhealthy. Elevated concentrations of ground-level ozone can cause reduced lung function and respiratory irritation, and can aggravate asthma.[26] Ozone has also been linked to immune system effects.[27] People with respiratory conditions should limit outdoor exertion if ozone levels are elevated. Even healthy individuals may experience respiratory symptoms on a high-ozone day. Ground-level ozone can also damage agricultural crops and forests, interfering with their ability to produce food and grow.[28]

The majority of ozone monitoring stations are located in rural regions of the Puget Sound region, although the precursor chemicals that react with sunlight to produce ozone are generated primarily in large metropolitan areas. The photochemical formation of ozone takes several hours. Thus, the highest concentrations of ozone are measured in the communities downwind of these large urban areas. In the Puget Sound region, the hot sunny days favorable for ozone formation also tend to have light north-to-northwest winds. Ozone has typically been transported 10 to 30 miles downwind from the original source by the time the highest concentrations have formed in the afternoon and early evening. Regional meteorology inhibits regular production of elevated ozone levels. As shown on Map 3, the highest ozone concentrations occur at monitors southeast of the urban area (especially the Enumclaw and Pack Forest monitors, labeled DF and FH on the map).

[26]EPA AirNow. How Can Ground-Level Ozone Affect Your Health?; http://www.airnow.gov/index.cfm?action=static.ozone2#3.
[27]EPA Health and Environmental Effects of Ground Level Ozone; http://www.epa.gov/ttn/oarpg/naaqsfin/o3health.html.
[28]EPA Health and Environmental Effects of Ground Level Ozone; http://www.epa.gov/ttn/oarpg/naaqsfin/o3health.html.

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2008



* Seattle Beacon Hill was down most of 2006 and has fewer data points to calculate the 98th percentile 3-year average.

Figure 22 presents data for each monitoring station and the 8-hour federal standard. Although ozone levels have remained fairly stable, ozone is still a concern for the region because EPA revised its 8-hour ozone standard from 0.08 parts per million (ppm) to 0.075 ppm in March 2008, and has expressed intent to further strengthen the standard in 2010.[29] The new standard was finalized on March 27, 2008 in response to the determination that the former standard was not sufficiently protective of human health.[30]

Figure 22 shows that the Enumclaw Mud Mountain monitor violated the new strengthened 8-hour ozone standard for the period 2006 through 2008. The federal standard is based on the 3-year average of the 4th highest 8-hour concentration, called the “design value”. The year on the x-axis represents the last year averaged. For example, concentrations shown for 2008 are an average of 2006, 2007, and 2008 4th highest concentrations. The 2008 design value is 0.076 ppm, violating the strengthened standard. The highest 2008 8-hour ozone concentration of 0.091 ppm was recorded on June 29 at the Enumclaw Mud Mountain monitor.

As of the publication of this report, the Puget Sound area is unlikely to be designated nonattainment under the 0.075 ppm standard, as preliminary data for 2007 – 2009 did not indicate violations of the standard. However, EPA expressed its intent in September 2009 to further strengthen the ozone standard in 2010. It is highly likely that the region would violate a future further strengthened standard.

Figure 23 presents 8-hour average data for the months of May through September, the months when ozone levels are greatest. The late June and mid-August ozone episodes, when levels reached the AQI “unhealthy for sensitive groups” category, are apparent.

Statistical summaries for 8-hour average ozone data are provided on page A-13 of the Appendix.

For additional information on ozone, visit www.epa.gov/air/ozonepollution.

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[29] EPA. EPA to Reconsider Ozone Pollution Standards. http://www.epa.gov/air/ozonepollution/pdfs/O3_Reconsideration_FACT%20SHEET_091609.pdf. September 2009.
[30] EPA. 2008 Revised Ground-Level Ozone Standards; http://www.epa.gov/air/ozonepollution/actions.html.

Figure 22: Ozone 8-Hour for Puget Sound Region

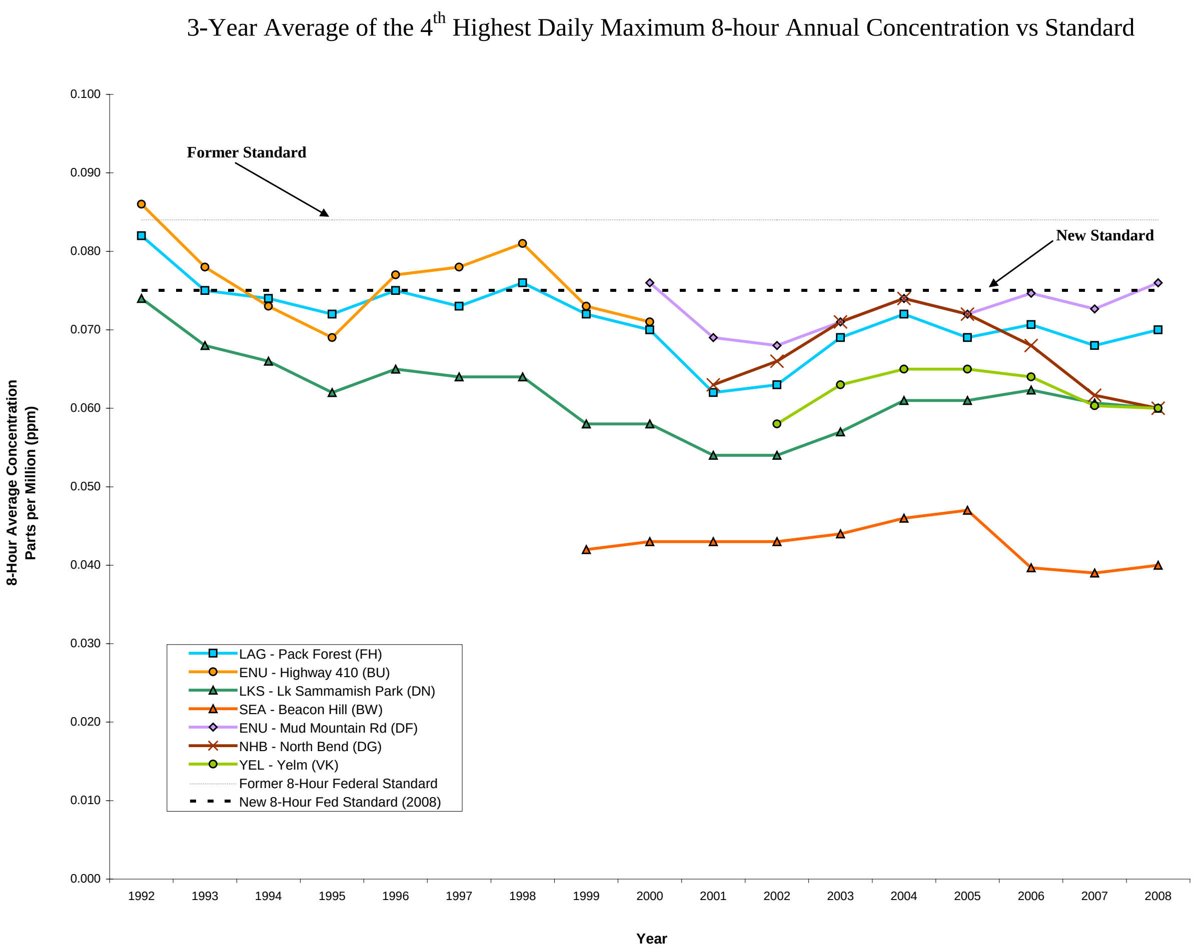
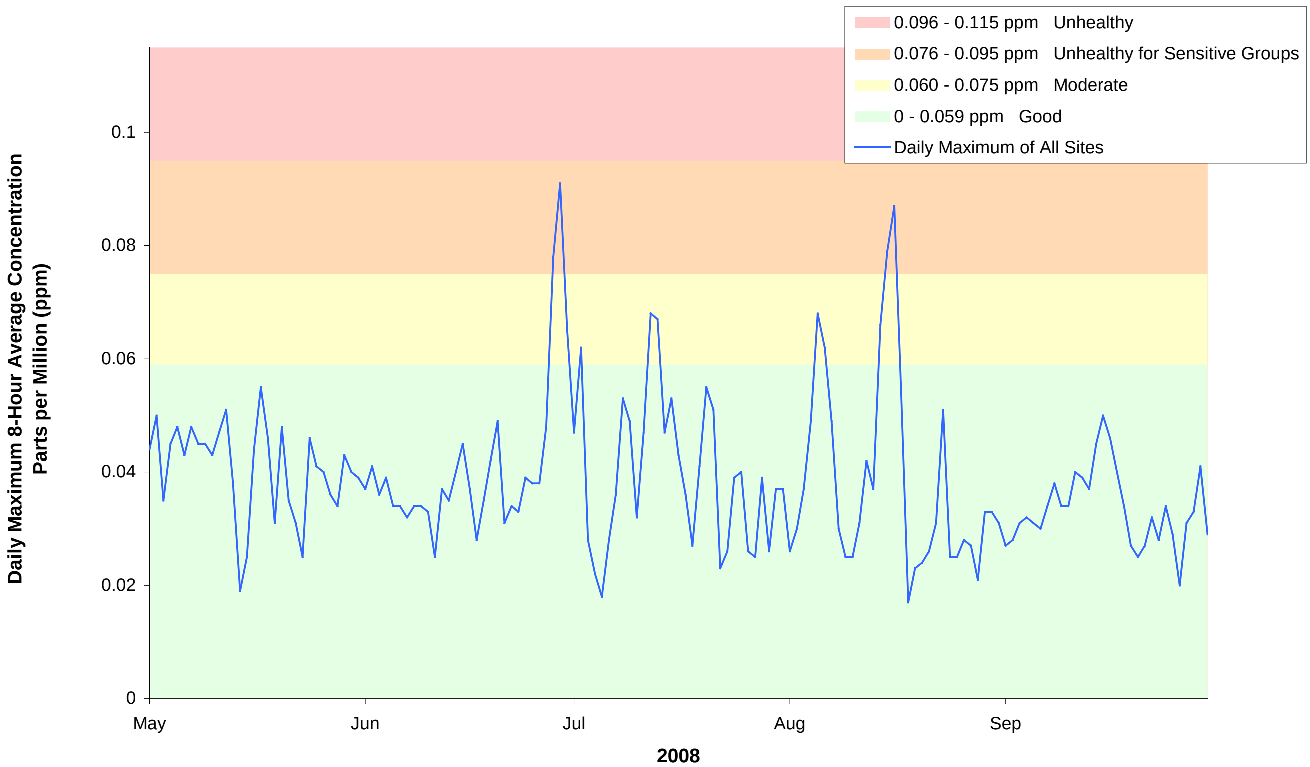


Figure 23: Ozone (O_3) for Puget Sound Region May-September 2008

Daily Maximum 8-Hour Concentration for all sites in the Puget Sound Region



NITROGEN DIOXIDE

Nitrogen dioxide (NO_2) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and oxygen in the atmosphere. NO_2 can cause respiratory symptoms such as coughing, wheezing, and shortness of breath in people with respiratory diseases such as asthma.[31] Long-term exposure can lead to respiratory infections.

The term "NO_X", which is frequently used, is defined as NO + NO_2. NO_2 will react with volatile organic compounds (VOCs) and can result in the formation of ozone. NO_X, NO + NO_2, can form nitrates in the atmosphere, a component of fine particulate matter. On-road vehicles such as trucks and automobiles and off road vehicles such as construction equipment and port cargo-handling equipment are the major sources of NO_X. Industrial boilers and processes, home heaters, and gas stoves also produce NO_X.

Motor vehicle and non-road engine manufacturers have been required by EPA to reduce NO_X emissions from cars, trucks and non-road equipment. As a result, emissions have reduced dramatically. NO_2 in itself is not considered a significant pollution problem in the Puget Sound area. However, NO_X emissions are important, as they affect ozone and nitrate formation.

EPA proposed a strengthened national ambient air quality standard for nitrogen dioxide on June 26, 2009.[32] EPA proposed to keep the current annual health-based standard for nitrogen dioxide and add a 1-hour standard to be more protective of short-term exposures. Nitrogen dioxide levels in the Puget Sound region, as currently monitored by Washington Ecology, are typically below (cleaner than) the levels being proposed in the new standard. However, potential changes to where NO_2 is monitored (for example, closer to roadways) may affect this – it's unclear at this time what these changes may be. EPA plans to promulgate a new NO_2 standard by January 2010.

The Washington State Department of Ecology maintains one monitoring site for nitrogen dioxide at the Beacon Hill monitoring site. In 2007, the monitoring technique and equipment changed slightly to record NO_Y instead of NO_X to incorporate the notroxyl compounds, which are important in monitoring ozone formation chemicals and fine particulate matter. The additional notroxyl compounds are in trace amount in comparison to NO_2. Figure 24 shows NO_2 concentrations through 2005. In 2006, no data were recorded due to the relocation of the Beacon Hill monitor to a different location in the same property. In 2007 and 2008, the concentration of NO_2 is represented as NO_Y - NO since NO_2 is no longer directly recorded. The annual average for each year has consistently been less than half of the current federal standard, as shown in Figure 24 and in the statistical summary on page A-14 of the Appendix.

The maximum 1-hour average of NO_Y- NO, measured in 2008, was 0.065 ppm on August 6. Visit www.epa.gov/air/urbanair/nox/index.html for additional information on NO_2.

[31] EPA, Airnow, NO_X Chief Causes for Concern, http://epa.gov/air/urbanair/nox/chf.html.

[32] EPA. Proposed Revisions to the National Ambient Air Quality Standards for Nitrogen Dioxide. http://www.epa.gov/air/nitrogenoxides/pdfs/20090722fs.pdf. June 2009.

Figure 24: Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (2007-2008)

Annual Mean of 1-Hour Averages vs Standard

CARBON MONOXIDE

Carbon monoxide (CO) is an odorless, colorless gas that can enter the bloodstream through the lungs and reduce the amount of oxygen that reaches organs and tissues. Carbon monoxide forms when the carbon in fuels doesn't burn completely. The vast majority of CO emissions come from motor vehicle exhaust.

Elevated levels of CO in ambient air can occur in areas with heavy traffic congestion, and happen during the colder months of the year when temperature inversions are more frequent. People with cardiovascular disease or respiratory problems may experience chest pain and increased cardiovascular symptoms, particularly while exercising, if CO levels are high. High levels of CO can affect alertness and vision even in healthy individuals.

EPA designated the Puget Sound region as a CO attainment area in 1996.

The Washington State Department of Ecology conducts all of the CO monitoring in the region. Historically, CO monitoring stations are located in areas with heavy traffic congestion. These include central business areas, roadsides, and shopping malls. Although urban portions of the Puget Sound region violated the CO standard for many years, CO levels have decreased significantly in the Puget Sound area, primarily due to cleaner car technology. The Department of Ecology has substantially reduced its CO monitoring network, and only the Bellevue 148th Ave site and the Beacon Hill site ran during 2008.

The CO national ambient air quality standard is based on the second highest 8-hour average. Figure 25 shows the second highest 8-hour concentrations and the federal standard (9 ppm) for the Puget Sound region. There currently are no CO monitoring stations in Kitsap, Pierce, or Snohomish Counties.

The maximum 8-hour concentration for CO in 2008 was 2.4 parts per million (ppm) and occurred on November 24 and January 25.

EPA's federal standards also include a 1-hour standard for CO of 35 ppm, not to be exceeded more than once a year. Measured 1-hour concentrations in the Puget Sound area are historically much lower than the 35 ppm standard, and therefore 1-hour CO trends are not graphed.

As of the publication of this report, EPA had begun a NAAQS review process for carbon monoxide. EPA plans to propose CO standards in fall 2010 (with potentially no change), with the publication of a final standard in spring 2011.[33]

Statistical summaries for 8-hour average CO data are provided on page A-15 of the Appendix. For additional information on CO, visit www.epa.gov/air/urbanair/co/index.html.

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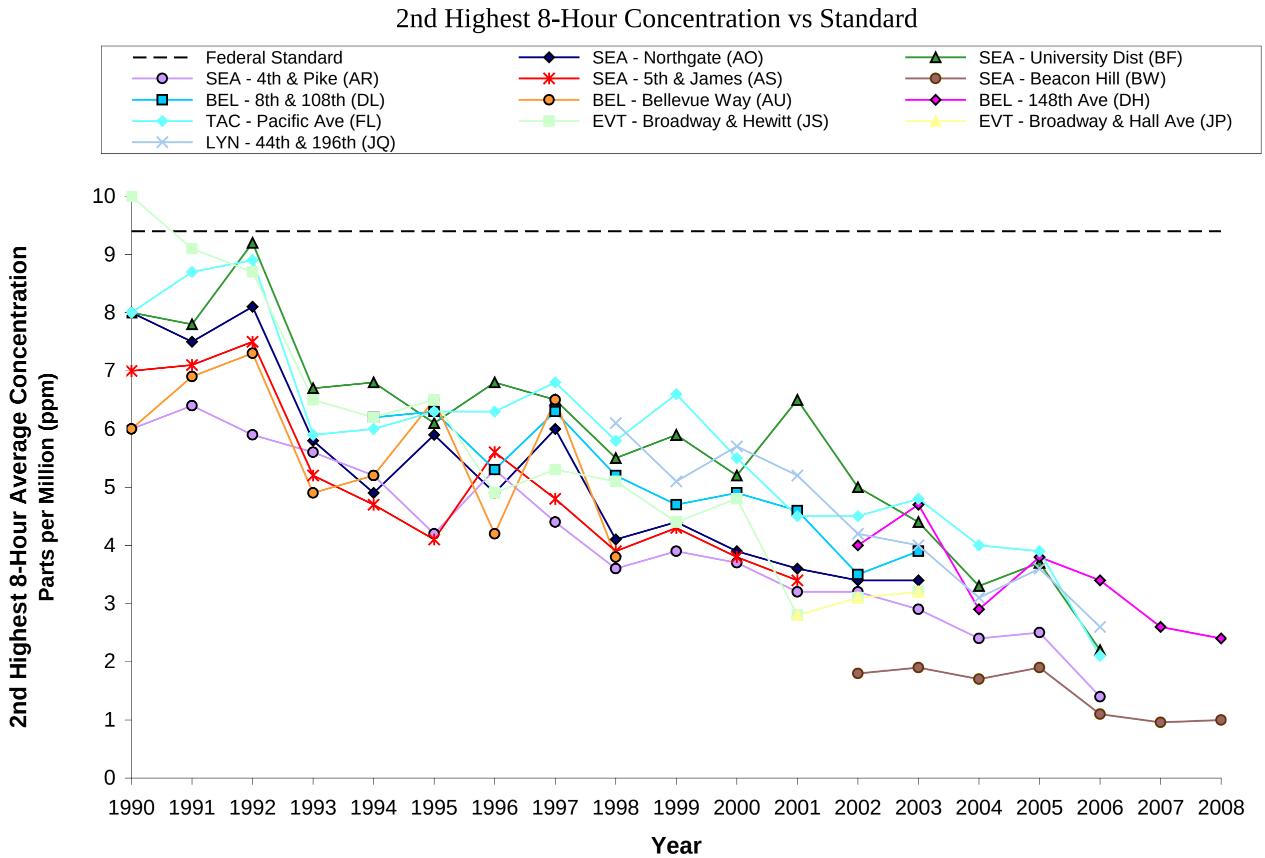
[33] US EPA. Plan for Review of the National Ambient Air Quality Standards for Carbon Monoxide. August 2008. http://www.epa.gov/ttn/naaqs/standards/co/data/2008_08_co_naaqs_review_plan.pdf. Schedule on page 2-1.

Figure 25: Carbon Monoxide (CO) for Puget Sound Region



SULFUR DIOXIDE

Sulfur dioxide (SO_2) is a colorless, reactive gas produced by burning fuels containing sulfur, such as coal and oil, and by industrial processes. Historically, the greatest sources of SO_2 were industrial facilities that derived their products from raw materials such as metallic ore, coal, and crude oil, or that burned coal or oil to produce process heat (petroleum refineries, cement manufacturing, and metal processing facilities). Today, on-road vehicles, diesel construction equipment, and marine vessels release significant SO_2 emissions to the air.

People with asthma who are active outdoors may experience bronchial constriction, where symptoms include wheezing, shortness of breath, and tightening of the chest. People should limit outdoor exertion if SO_2 levels are high. SO_2 can also form sulfates in the atmosphere, a component of fine particulate matter.

The Puget Sound area has experienced a significant decrease in SO_2 from sources such as pulp mills, cement plants, and smelters in the last two decades. Additionally, levels of sulfur in diesel and gasoline fuels have decreased due to EPA regulations. The Puget Sound Clean Air Agency stopped monitoring for SO_2 in 1999 because of these decreases. Monitoring sites for SO_2 were historically sited in or near former industrial areas. The Washington State Department of Ecology monitored SO_2 at the Beacon Hill site from 2000-2005. In 2006 the SO_2 monitor was relocated to a different location on the same property. The monitor was not operating most of 2006, so no data are reported for that year.

Figures 26 and 27 show the maximum 24-hour and 1-hour concentrations, respectively, at individual monitoring sites. The July 1994 spike shown on these graphs was the result of a short-term release from an Everett paper mill. The maximum measured SO_2 concentrations in 2008 were below all federal and regional standards. The maximum 24-hour and 1-hour Beacon Hill averages in 2008 were 0.073 ppm on August 22 and 24 and 0.011 ppm on August 16 and 17, respectively.

At the time of publication of this report, EPA was in the process of reviewing the SO2 NAAQS, with a proposed timeline for a new standard (potentially no change) in 2010.[34]

Statistical summaries for SO_2 data from the Beacon Hill site are available on page A-16 of the Appendix.

Additional information on SO_2 is available at www.epa.gov/air/urbanair/so2/index.html.

[34] EPA. Integrated Plan for the Review of the Primary NAAQS for Sulfur Oxides. http://www.epa.gov/ttn/naaqs/standards/so2/data/so2_review_plan_final_10-09-07.pdf. October 2007. Proposed schedule on page 2-1.

Figure 26: Sulfur Dioxide (SO_2) 24-Hour Average for Puget Sound Region

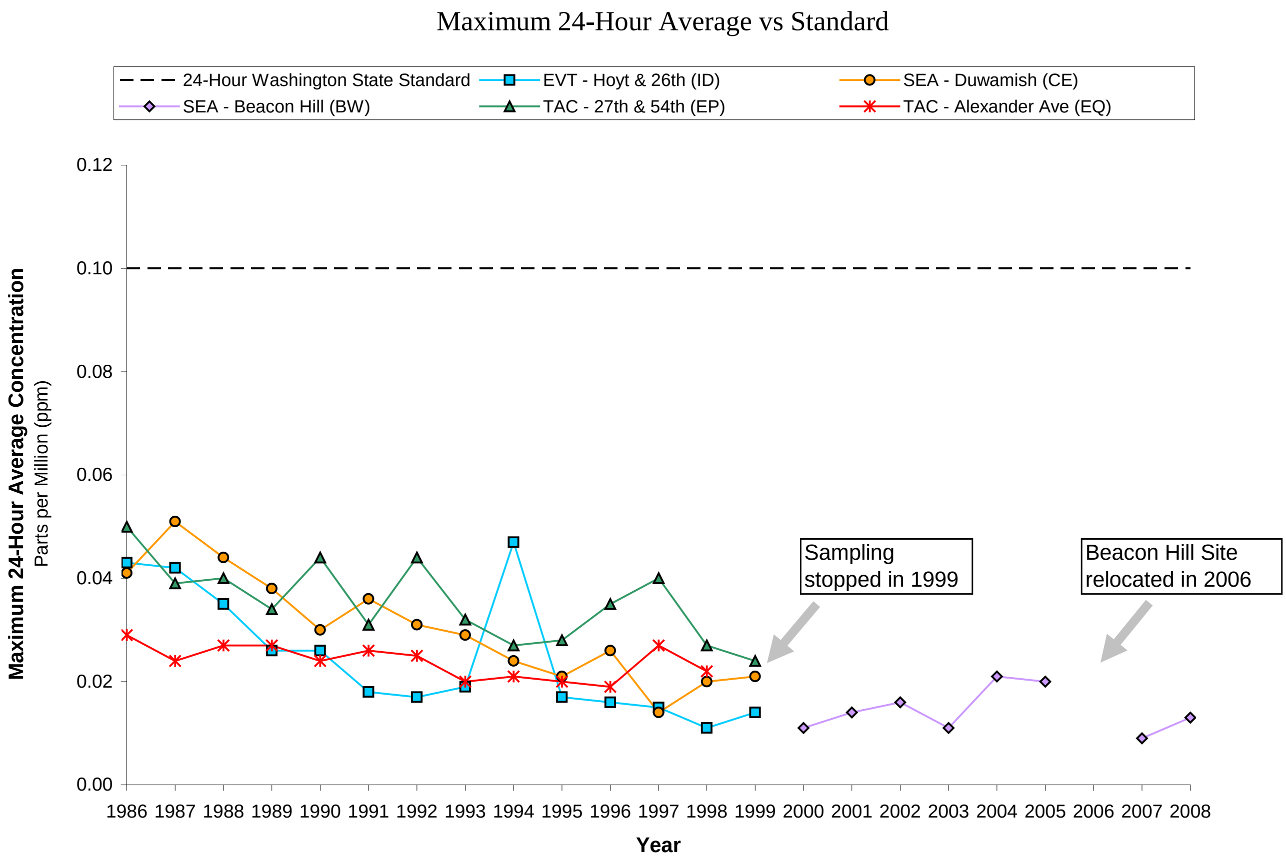
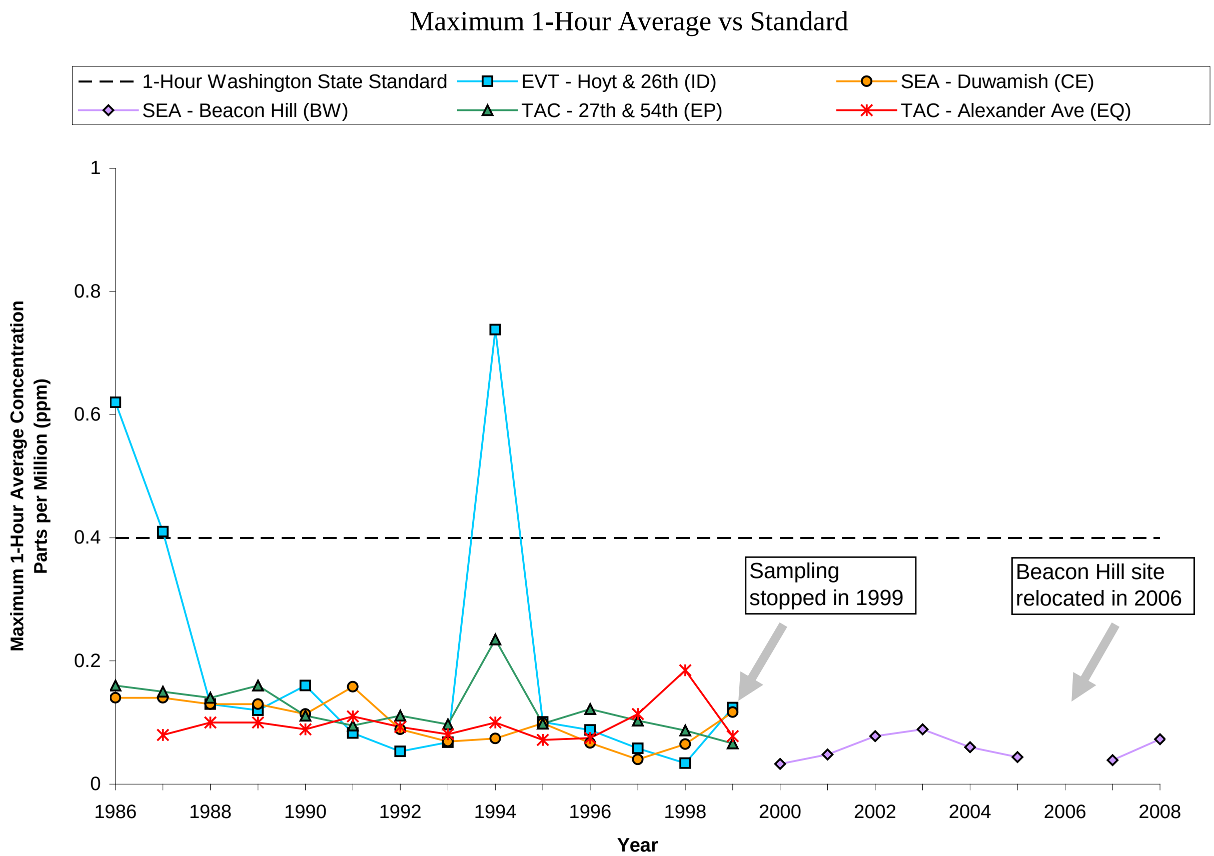


Figure 27: Sulfur Dioxide (SO_2) 1-Hour Average for Puget Sound Region



LEAD

Lead is a highly toxic metal that was used for many years in household products (e.g., paints), automobile fuel, and industrial chemicals. Nationally, industrial processes, particularly primary and secondary lead smelters and battery manufacturers, are now responsible for most of the remaining lead emissions. Locally, airborne lead was associated primarily with automobile exhaust and a secondary lead smelter; however, reductions in lead emissions from motor vehicles and the closure of the secondary lead smelter have made lead in ambient air less of a concern.

People, animals, and fish are mainly exposed to lead by breathing and ingesting it in food, water, soil, or dust. Lead accumulates in the blood, bones, muscles, and fat. Infants and young children are especially sensitive to even low levels of lead. Lead can have health effects ranging from behavioral problems and learning disabilities to seizures and death.

According to EPA, the primary sources of lead exposure are lead-based paint, lead-contaminated dust, and lead-contaminated residual soils. See the EPA website at www.epa.gov/ttnatw01/hlthef/lead.html for ways to limit your exposure to these lead sources.

Lead has not been monitored for comparison to the federal standard in the Puget Sound area since 1999.[35] Since the phase-out of lead in fuel and the closure of the Harbor Island secondary lead smelter, levels of lead in ambient air has decreased substantially. For a historic look at Puget Sound area lead levels, please see page 87 of the 2007 data summary at http://www.pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

In October 2008, EPA strengthened the lead standard from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$.[36] Although lead has not been monitored using the federal reference method since 1999, the fine particle fraction of lead is monitored at $PM_{2.5}$ speciation sites. Although the $PM_{2.5}$ speciation only reflects fine particle lead fractions, the lead concentrations are so low that at this time the agency does not expect that the region will exceed the stricter lead standard.

For additional information on lead, visit www.epa.gov/air/lead.

[35]Lead is a pollutant that is both a criteria air pollutant and an air toxic. Lead is no longer monitored by FRM as a criteria air pollutant in Puget Sound; however, the lead fraction of $PM_{2.5}$ is measured at speciation monitors.
[36]US EPA, National Ambient Air Quality Standard for Lead, FinalRule. Federal Register, November 12, 2008. http://www.epa.gov/fedrgstr/EPA-AIR/2008/November/Day-12/a25654.pdf. .

VISIBILITY

There are no federal or state standards established for visibility. Visibility data is presented (without comparison to a standard) as an indicator of air quality. Visibility is often explained in terms of visual range and light extinction. *Visual range* is the maximum distance – usually miles or kilometers – that you can see a black object against the horizon. *Light extinction* is the sum of light scattering and light absorption by fine particles and gases in the atmosphere. The more light extinction, the shorter the visual range. Visual range as measured by nephelometer instruments using light-scattering methodology provides an objective approach to measuring visibility at a specific location, but does not address individual perceptions regarding the "quality" of a view on a given day.

Reduced visibility is caused by weather such as clouds, fog, and rain, and air pollution, including fine particles and gases. The major contributor to reduced visual range is fine particulate matter ($PM_{2.5}$), which is transported aloft and may remain suspended for a week or longer. Fine particles have a greater impact than coarse particles at locations far from the emitting source because they remain suspended in the atmosphere longer, and travel farther.

Figures 28 through 32 show visibility for the overall Puget Sound area, as well as King, Kitsap, Pierce, and Snohomish Counties. Visibility on these graphs, in units of miles, is determined by continuous nephelometer monitoring. The nephelometer measures light scattering due to particulate matter, and then converts this unit (b_{sp}) into miles, more readily understood. The nephelometer does not take into account meteorology visibility effects such as cloudiness, so the visibility in these graphs is visibility as related to particulate matter. Nephelometer data are shown on page A-9 of the Appendix.

The red line on the graphs represents the monthly average visibility; it is apparent that there are large fluctuations, which correspond to the highest levels of visibility in the summer months and the lowest levels in the winter. The blue line shows a 12-month moving average, which incorporates the average of the previous 12 months to aid in smoothing out this seasonal variation. The blue line shows that the average visibility for the Puget Sound area has steadily increased over the last decade with year-to-year variability caused by meteorology. For the 19-year period from December 1990 through December 2008, the 12-month moving average of visual range increased from 49 miles to 81 miles.

For additional information on visibility, visit http://www.epa.gov/air/visibility/index.html.

Figure 28: Puget Sound Visibility

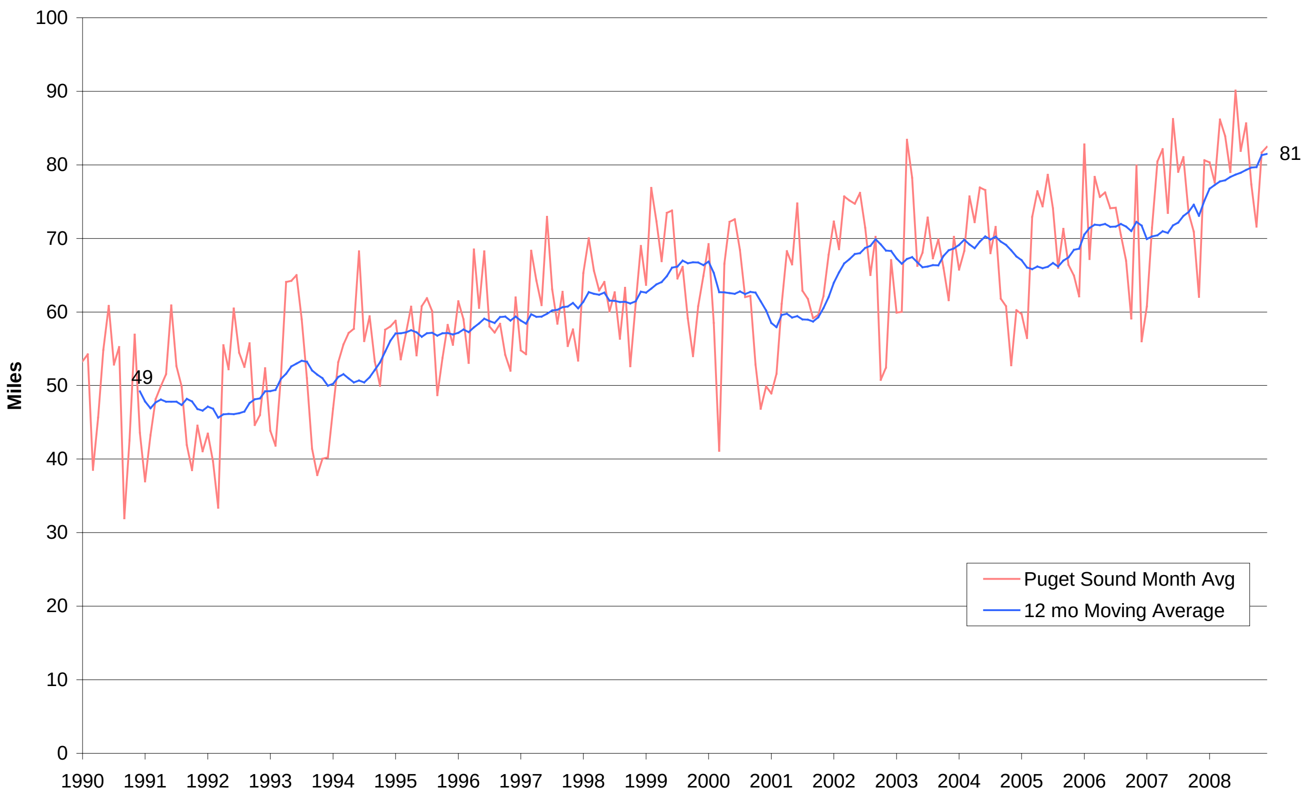


Figure 29: King County Visibility

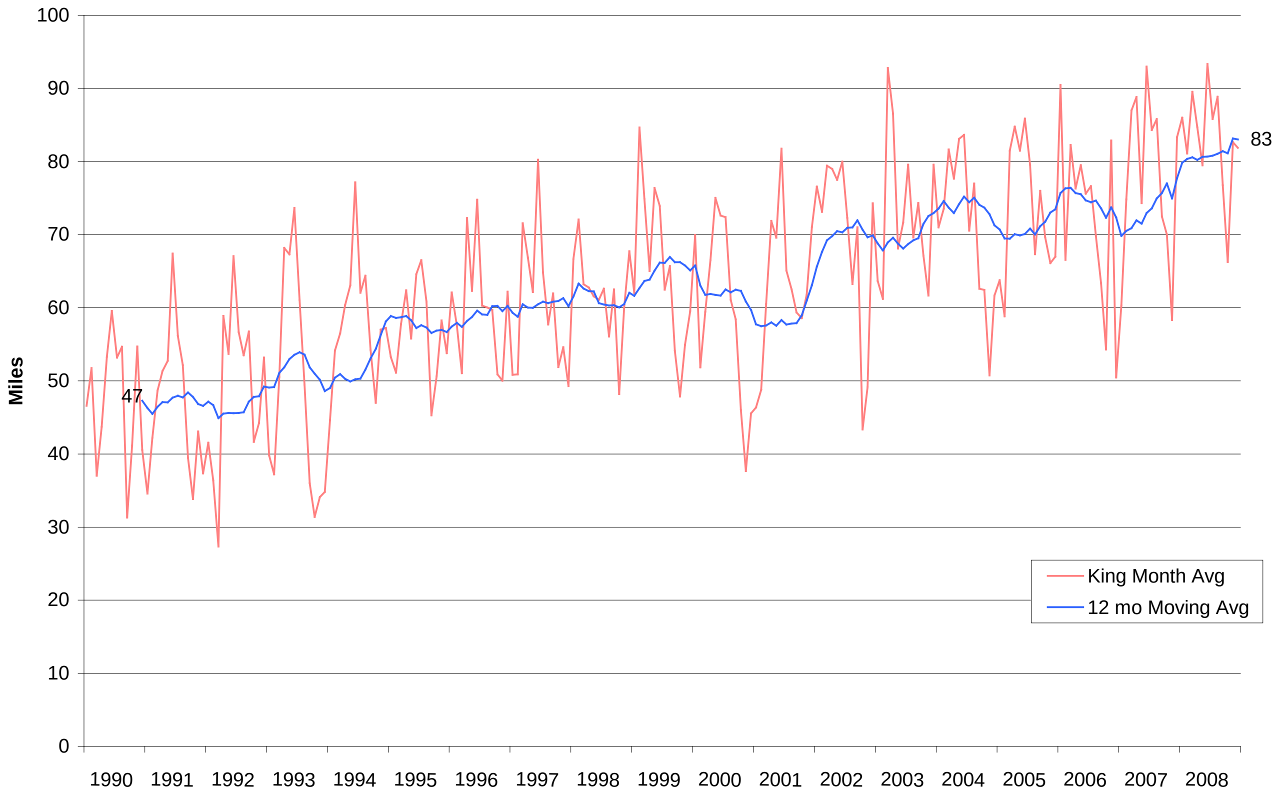


Figure 30: Kitsap County Visibility

Figure 31: Pierce County Visibility

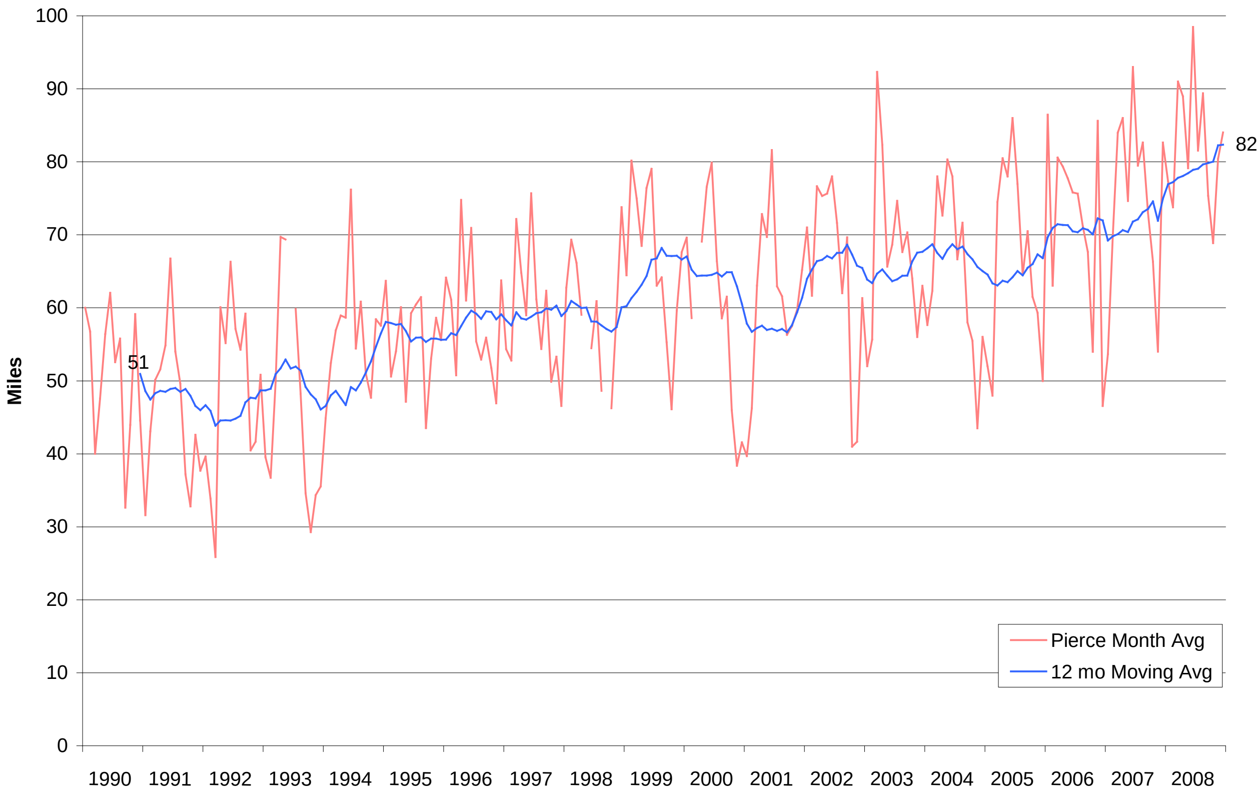
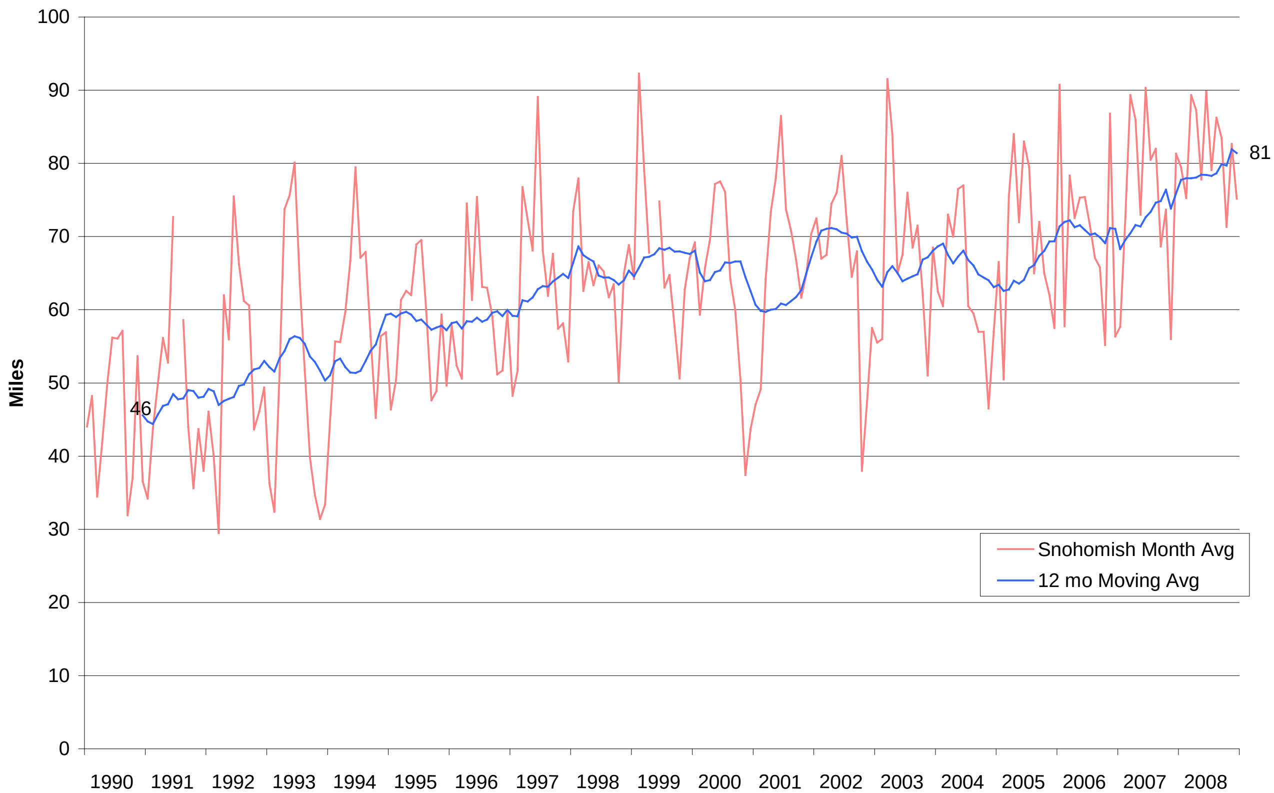


Figure 32: Snohomish County Visibility



AIR TOXICS

The Washington State Department of Ecology (Ecology) monitored for air toxics in 2008 at the Seattle Beacon Hill site. The Beacon Hill site is part of an EPA-sponsored network of National Air Toxics Trends Sites. As in previous years, Ecology monitored toxics every six days. This section presents a relative ranking of these toxics based on potential cancer health risks, as well as annual average graphs. Data for 2006 do not appear on these graphs because the 2006 dataset is incomplete (due to relocation of the Beacon Hill site in 2006). A short description of health effects associated with each air toxic and sources are also provided.

A comprehensive risk evaluation is beyond the scope of this summary report. For more information, see the 2003 Puget Sound Air Toxics Evaluation at http://www.pscleanair.org/airq/basics/psate_final.pdf. For general information on air toxics, see http://www.pscleanair.org/airq/basics/airtoxics.aspx. Air toxics statistical summaries are provided on page A-17 of the Appendix.

RELATIVE RANKING BASED ON CANCER RISK & UNIT RISK FACTORS

Table 4 ranks 2008 air toxics from the Beacon Hill monitoring site according to mean potential cancer risk per million. The ranking shows monitored pollutants ranked from highest concern/risk (#1) to lowest, and is based on risk using the most protective unit risk factor (explained below). Potential cancer risk estimates are shown here to provide a meaningful basis of comparison between pollutants, and are not intended to represent any community's or individual's potential exposure.

Potential cancer risk estimates can be interpreted as the number of potential additional cancers (out of a population of one million) that may develop from exposure to air toxics. A risk level of one in a million is commonly used as a screening value, and is used here.[37]

For details on how air toxics were ranked, please see page A- 18 and A-19 in the Appendix.

Risks presented in this table are based on annual average concentrations. Risks based on 95th percentile concentrations (a more protective statistic than presented in Table 4) are presented on page A-20 of the Appendix. Page A-20 also lists the frequency (percentage) of samples that were over the cancer screening level of one in a million risk.

[37]US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, February 2006; http://www.gpoaccess.gov/harvesting/airtoxics.pdf.

Table 4: 2008 Beacon Hill Air Toxics Ranking
(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Risk with IRIS URF	Average Risk with OEHHA URF	Risk Range
Carbon Tetrachloride	1	13	38	13-38
Benzene	2	6	23	6-23
1,3-Butadiene	3	2	12	2-12
Formaldehyde	4	10	4	4-10
Chromium 6 TSP	5	<1	6	<1-6
Arsenic PM_{10} (M)	6	3	2	2-3
Acetaldehyde	7	2	2	2
Chloroform	8	3	1	1-3
Nickel PM_{10} (M)	9	1	<1	1
Tetrachloroethylene	10	na	<1	<1
Trichloroethylene	10	na	<1	<1
Cadmium PM_{10} (M)	10	<1	<1	<1
Lead PM_{10} (M)	10	na	<1	<1
Beryllium PM_{10} (M)	10	<1	<1	<1
Dichloromethane	10	<1	<1	<1

IRIS = Integrated Risk Information System
URF = Unit Risk Factor
OEHHA = California EPA's Office of Environmental Health and Hazard
M = metal
PM_{10} = fine particles less than 10 micrometers in diameter
TSP = total suspended particulate
na = no unit risk factor available from this source

The two air toxics that present the majority of potential health risk in the Puget Sound area, diesel particulate matter and wood smoke particulate, are not included in the table. No direct monitoring method currently exists for these toxics. Modeling for these air toxics was not conducted for this report.

HEALTH EFFECTS OTHER THAN CANCER

Air toxics can also have chronic non-cancer health effects. These include respiratory, cardiac, immunological, nervous system, and reproductive system effects.

In order to determine non-cancer health risk, each air toxic was compared to its reference concentration, as established by California EPA (the most comprehensive dataset available). A reference concentration (RfC) is considered a safe level for toxics for non-cancer health effects.

Only one air toxic, acrolein, failed the screen for non-cancer health effects, with measured concentrations consistently exceeding the reference concentration. Acrolein irritates the lungs, eyes, and nose, and is a combustion by-product.[38] Monitoring for Acrolein started in 2007. Due to the limited number of data points a graph was not included in this report. Reference concentrations and hazard indices are shown for each air toxic on page A-21 of the Appendix. A hazard index is the concentration of a pollutant (either mean or other statistic) divided by the reference concentration. Typically, no adverse non-cancer health effects for that pollutant are associated with a hazard index less than 1, although it is important to consider that people are exposed to many pollutants at the same time.

Acute non-cancer health effects were not explored, because the Beacon Hill air toxics concentrations are based on 24-hour samples.

AIR TOXICS GRAPHS

Annual average concentrations are shown on the following pages for air toxics collected from 2000 to 2008 at Beacon Hill. A nine-year period is a relatively short time to characterize trends, and the annual average concentrations increase and decrease from year-to-year. While this report does not statistically investigate trends, a precursory look at most data show that annual average concentrations have typically decreased from 2000 to 2008. Graphs are not presented for metals because fewer years of data are available, and few exceed potential cancer risk screening levels. Federal ambient air concentration standards have not been set for air toxics, so graphs do not include reference lines for federal standards.

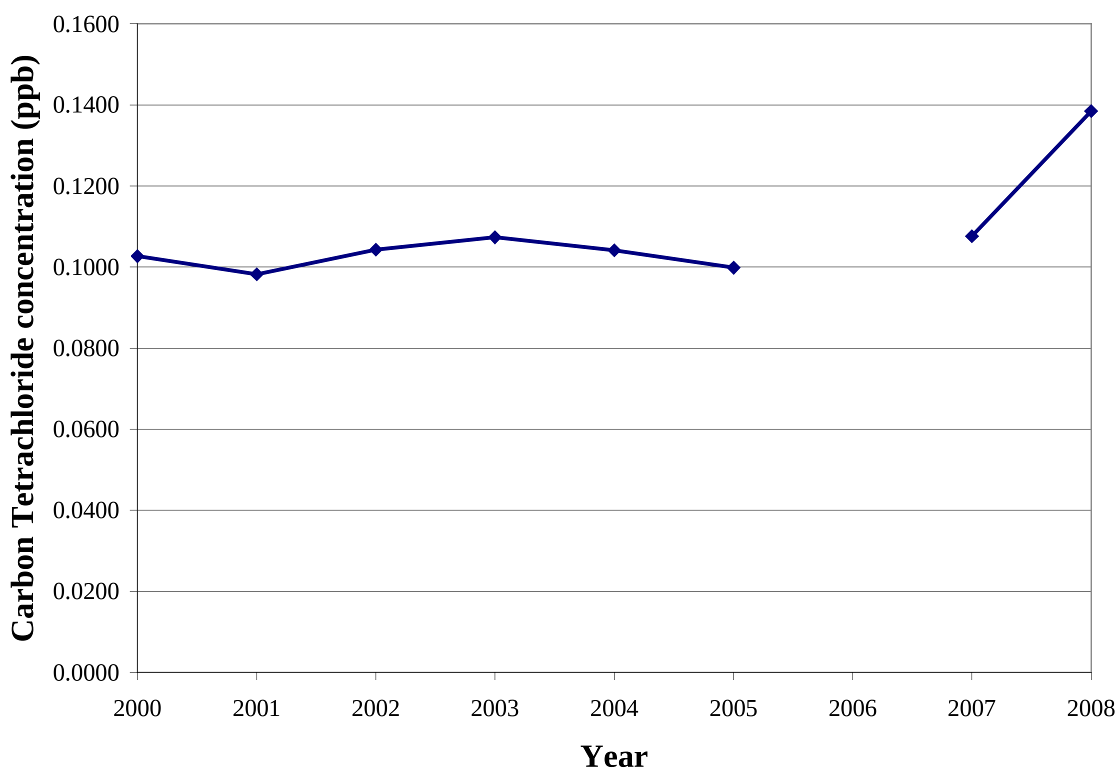
[38] EPA, Acrolein Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/acrolein.html.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[39] Carbon tetrachloride was widely used as a solvent for both industry and consumer users, and was banned from consumer use in 1996. Trace amounts are still emitted by local sewage treatment plants. Carbon tetrachloride is relatively ubiquitous and has a long half-life. Concentrations are similar in urban and rural areas. Carbon tetrachloride's 2008 average potential cancer risk range estimate at Beacon Hill was 13-to-38 in a million.

The agency does not target efforts at reducing carbon tetrachloride emissions, as it has already been banned.

Figure 33: Carbon Tetrachloride Annual Average Concentrations at Beacon Hill, 2000-2008



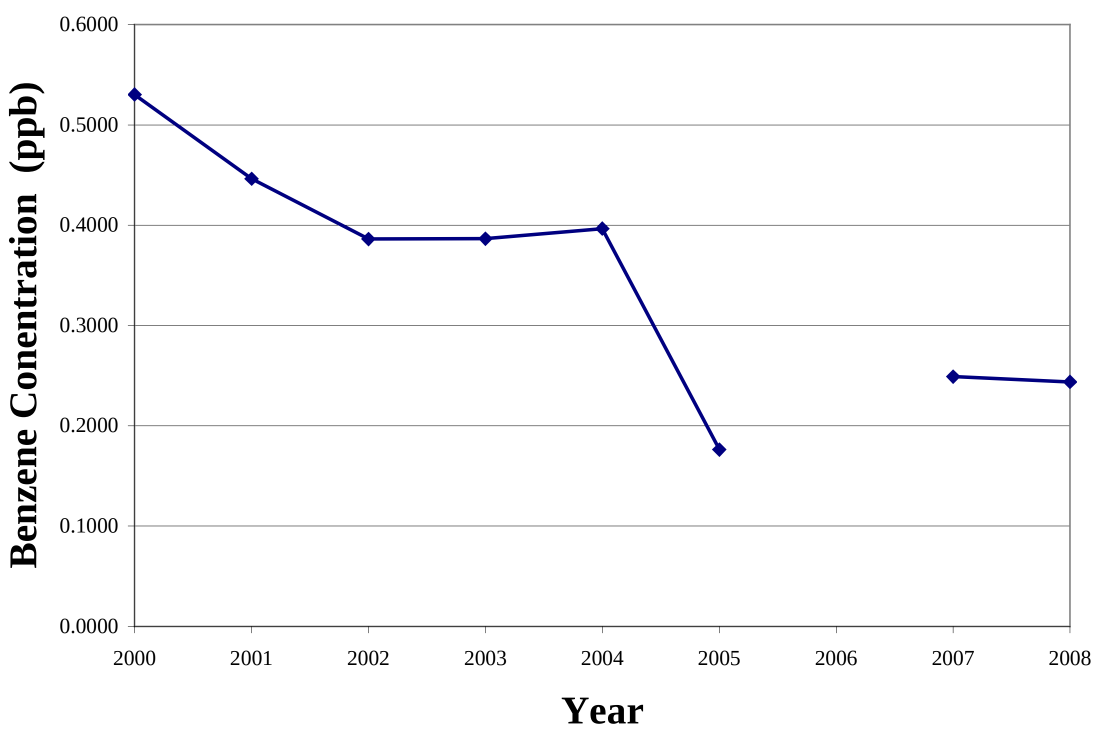
[39] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/carbonte.html.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune, and nervous system disorders.[40] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvents, and other combustion. Benzene's 2008 average potential cancer risk range estimate at Beacon Hill was 6-to-23 in a million.

Benzene levels are likely decreasing in our area due to factors including: less automobile pollution with newer, cleaner vehicles coming into the fleet; major refiners in the area reducing benzene gasoline content, and fewer gas station emissions due to better compliance (vapor recovery at the pump and during filling of gas station tanks).

Figure 34: Benzene Annual Average Concentrations at Beacon Hill, 2000-2008



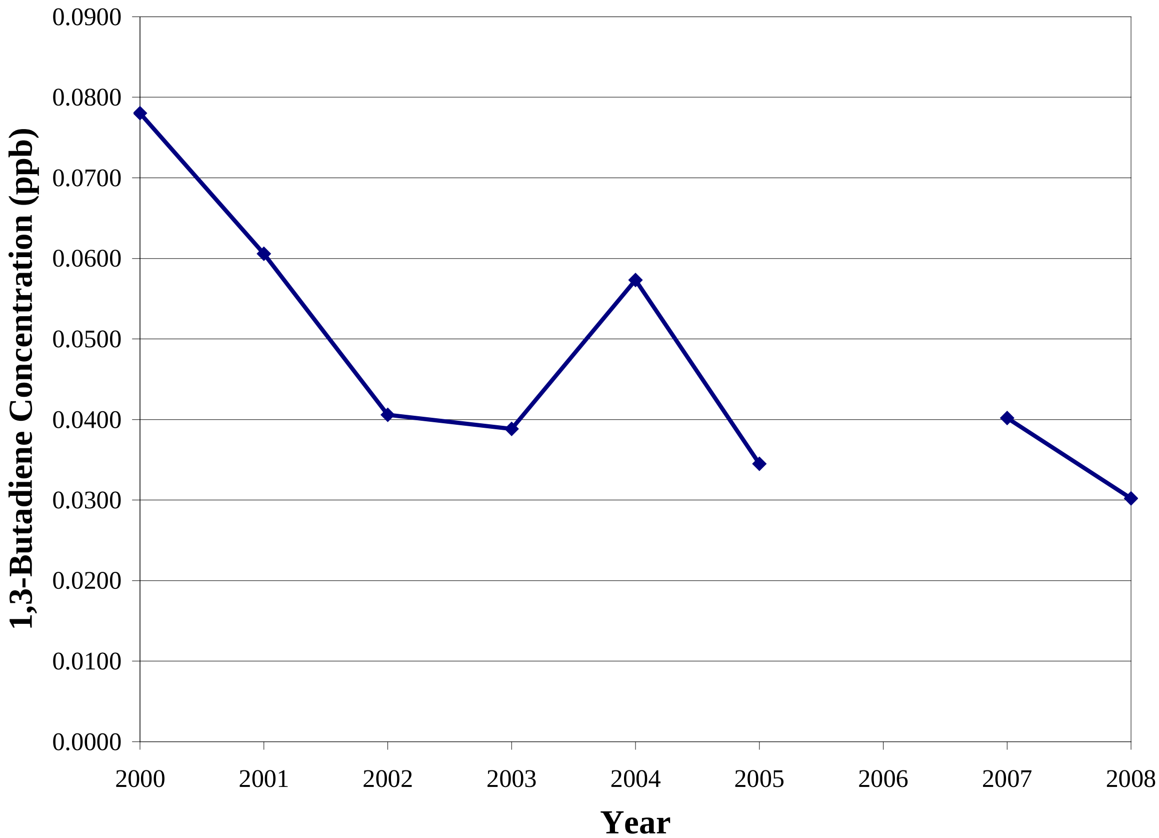
[40]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/benzene.html.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-Butadiene inhalation is also associated with neurological effects.[41] Primary sources of 1,3-butadiene include cars, trucks, buses, and wood burning. 1,3-Butadiene's 2008 average potential cancer risk range estimate at Beacon Hill was 2-to-12 in a million.

Agency efforts that target vehicle exhaust and wood stoves emission reductions also reduce 1,3-butadiene emissions.

Figure 35: 1,3-Butadiene Annual Average Concentrations at Beacon Hill, 2000-2008



[41]EPA Hazard Summary; http://www.epa.gov/ttnatw01/hlthef/butadien.html.

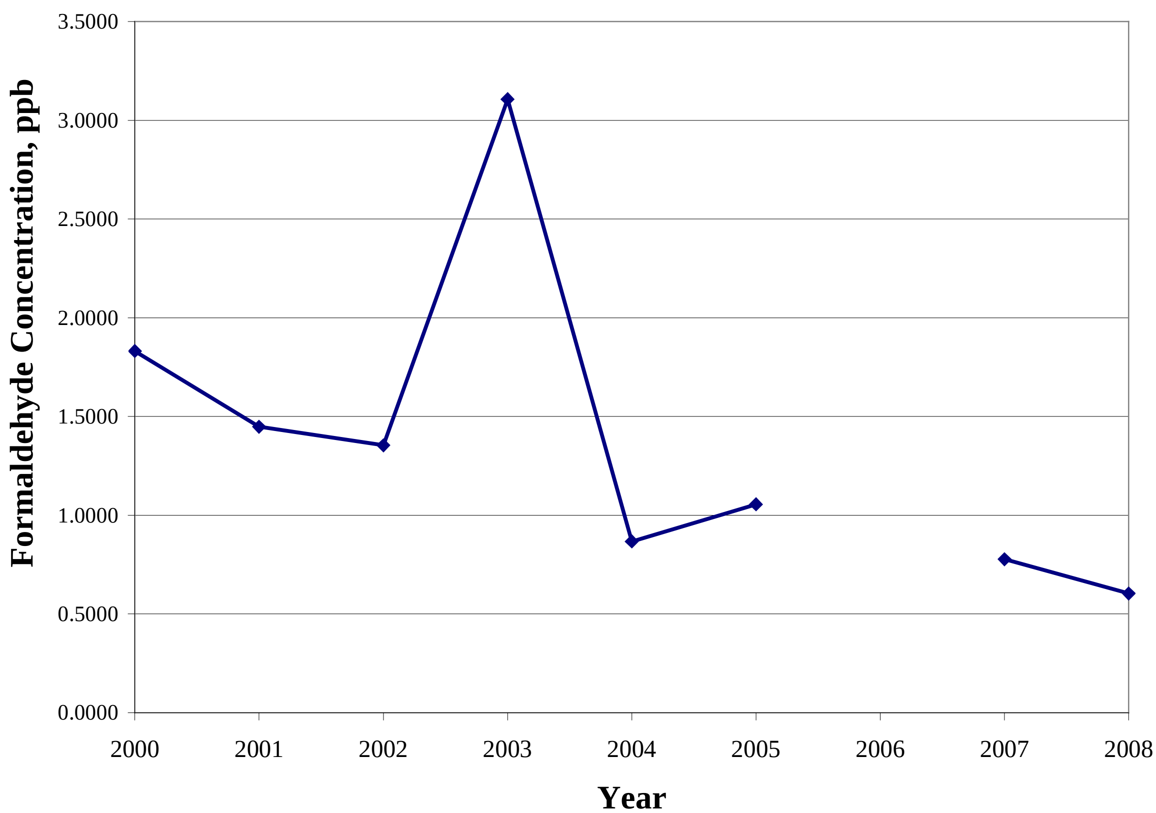
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat, and lung irritation.[42] Sources of ambient formaldehyde include automobiles, trucks, wood burning, and other combustion. Formaldehyde's 2008 average potential cancer risk range estimate at Beacon Hill was 4-to-10 in a million.

The increase in formaldehyde 2003 concentrations is due to nine anomalous sampling days in July 2003 when levels were roughly ten times the normal levels. It is possible that a local formaldehyde source was present at the Beacon Hill reservoir during this month, and inadvertently affected the monitors.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce formaldehyde emissions.

Figure 36: Formaldehyde Annual Average Concentrations at Beacon Hill, 2000-2008



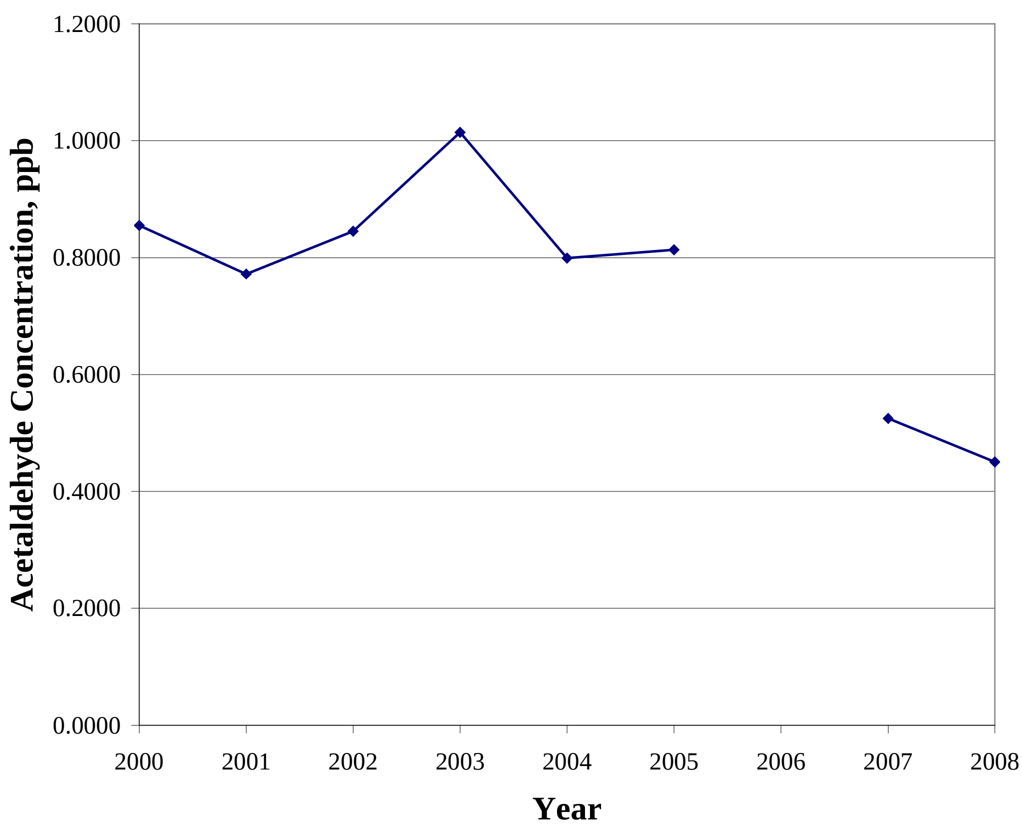
[42]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/formalde.html.

Acetaldehyde

The EPA lists acetaldehyde as a probable human carcinogen. Acetaldehyde inhalation is also associated with irritation of eyes, throat, and lungs, and effects similar to alcoholism.[43] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2008 average potential cancer risk estimate at Beacon Hill was two in a million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce acetaldehyde emissions.

Figure 37: Acetaldehyde Annual Average Concentrations at Beacon Hill, 2000-2008



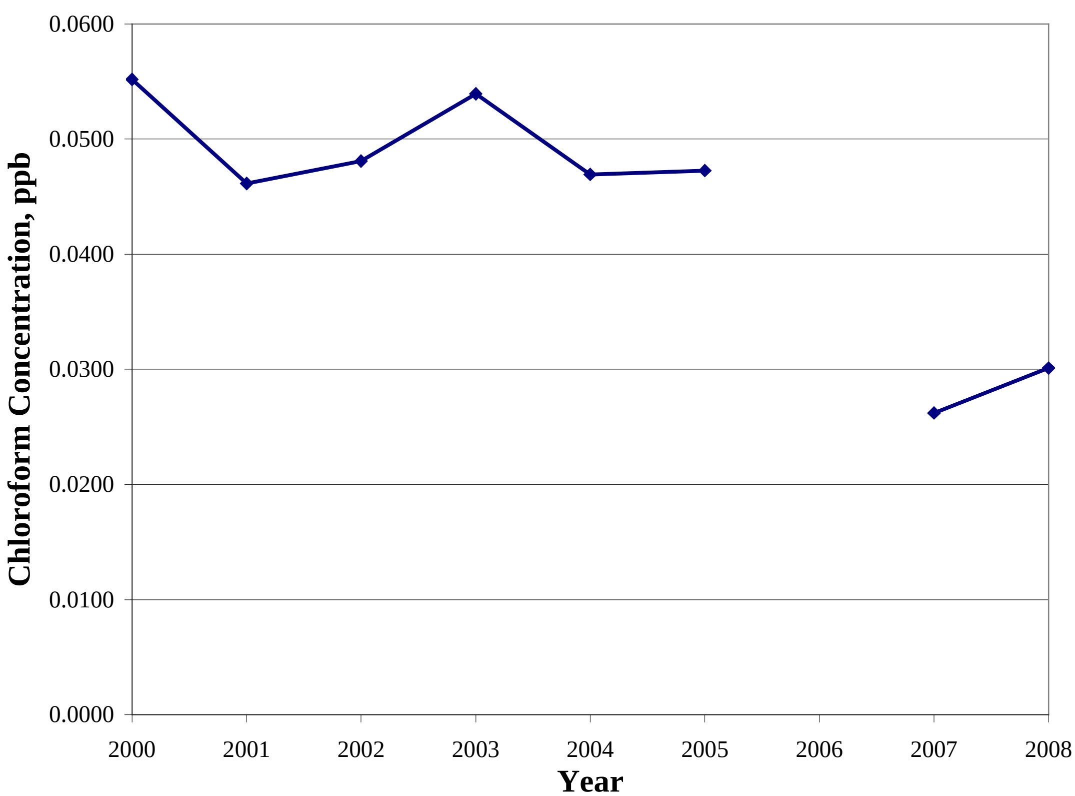
[43] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/acetalde.html.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is also associated with central nervous system effects and liver damage.[44] Main sources of chloroform are water treatment plants and reservoirs. The Beacon Hill monitoring site is located at the Beacon Hill Reservoir; concentrations measured and risks estimated are likely not representative of actual regional concentrations and potential risk (they are likely higher than typical levels). Chloroform's 2008 average potential cancer risk range estimate at Beacon Hill was 1-to-3 in a million. The Beacon Hill 2006 monitor location change and 2006 covering of the Beacon Hill reservoir potentially contribute to reduced post-2005 chloroform emissions and concentrations.

The agency does not prioritize efforts to reduce chloroform emissions, as it doesn't likely present risk in areas other than those directly adjacent to reservoirs.[45]

Figure 38: Chloroform Annual Average Concentrations at Beacon Hill, 2000-2008



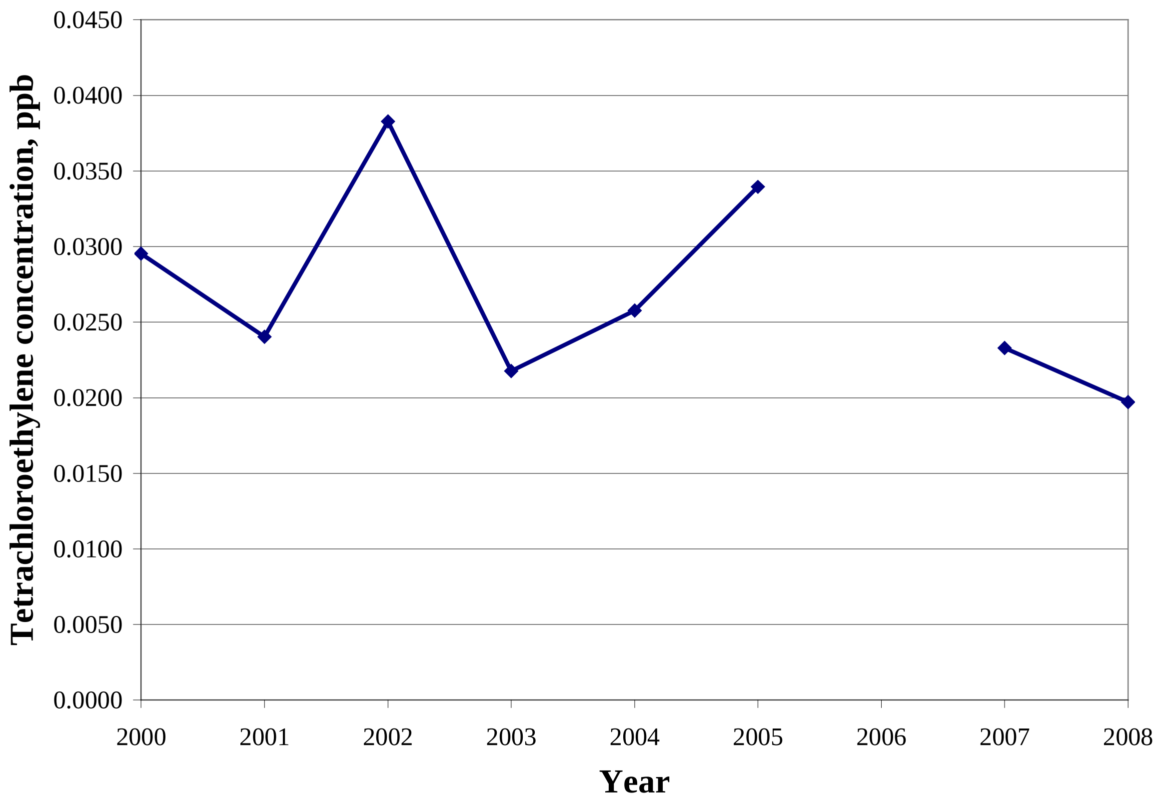
[44]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/chlorofo.html.
[45]Seattle Public Utilities. 2008 Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/stellent/groups/public/@spu/@fom/documents/webcontent/spu01_003889.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform; http://www.ci.seattle.wa.us/util/About_SPU/Water_System/Water_Quality/GLOSSARYO_200312020916386.asp.

Tetrachloroethylene

EPA lists tetrachloroethylene, also known as "perc" or perchloroethylene, as a probable human carcinogen. Tetrachloroethylene inhalation is also associated with central nervous system effects, liver and kidney damage, and cardiac arrhythmia.[46] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2008 average potential cancer risk estimate at Beacon Hill was less than one in a million.

In an effort to reduce perc emissions and exposures, the agency has required local dry cleaners to adopt closed systems and perform regular inspection and maintenance.[47]

Figure 39: Tetrachloroethylene Annual Average Concentrations at Beacon Hill, 2000-2008



[46]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html.
[47]Agency Regulations, Article 3, Section 3.03; http://www.pscleanair.org/regulated/businesses/regulations.aspx.

Trichloroethylene

EPA lists trichloroethylene as a probable/possible human carcinogen. Trichloroethylene is also associated with central nervous system effects.[48] Local sources of trichloroethylene include solvents used for degreasing and surface-coating operations. Trichloroethylene's 2008 average potential cancer risk estimate at Beacon Hill was less than one in a million, based on estimated concentrations. More than 75% of the trichloroethylene dataset was below the laboratory report detection limit, so no graph of estimated concentrations is presented.

The agency's works with and regulates solvent-using businesses to reduce trichloroethylene emissions.

METALS

Table 4 (2008 Beacon Hill Air Toxics Ranking), shown previously in this section, includes estimated potential cancer risks for several PM_{10} metals monitored at Beacon Hill, as well as total suspended particulate (TSP) hexavalent chromium. Hexavalent chromium and arsenic posed the greatest potential cancer risks. Other metals were below non-cancer screening levels (see Appendix page A-21).

Health effects from exposure to these and other monitored metals are listed below, along with local sources.

Hexavalent Chromium

Chromium is present in two chemical states in our airshed, trivalent and hexavalent. Trivalent chromium occurs naturally, while hexavalent comes from human activities and is much more toxic. EPA lists hexavalent chromium as a known carcinogen, associated primarily with lung cancer. Exposure to hexavalent chromium is also associated with adverse respiratory, liver, and kidney effects.[49] Sources of hexavalent chromium include chrome electroplaters, as well as combustion of distillate oil, and combustion of gasoline and diesel fuels (car, truck, and bus exhaust).

In recent years, the monitoring method for total suspended particulate (TSP) hexavalent chromium has improved. The estimated average potential cancer risk range for hexavalent chromium at Beacon Hill was <1-to-6 in a million.

The agency's permitting program works with and regulates industrial chromium plating operations to reduce hexavalent chromium emissions.

[48] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html.
[49] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/chromium.html.

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation, and liver and kidney damage.[50] Arsenic is used to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2008 average potential cancer risk range estimate at Beacon Hill was 2-3 in a million.

Nickel

EPA lists nickel as a known human carcinogen. Nickel is also associated with dermatitis and respiratory effects.[51] Combustion of gasoline and diesel fuels (car, truck, and bus exhaust) is a main source of nickel in the Puget Sound area. Nickel's 2008 average potential cancer risk estimate at Beacon Hill was one in a million.

Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[52] Combustion of distillate oil is a main source of cadmium in the Puget Sound area. Cadmium's 2008 average potential cancer risk estimate at Beacon Hill was less than one in a million.

Lead

EPA lists lead as a probable human carcinogen. Lead is associated primarily with central nervous system effects, and is also associated with reproductive and digestive effects.[53] Lead is especially harmful to children.

Lead is not present at significant levels in ambient air in the Puget Sound area, although a local source includes steel foundries. National ambient levels declined dramatically after leaded gasoline was phased out.

Lead can be present in indoor environments, particularly in homes with lead paint that is disturbed (peeling or crumbling). For more information, visit EPA's website at http://www.epa.gov/lead/. Lead's 2008 average potential cancer risk estimate at Beacon Hill was less than one in a million.

Lead is uniquely listed as both an air toxic and a criteria pollutant. For more information on the review of the national ambient air quality standards for lead, please see page 86.

[50] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/arsenic.html.
[51] EPA Hazard Summary; http://www.epa.gov/iris/subst/0273.htm.
[52] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/cadmium.html.
[53] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/lead.html.

Beryllium

EPA has classified beryllium as a probable human carcinogen. Beryllium exposures are also associated with lung inflammation and immunological effects.[54] Beryllium sources include combustion of coal and fuel oil that contain beryllium, and tobacco smoke. Beryllium's 2008 average potential cancer risk estimate was less than one in a million, based on estimated concentrations. More than 75% of the beryllium dataset was below the laboratory report detection limit.

Manganese

EPA lists manganese as "not classifiable" for cancer. Manganese exposures are primarily associated with central nervous system effects.[55] Manganese is naturally-occurring and is usually present in the air in small amounts. Additional local sources include steel foundries and blasting of metal parts. 2008 manganese levels in the Puget Sound area are below levels indicating health risk, with a hazard index of less than one1.

[54] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/berylliu.html.
[55] EPA National Air Toxics Assessment; http://www.epa.gov/ttnatw01/hlthef/manganes.html.

DEFINITIONS

GENERAL DEFINITIONS

Air Quality Index

Table 5: 2008 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
0_3 (ppm) 8-hour	**0_3 (ppm) 1-hour[(a)]**	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)	AQI value	Category
0.000–0.059	—	0.0–15.4	0–54	0.0–4.4	0.000–0.034	(b)	0–50	Good
0.060–0.075	—	15.5–40.4	55–154	4.5–9.4	0.035–0.144	(b)	51–100	Moderate
0.076–0.095	0.125–0.164	40.5–65.4	155–254	9.5–12.4	0.145–0.224	(b)	101–150	Unhealthy for sensitive groups
0.096–0.115	0.165–0.204	65.5–150.4	255–354	12.5–15.4	0.225–0.304	(b)	151–200	Unhealthy
0.116–0.374	0.205–0.404	150.5–250.4	355–424	15.5–30.4	0.305–0.604	0.65–1.24	201–300	Very unhealthy
(c)	0.405–0.504	250.5–350.4	425–504	30.5–40.4	0.605–0.804	1.25–1.64	301–400	Hazardous
(c)	0.505–0.604	350.4–500.4	505–604	40.5–50.4	0.805–1.004	1.65–2.04	401–500	

[(a)]Areas are generally required to report the AQI based on 8-hour ozone values. However, there are a small number of areas where an AQI based on 1-hour ozone values would be safer. In these cases, in addition to calculating the 8-hour ozone value, the 1-hour ozone value may be calculated, and the greater of the two values reported.

[(b)]NO_2 has no short-term National Ambient Air Quality Standard (NAAQS) and can generate an AQI only above a value of 200.

[(c)]8-hour O_3 values do not define higher AQI values (above 300). AQI values above 300 are calculated with 1-hour 0_3 concentrations.

For more information on the AQI and the pollutants it measures, see www.epa.gov/airnow/aqibroch.

Airshed

A geographic area that shares the same air, due to topography, meteorology, and climate.

Air Toxics

Air toxics are broadly defined as over 400 pollutants that the agency considers potentially harmful to human health and the environment. These pollutants are listed in Washington Administrative Code at http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150. Hazardous air pollutants (see below) are checked on this list to identify them as a subset of air toxics. Air toxics are also called Toxic Air Contaminants (TAC) under Regulation III.

Certified Wood Stove and Fireplace Inserts

A wood stove or fireplace insert that has been certified by EPA or Washington State to meet emission limits. Certified wood stoves and inserts emit significantly less pollution than non-certified stoves and inserts and are identified by an EPA certification label. Visit http://www.pscleanair.org/actions/woodstoves/default.aspx to learn more about certified wood burning devices.

Criteria Air Pollutant (CAP)

The Clean Air Act of 1970 defined *criteria pollutants* and provided EPA the authority to establish ambient concentrations for these criteria pollutants to protect public health. EPA periodically has revised the original concentration limits and methods of measurement, most recently in 2008. The six criteria air pollutants are: particulate matter (10 micrometers and 2.5 micrometers), ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead.

Hazardous Air Pollutant (HAP)

A *hazardous air pollutant* is an air contaminant listed in the Federal Clean Air Act, Section 112(b). 188 pollutants are currently listed as HAPs by EPA. They are listed by EPA at http://www.epa.gov/ttn/atw/188polls.html. They are also included under Puget Sound Clean Air Agency Regulation III.

Temperature Inversions

The earth gains and loses most of its energy at its surface. It is warmed by solar heating during the day and cooled by radiation emissions at night. During the late morning and afternoon hours, the air near the surface is warmer than the air aloft and allows for good pollutant dispersion (vertical mixing may be 1,500 meters or more). At night with clear skies, the surface radiates heat into outer space, creating cooler air at the surface and warmer air aloft. Warmer air above cooler air (temperature inversion) is a stable condition and limits the upward movement of pollution because the warmer air acts as a barrier. With little or no wind, pollutants are trapped near the surface (vertical mixing may be 200 meters or less) and can reach high levels of concentration.

Uncertified Wood Stove or Fireplace Insert

A wood stove or insert that is not certified by the EPA. These wood burning devices emit twice as much pollution as certified devices.

Unit Risk Factor (URF)

A unit risk factor is a measure of a pollutant's cancer risk based on a 70-year inhalation exposure period. The units are risk/concentration. Unit risk factors are multiplied by concentrations to estimate potential cancer risk.

Volatile Organic Compound (VOC)

An organic compound that participates in atmospheric photochemical reactions. This excludes all compounds determined to have negligible photochemical reactivity by EPA and listed in 40 CFR 51.100(s) in effect July 1, 2005.

Visibility/Regional Haze

Visibility is often explained in terms of visual range and light extinction. *Visual range* is the maximum distance – usually miles or kilometers – that you can see a black object against the horizon. *Light extinction* is the sum of light scattering and light absorption by fine particles and gases in the atmosphere. The more light extinction you have, the shorter your visual range will be. Reduced visibility (or visual range) is caused by weather (clouds, fog, and rain) and air pollution (fine particles and gases).

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2008
Air Quality Data Summary Appendix

October 2009

Working Together for Clean Air

Air Quality Index
1980 – 2008

King County

	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1980	73	275		18	0	95	270	1		1	17		194	Jan 23	PM
1981	69	267		28	1	109	254	2		5	24		213	Jan 15	CO
1982	86	268		10	1	96	264	5		1	10		214	Feb 6	PM
1983	98	258		9	0	101	261	3		0	9		183	Jan 28	CO
1984	146	218		2	0	111	242	13		2	0		103	Dec 6	PM
1985	150	202		10	3	156	206	3		6	7		204	Dec 12	PM
1986	130	226		8	1	113	246	6		1	8		206	Jan 7	PM
1987	120	238		7	0	119	246	0		3	4		184	Feb 6	PM
1988	215	146		5	0	67	298	1		2	3		150	Dec 3	CO
1989	231	134		0	0	129	233	3		0	0		100	Jan 19 #	CO
1990	216	145		4	0	139	201	6	19	0	0	4	131	Aug 11	O_3
1991	229	136		0	0	140	190	8	27	0	0	0	100	Dec 15 #	CO
1992	206	159		1	0	103	230	1	32	0	1	0	167	Feb 3	CO
1993	240	125		0	0	118	235	1	11	0	0	0	88	Jan 11	PM
1994	293	70		2	0	72	270	1	22	0	0	2	134	Jul 21	O_3
1995	299	66		0	0	95	249	5	16	0	0	0	89	Jan 3	CO
1996	297	69		0	0	85	252	2	27	0	0	0	100	Oct 9	CO
1997	302	63		0	0	117	230	0	18	0	0	0	94	Jan 16	PM
1998	317	46		2	0	111	228	0	26	0	0	2	114	Jul 27 #	O_3
1999	267	92	6	0	0	251	60	0	54	5	0	1	134	Jan 4	PM
2000	241	118	7	0	0	288	25		53	5	0	2	114	Nov 21	PM
2001	273	86	6	0	0	295	10		60	6	0	0	118	Nov 10	PM
2002	262	99	4	0	0	275	11		79	4	0	0	113	Nov 27	PM
2003	268	95	2	0	0	250	5		110	0	0	2	132	Jun 6	O_3
2004	256	105	5	0	0	280	2		84	4	0	1	132	Dec 18	PM
2005	254	106	5	0	0	302	3		60	5	0	0	117	Dec 11	PM
2006	268	87	6	4	0	273	2		90	6	0	4	169	Jul 22	O_3
2007	285	77	3	0	0	278	0		87	2	0	1	115	Jan 29	PM
2008	287	76	3	0	0	306	0		60	0	0	3	140	Jun 29	O_3
Totals	6378	4052	47	110	6	4874	4723	61	935	58	83	22			

PM = Particulate Matter CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM2.5) and 8-hour ozone (O3) standards. The O3 standard was again revised in March 2008.

Air Quality Index
1990 – 2008

Kitsap County															
	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1990															
1991															
1992	353	8		0	0	361				0			68	Nov 25	PM
1993	343	12		0	0	355				0			62	Jan 11	PM
1994	364	1		0	0	248	117			0	0		54	Dec 23	CO
1995	361	4		0	0	86	279			0	0		57	Jan 5	CO
1996	361	1		0	0	206	156			0	0		51	Mar 2	PM
1997	361	1		0	0	362				0			55	Jan 15	PM
1998	347	9		0	0	356				0			87	Nov 8	PM
1999	333	32	0	0	0	365				0			81	Jan 5 #	PM
2000	290	75	0	1	0	366				1			159	Jul 4	PM
2001	320	42	0	0	0	362				0			91	Dec 25	PM
2002	324	41	0	0	0	365				0			78	Nov 2	PM
2003	318	47	0	0	0	365				0			78	Nov 3	PM
2004	340	26	0	0	0	366				0			80	Jul 4	PM
2005	328	35	2	0	0	365				2			136	Jul 4	PM
2006	339	25	1	0	0	365				1			105	Dec 17	PM
2007	322	42	0	0	0	364				0			92	Nov 24	PM
2008	342	24	0	0	0	366				0			78	Dec 23	PM
Totals	5746	425	3	1	0	5623	552	0	0	4	0	0			

PM = Particulate Matter   CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone   # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM2.5) and 8-hour ozone (O3) standards. The O3 standard was again revised in March 2008.

Air Quality Index
1980 – 2008

Pierce County															
Days in Each Air Quality Category						Pollutant Determining the AQI							Highest Value		
						All Days				Unhealthy Days					
Year	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1980	83	271		12	0	256	107	3		4	8		160	Apr 12	PM
1981	74	278		10	3	222	137	6		1	12		227	Jan 12	CO
1982	119	242		4	0	255	101	9		0	4		167	Dec 30	CO
1983	140	222		3	0	228	128	9		1	2		137	Dec 23	PM
1984	162	198		6	0	207	149	10		0	6		117	Jan 19 #	CO
1985	140	213		12	0	252	109	4		1	11		165	Dec 13	PM
1986	161	197		7	0	247	114	4		2	5		167	Oct 23	CO
1987	173	177		13	2	227	136	2		5	10		220	Feb 5	CO
1988	226	132		8	0	184	175	7		3	5		183	Jan 27	CO
1989	260	103		2	0	217	121	27		0	2		117	Nov 30 #	CO
1990	271	91		3	0	219	87	41	18	1	0	2	118	May 5	PM
1991	261	103		1	0	247	85	12	21	0	1	0	117	Jan 31	CO
1992	260	106		0	0	231	83	27	25	0	0	0	100	Feb 3 #	CO
1993	289	76		0	0	247	82	23	13	0	0	0	89	Feb 1	CO
1994	313	51		1	0	235	75	31	24	0	0	1	105	Jul 21	O_3
1995	307	58		0	0	239	97	13	16	0	0	0	83	Jan 3	PM
1996	322	44		0	0	206	119	23	18	0	0	0	78	Oct 9	CO
1997	316	49		0	0	262	75	16	12	0	0	0	84	Jan 16	PM
1998	338	25		2	0	213	112	25	15	0	0	2	120	Jul 27	O_3
1999	265	97	3	0	0	318	1	1	45	3	0	0	139	Jan 4	PM
2000	242	110	13	1	0	318	2		46	14	0	0	153	Dec 6	PM
2001	271	83	11	0	0	306	2		57	11	0	0	139	Nov 10	PM
2002	267	88	9	1	0	291	1		73	10	0	0	158	Nov 27	PM
2003	265	92	8	0	0	264	1		100	8	0	0	122	Jan 7	PM
2004	251	110	5	0	0	272			94	5	0	0	133	Nov 5	PM
2005	275	82	8	0	0	276	2		87	8	0	0	120	Dec 10	PM
2006	283	71	7	4	0	270			95	8	0	3	170	Dec 17	PM
2007	298	57	10	0	0	261			104	9	0	1	137	Jan 29	PM
2008	295	63	8	0	0	259			107	5	0	3	129	Aug 16	O_3
Totals	6927	3489	82	90	5	7229	2101	293	970	99	66	12			

PM = Particulate Matter   CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone   # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM2.5) and 8-hour ozone (O3) standards. The O3 standard was again revised in March 2008.

Air Quality Index
1980 – 2008

Snohomish County

	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	SO_2	AQI	Date	Pollutant
1980	340	19		0	0	356		3		0		0	60	Jan 23	PM
1981	350	11		0	0	340		21		0		0	62	Jan 16	PM
1982	334	30		1	0	277	70	18		0	1	0	117	Dec 30	CO
1983	308	56		1	0	191	150	24		0	1	0	117	Nov 30	CO
1984	309	57		0	0	105	217	44		0	0	0	92	Sep 28	PM
1985	300	64		1	0	152	166	47		0	1	0	117	Dec 11	CO
1986	324	41		0	0	169	148	48		0	0	0	89	Jan 25	CO
1987	203	158		3	0	96	250	18		0	3	0	117	Jun 26 #	CO
1988	174	184		8	0	15	345	6		0	8	0	133	Sep 13 #	CO
1989	150	213		2	0	26	338	1		0	2	0	133	Feb 10	CO
1990	166	197		2	0	29	335	1		0	2	0	117	Mar 2 #	CO
1991	188	176		1	0	32	333	0		0	1	0	117	Dec 16	CO
1992	180	186		0	0	34	332	0		0	0	0	100	Feb 4 #	CO
1993	237	128		0	0	56	306	0	3	0	0	0	79	Jan 11	PM
1994	294	71		0	0	28	334	1	2	0	0	0	78	Dec 30	CO
1995	316	49		0	0	59	294	1	11	0	0	0	78	Jul 7	CO
1996	340	26		0	0	54	299	0	13	0	0	0	67	Jul 26	O_3
1997	348	17		0	0	210	151	0	4	0	0	0	67	Jan 14	PM
1998	353	11		1	0	143	219	3		1	0	0	153	Dec 22	PM
1999	300	62	3	0	0	260	105	0		3	0	0	129	Jan 3	PM
2000	253	79	5	0	0	301	36			5	0		113	Jul 4	PM
2001	290	73	2	0	0	356	9			2	0		111	Nov 10	PM
2002	288	69	8	0	0	343	22			8	0		116	Nov 4	PM
2003	282	80	3	0	0	364	1			3	0		108	Nov 4	PM
2004	290	74	2	0	0	364	2			2	0		107	Nov 5	PM
2005	288	72	5	0	0	360	5			5	0		139	Dec 11	PM
2006	301	57	7	0	0	364	1			7	0		143	Dec 17	PM
2007	288	70	6	1	0	365	0			7	0		155	Jan 15	PM
2008	294	72	0	0	0	366	0			0	0		96	Dec 19	PM
Totals	8088	2402	41	21	0	5815	4468	236	33	43	19	0			

PM = Particulate Matter   CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone   # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM2.5) and 8-hour ozone (O3) standards. The O3 standard was again revised in March 2008.

Monitoring Methods Used from 1999 to 2008 in Puget Sound Airshed

Pollutant Code	Measurement	Method	Units
Bap	Light Absorption by Particles	Light Absorption by Aethalometer	bap (x 10 exp-4)/m
Bsp	Light Scattering by Particles	Nephelometer - Heated Inlet	bsp (x 10 exp-4)/m
CO	Carbon Monoxide	Gas Nondispersive Infrared Radiation	Parts per Million
NO_x	Nitrogen Oxides (NO_x)	Chemiluminescence	Parts per Million
	Nitric Oxide (NO)	Chemiluminescence	Parts per Million
	Nitrogen Dioxide (NO_2)	Chemiluminescence	Parts per Million
NO_Y	Reactive Nitrogen Compounds (NO_X + other reactive compounds)	Chemiluminescence	Parts per Billion
O_3	Ozone	UV Absorption	Parts per Million
Pb	Lead	Standard High Volume	Micrograms per Standard Cubic Meter
PM_{10} ref	PM_{10} Reference	Reference - Hi Vol Andersen/ GMW 1200	Micrograms per Cubic Meter
PM_{10} bam	PM_{10} Beta Attenuation	Andersen FH621-N	Micrograms per Cubic Meter
PM_{10} teom	PM_{10} Teom	R&P Mass Transducer	Micrograms per Cubic Meter
$PM_{2.5}$ ref	$PM_{2.5}$ Reference	Reference—R&P Partisol 2025	Micrograms per Cubic Meter
$PM_{2.5}$ bam	$PM_{2.5}$ Beta Attenuation	Andersen FH621-N	Micrograms per Cubic Meter
$PM_{2.5}$ teom	$PM_{2.5}$ Teom	R&P Mass Transducer	Micrograms per Cubic Meter
$PM_{2.5}$ ls	$PM_{2.5}$ Nephelometer	Radiance Research M903 Nephelometer	Micrograms per Cubic Meter
$PM_{2.5}$ bc	$PM_{2.5}$ Black Carbon	Light Absorption by Aethalometer	Micrograms per Cubic Meter
RH	Relative Humidity	Continuous Instrument Output	Percent Relative Humidity
SO2	Sulfur Dioxide	UV Fluorescence	Parts per Million
Temp	Temperature	Continuous Instrument Output	Degrees F
TSP	PM Total Hi-Vol	Standard High Volume	Micrograms per Standard Cubic Meter
Vsby	Visual Range	Light Scattering by Nephelometer	Miles
Wind	Wind Speed/ Wind Direction	RM Young 05305 Wind Monitor AQ (old method)	Miles per Hour/ Degrees
	Wind Speed/ Wind Direction	Ultrasonic (new method)	Miles per Hour/ Degrees

Burn Bans
1988 – 2008

1988
- Jan 25(0830) - Jan 28 (0830)
- Feb 5 (1630) - Feb 6 (0930)
- Dec 1 (1430) - Dec 2 (0800)
- Dec 4 (1430) - Dec 5 (1400)
- Dec 16 (1430) - Dec 18 (1430)

1989
- Jan 19 (1430) - Jan 20 (1430)
- Jan 24 (1430) - Jan 26 (0930)
- Feb 6 (1430) - Feb 8 (0930)
- Feb 10 (1430) - Feb 16 (0930)
- Nov 29 (1430) - Dec 2 (0930)
- Dec 22 (1430) - Dec 23 (1430)

1990
- Jan 19 (1430) - Jan 21 (1430)
- Dec 7 (1430) - Dec 8 (0930)
- Dec 25 (1430) - Dec 27 (0815)*
  *(Dec 26 1430 – Dec 27 0815) 2nd Stage

1991
- Jan 5 (1430) - Jan 6 (0930)
- Jan 21 (1430) - Jan 24 (1500)*
  *(Jan 22 0930 – Jan 24 1500) 2nd Stage
- Jan 29 (1430) - Jan 31 (0830)
- Dec 15 (1430) - Dec 17 (1430)*
  *(Dec 16 1430 – Dec 17 0930) 2nd Stage

1992
- Jan 8 (1430) - Jan 9 (0930)
- Jan 19 (1430) - Jan 20 (1430)
- Feb 5 (1000) - Feb 6 (1430)
- Nov 25 (1430) - Nov 26 (1430)

1993
- Jan 11 (1430) - Jan 13 (0830)
- Jan 15 (1430) - Jan 16 (0700)
- Jan 17 (1430) - Jan 19 (0600)
- Jan 31 (1430) - Feb 3 (0830)
- Dec 20 (1430) - Dec 21 (1430)
- Dec 26 (1430) - Dec 29 (0830)

1994 None

1995
- Jan 4 - Jan 7

1996
- Feb 14 (1430) - Feb 16 (1630)

1997
- Nov 13 (1500) - Nov 15 (1500)
- Dec 4 (1500) - Dec 7 (1800)

1998 None

1999
- Jan 5 (1400) - Jan 6 (1000)
- Dec 29 (1400) - Dec 31 (0600)

2000
- Feb 18 (1400) - Feb 20 (1000)
- Nov 15 (1700) - Nov 23 (0600)

2001
- Nov 8 (1400) - Nov 12 (1800)

2002
- Nov 1 (1500) - Nov 6 (0900)
- Nov 27 (1000) - Dec 4 (1000)

2003
- Jan 7 (1500) - Jan 9 (1300)

2004 None

2005
- Feb 21 (1600) - Feb 28 (0800)
- Dec 9 (1700) - Dec 18 (1200)

2006 None

2007
- Jan 13 (1400) - Jan 16 (1500)
- Jan 28 (1400) - Jan 31 (1400)
- Dec 9 (1400) - Dec 11 (0930)

2008
- Jan 23 (1400) - Jan 26 (1200)

PARTICULATE MATTER ($PM_{2.5}$) - Federal Reference Method

Micrograms per Cubic Meter

Reference Sampling Method: R&P Partisol 2025 Sampler Teflon Filter

2008

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	142	8.3	4.4	5.3	10.8	7.2	25	32
Marysville JHS, 1605 7th St, Marysville	340	9.1	6.3	7.4	10.4	8.3	28	38
17171 Bothell Way NE, Lake Forest Park **	16	-	-	-	-	-	-	33
Duwamish, 4752 E Marginal Way S, Seattle	122	9.5	7.4	7.9	11.1	9.0	24	34
7802 South L St, Tacoma	121	12.4	6.1	6.6	14.2	9.8	44	50

Notes

Sampling ended at Lake Forest Park 2/15/08

(1) Sampling occurs for a 24 hour period from midnight to midnight. Quarterly averages are shown only if 75 percent or more of the data is available.

(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum Observed Concentrations and Values >40

Location	Jan 24 Thu	Jan 25 Fri	Dec 5 Fri	Dec 19 Fri	Dec 23 Tue
Darrington HS, 1085 Fir St, Darrington				--	32
Marysville JHS, 1605 7th St Marysville				38	
17171 Bothell Way NE, Lake Forest Park	--	33	--	--	--
Duwamish, 4752 E Marginal Way, Seattle	--		34	--	
7802 South L St, Tacoma	44	50		--	49

-- Indicates no sample on specified day

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Darrington HS, 1085 Fir St, Darrington	128	14		
Marysville JHS, 1605 7th St, Marysville	304	36		
17171 Bothell Way NE, Lake Forest Park	11	5		
Duwamish, 4752 E Marginal Way S, Seattle	113	9		
7802 South L St, Tacoma	101	17	3	

PARTICULATE MATTER ($PM_{2.5}$) - Continuous TEOM

Micrograms per Cubic Meter

Reference Sampling Method: R&P Partisol 2025 Sampler Teflon Filter

2008

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	142	8.3	4.4	5.3	10.8	7.2	25	32
Marysville JHS, 1605 7th St, Marysville	340	9.1	6.3	7.4	10.4	8.3	28	38
17171 Bothell Way NE, Lake Forest Park **	16	-	-	-	-	-	-	33
Duwamish, 4752 E Marginal Way S, Seattle	122	9.5	7.4	7.9	11.1	9.0	24	34
7802 South L St, Tacoma	121	12.4	6.1	6.6	14.2	9.8	44	50

Notes

Sampling ended at Lake Forest Park 2/15/08

(1) Sampling occurs for a 24 hour period from midnight to midnight. Quarterly averages are shown only if 75 percent or more of the data is available.

(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum Observed Concentrations and Values >40

Location	Jan 24 Thu	Jan 25 Fri	Dec 5 Fri	Dec 19 Fri	Dec 23 Tue
Darrington HS, 1085 Fir St, Darrington				--	32
Marysville JHS, 1605 7th St Marysville				38	
17171 Bothell Way NE, Lake Forest Park	--	33	--	--	--
Duwamish, 4752 E Marginal Way, Seattle	--		34	--	
7802 South L St, Tacoma	44	50		--	49

-- Indicates no sample on specified day

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Darrington HS, 1085 Fir St, Darrington	128	14		
Marysville JHS, 1605 7th St, Marysville	304	36		
17171 Bothell Way NE, Lake Forest Park	11	5		
Duwamish, 4752 E Marginal Way S, Seattle	113	9		
7802 South L St, Tacoma	101	17	3	

PARTICULATE MATTER ($PM_{2.5}$) – Continuous - Nephelometer

Micrograms per Cubic Meter

Sampling Method: Equivalent - Radiance Research M903 Nephelometer

2008

Location	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean	98th Percentile	Daily Max Value
Darrington HS, 1085 Fir St, Darrington	363	7.0	3.3	4.6	9.8	6.2	22.3	29
Marysville JHS, 1605 7th St, Marysville	366	8.4	6.0	6.0	8.0	7.1	22.9	31
6120 212th St SW, Lynnwood	366	7.7	5.4	4.9	7.3	6.3	19.8	34
17171 Bothell Way NE, Lake Forest Park	362	8.5	6.0	6.0	9.4	7.5	23.0	30
Queen Anne Hill, 400 W Garfield St, Seattle	363	4.5	4.8	5.1	6.3	5.2	14.7	24
Olive & Boren, Seattle	349	5.5	5.6	6.3	6.0	5.9	14.8	23
15th S & Charlestown, Beacon Hill, Seattle	366	5.6	6.0	5.1	6.2	5.7	15.2	21
Duwamish, 4752 E Marginal Way S, Seattle	360	7.0	6.0	6.5	7.6	6.8	20.7	27
South Park, 8025 10th Ave S, Seattle	362	6.8	5.2	5.8	8.4	6.6	19.0	27
305 Bellevue Way NE, Bellevue	332	5.2	4.6	4.7	5.9	5.1	11.7	16
42404 SE North Bend Way, North Bend	362	4.8	5.4	6.0	5.4	5.4	12.1	18
James St & Central Ave, Kent	320	--	5.7	6.6	8.6	7.0	21.3	25
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	349	8.3	5.4	5.6	7.3	6.7	21.3	27
7802 South L St, Tacoma	364	9.3	4.8	5.8	8.8	7.2	30.2	41
South Hill, 9616 128th St E, Puyallup	364	8.4	4.8	5.7	8.0	6.7	22.0	32
30525 SE Mud Mountain Road, Enumclaw	355	2.1	3.6	4.6	2.5	3.2	8.9	15
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	308	7.4	--	--	9.5			29
10955 Silverdale Way NW, Silverdale	243	6.0	4.9	--	--			19

Notes
(1) At the time of publication, we are aware that many of the 2008 nephelometer values are biased low when compared to the federal reference method. The agency is in the process of correcting this issue with the Washington State Department of Ecology.
(2) Sampling occurs continuously for 24 hours each day.
Quarterly averages are shown only if 75 percent or more of the data is available.
(3) Annual averages are shown only if there are at least three quarterly averages.
(4) All data values are correlated using site-specific relationships with Federal Reference Method samplers.

Summary of Maximum Observed Concentrations and Values >40

Location	Jan 23 Wed	Jan 25 Fri	Feb 19 Tue	Jul 1 Tue	Oct 1 Wed	Oct 30 Thu	Nov 16 Sun	Dec 5 Fri	Dec 23 Tue
Darrington HS, 1085 Fir St, Darrington									29
Marysville JHS, 1605 7th St, Marysville		31							
6120 212th St SW, Lynnwood		34							
17171 Bothell Way NE, Lake Forest Park		30							
Queen Anne Hill, 400 W Garfield St, Seattle							24		
Olive & Boren, Seattle	--				23				
15th S & Charlestown, Beacon Hill, Seattle							21		
Duwamish, 4752 E Marginal Way S, Seattle								27	
South Park, 8025 10th Ave S, Seattle								27	
305 Bellevue Way NE, Bellevue			16	--					
42404 SE North Bend Way, North Bend				18					
James St & Central Ave, Kent						25			
Tacoma Tideflats, 2301 Alexander Ave, Tacoma							27		
7802 South L St, Tacoma	41	41							
South Hill, 9616 128th St E, Puyallup						--	32		
30525 SE Mud Mountain Road, Enumclaw				15					--
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co				--					29
10955 Silverdale Way NW, Silverdale		19			--	--	--	--	--

-- Indicates no sample on specified day

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Darrington HS, 1085 Fir St, Darrington	334	29		
Marysville JHS, 1605 7th St, Marysville	341	25		
6120 212th St SW, Lynnwood	348	18		
17171 Bothell Way NE, Lake Forest Park	337	25		
Queen Anne Hill, 400 W Garfield St, Seattle	357	6		
Olive & Boren, Seattle	343	6		
15th S & Charlestown, Beacon Hill, Seattle	360	6		
Duwamish, 4752 E Marginal Way S, Seattle	345	15		
South Park, 8025 10th Ave S, Seattle	345	17		
305 Bellevue Way NE, Bellevue	331	1		
42404 SE North Bend Way, North Bend	359	3		
James St & Central Ave, Kent	295	25		
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	324	25		
7802 South L St, Tacoma	335	27	2	
South Hill, 9616 128th St E, Puyallup	338	26		
30525 SE Mud Mountain Road, Enumclaw	355			
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	285	23		
10955 Silverdale Way NW, Silverdale	241	2		

$PM_{2.5}$ Speciation Analytes Monitored in 2008
Average Annual Concentrations in Micrograms per Cubic Meter

Analyte	Beacon Hill	South L
Total PM2.5 Mass	6.8	9.8
Aluminum	NA	NA
Antimony	NA	NA
Arsenic	NA	NA
Barium	NA	NA
Bromine	2.27E-03	2.09E-03
Cadmium	NA	NA
Calcium	2.98E-02	3.22E-02
Cerium	NA	NA
Cesium	NA	NA
Chlorine	5.63E-02	1.40E-01
Chromium	NA	NA
Cobalt	NA	NA
Copper	1.80E-02	NA
Europium	NA	NA
Gallium	NA	NA
Gold	NA	NA
Hafnium	NA	NA
Indium	NA	NA
Iridium	NA	NA
Iron	6.46E-02	6.25E-02
Lanthanum	NA	NA
Lead	NA	NA
Magnesium	NA	NA
Manganese	5.23E-03	NA
Mercury	NA	NA
Molybdenum	NA	NA
Nickel	2.32E-03	NA
Niobium	NA	NA
Phosphorus	NA	NA
Potassium	5.39E-02	9.63E-02
Rubidium	NA	NA
Samarium	NA	NA
Scandium	NA	NA
Selenium	NA	NA
Silicon	5.71E-02	8.28E-02
Silver	NA	NA
Sodium	1.09E-01	1.51E-01
Strontium	NA	NA
Sulfur	3.52E-01	3.07E-01
Tantalum	NA	NA
Terbium	NA	NA
Tin	NA	NA
Titanium	NA	NA
Tungsten	NA	NA
Vanadium	NA	NA
Yttrium	NA	NA
Zinc	8.06E-03	7.42E-03
Zirconium	NA	NA
Ammonium Ion	4.42E-01	3.81E-01
Sodium Ion	1.88E-01	2.66E-01
Potassium Ion	NA	9.07E-02
Nitrate	0.85	0.73
Sulfate	1.05	0.95
Elemental Carbon	0.76	0.79
Organic Carbon	2.20	2.88
Total Carbonaceous Mass	2.95	3.67
Soil	0.40	0.47
Reconstructed Fine Mass - Urban PM2.5	8.30	9.30

NA = > 50% of levels below detection
In Red = Levels between 25-50% below detection.
Numbers below detection were substituted with 1/2 the MDL.

Pm2.5 BLACK CARBON

Micrograms per Cubic Meter

Sampling Method: Light Absorption by Aethalometer

2008

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Darrington HS, 1085 Fir St, Darrington	340	0.6	0.3	0.5	0.8	0.6	2.5
Marysville JHS, 1605 7th St, Marysville	316		0.7	1.0	1.5	1.1	4.4
17171 Bothell Way NE, Lake Forest Park	263	1.3	0.5	0.6		0.8	4.5
Olive & Boren, Seattle	360	1.5	1.1	1.2	1.7	1.4	4.8
Duwamish, 4752 E Marginal Way S, Seattle	338	2.0	1.2	1.3	2.0	1.6	7.4
7802 South L St, Tacoma	287		0.5	0.6	1.4	0.8	5.0

Notes

(1) Sampling occurs continuously for 24 hours each day.
Quarterly averages are shown only if 75 percent or more of the data is available.

(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum Observed Concentrations

Location	Jan 25 Fri	Oct 1 Wed	Oct 29 Wed	Nov 16 Sun	Nov 24 Mon	Dec 5 Fri
Darrington HS, 1085 Fir St, Darrington			2.5			
Marysville JHS, 1605 7th St, Marysville	--				4.4	
17171 Bothell Way NE, Lake Forest Park	4.5	--	--	--	--	--
Olive & Boren, Seattle						4.8
Duwamish, 4752 E Marginal Way S, Seattle		7.4				
7802 South L St, Tacoma	--			5.0		

-- Indicates no sample on specified day

OZONE
(Parts per Million)
2008

Location / Continuous Sampling Period(s)	2008 Six Highest Daily 8-Hour Concentrations		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2006	2007	2008	2006 - 2008
Beacon Hill, 15th S & Charlestown	.052	29 Jun				
Seattle, Wa	.049	28 Apr				
1 Jan-31 Dec	.048	29 Apr				
	.047	17 May	.028	.046	.047	.040
	.046	18 Apr				
	.046	11 May				
20050 SE 56th	.083	29 Jun				
Lake Sammamish State Park, Wa	.061	28 Jun				
1 May-30 Sep	.054	17 May				
	.054	2 Jul	.070	.058	.054	.060
	.053	12 Jul				
	.053	5 Aug				
42404 SE North Bend Way,	.078	29 Jun				
North Bend, Wa	.065	30 Jun				
1 May-30 Sep	.059	16 Aug				
	.058	15 Aug	.067	.057	.058	.060
	.055	2 Jul				
	.054	17 May				
30525 SE Mud Mountain Road,	.091	29 Jun				
Enumclaw, Wa	.083	16 Aug				
1 May-30 Sep	.078	28 Jun				
	.075	15 Aug	.087	.068	.075	.076
	.068	12 Jul				
	.068	5 Aug				
Charles L Pack Forest	.087	16 Aug				
La Grande, Wa	.079	15 Aug				
17 May-30 Sep	.077	28 Jun				
	.068	29 Jun	.080	.063	.068	.070
	.066	14 Aug				
	.064	12 Jul				
931 Northern Pacific Rd SE,	.066	16 Aug				
Yelm, Wa	.063	28 Jun				
1 May-30 Sep	.062	29 Jun				
	.060	2 Jul	.068	.054	.060	.060
	.060	15 Aug				
	.057	6 Aug				

Notes
(1) All ozone stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations ozone was measured using the continuous ultraviolet photometric detection method.

REACTIVE NITROGEN

(Parts per Million)
2008

Monthly and Annual Arithmetic Averages

Location	Monthly Arithmetic Averages							No of 1 Hour Samples	Year Arith Mean
	Jan	Feb Aug	Mar Sep	Apr Oct	May Nov	Jun Dec	Jul		
Beacon Hill, 15th S & Charlestown, Seattle	.018	.019 .013	.015 .017	.014 .017	.014 .015	.012 .015	.012	8620	.015

Maximum and Second Highest Concentrations

Location / Continuous Sampling Periods(s)	1 Hour Average		
	Value	Date	End Time
Beacon Hill, 15th S & Charlestown, Seattle 1 Jan - 31 Dec	.065 .059	6 Aug 26 Apr	2000 2100

Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) At all stations nitrogen dioxide was measured using the continuous chemiluminescence method

CARBON MONOXIDE

(Parts per Million)
2008

Location / Continuous Sampling Period(s)	Six Highest Concentrations					Number of 8 Hour Averages Exceeding 9 ppm	Number of Days 8 Hour Average Exceeded 9 ppm
	1 Hour Average			8 Hour Average			
	Value	Date	End Time	Value	Date		
2421 148th Ave NE Bellevue 1 Jan-31 Dec	3.7	24 Nov	1900	2.4	25 Jan	0	0
	3.5	25 Jan	1800	2.4	24 Nov		
	3.2	25 Jan	1700	1.9	23 Jan		
	3.1	24 Nov	1800	1.9	26 Feb		
	2.9	24 Nov	1700	1.8	18 Feb		
	2.7	27 Oct	1900	1.8	27 Oct		
Beacon Hill, 15th S and Charlestown Seattle 1 Jan-31 Dec	1.6	5 Dec	2300	1.0	5 Dec	0	0
	1.6	16 Nov	2000	1.0	16 Nov		
	1.5	5 Dec	2200	1.0	6 Dec		
	1.5	16 Nov	1900	0.9	25 Jan		
	1.4	5 Dec	2000	0.9	17 Nov		
	1.4	5 Dec	1800	0.9	1 Oct		

Notes
(1) All carbon monoxide stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations carbon monoxide was measured using the continuous nondispersive infrared method.
method.

SULFUR DIOXIDE
(Parts per Million)
2008

Monthly and Annual Arithmetic Averages

Location	Monthly Arithmetic Averages							No of 1 Hour Samples	Year Arith Mean
	Jan	Feb Aug	Mar Sep	Apr Oct	May Nov	Jun Dec	Jul		
Beacon Hill, 15th S & Charlestown, Seattle	.001	.002 .003	.001 .002	.001 .002	.001 .001	.002 .001	.001	8536	.001

Maximum and Second Highest Concentrations for Various Averaging Periods

Location / Continuous Sampling Periods(s)	1 Hour Average			24 Hour Average	
	Value	Date	End Time	Value	Date
Beacon Hill, 15th S & Charlestown, Seattle 1 Jan-31 Dec	.073 .073	24 Aug 22 Aug	0300 0300	.011 .011	16 Aug 17 Aug

Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) Sulfur dioxide was measured using the continuous ultraviolet fluorescence method.

2008 Beacon Hill Air Toxics Statistical Summary for Air Toxics Gases (units in parts per billion)

	benzene	1,3-butadiene	carbon tet	chloroform	dichloromethane	Perc	trichloroethylene	acrolein	acetaldehyde	formaldehyde
2008 count	61	61	61	61	61	61	61	61	62	62
NDs (reported as 0)	0	2	0	0	0	4	46	1	0	0
Median (ppb)	0.215	0.027	0.135	0.030	0.132	0.016	0.000	0.140	0.3665	0.485
Mean (ppb)	0.244	0.030	0.138	0.030	0.156	0.020	0.003	0.170	0.4505	0.603
95%tile (ppb)	0.466	0.070	0.186	0.040	0.254	0.047	0.018	0.335	1.149	1.549
Max (ppb)	0.592	0.118	0.198	0.053	1.310	0.054	0.023	1.050	1.510	1.690
MDL (ppb)	0.010	0.005	0.004	0.007	0.018	0.006	0.004	0.020	0.013	0.006
# below MDL	0	2	0	0	0	5	46	1	0	0
% below MDL	0%	3%	0%	0%	0%	8%	75%	2%	0%	0%

NDs – nondetects – reported as “0” in dataset.

MDL – minimum detection limit provided by laboratory. Concentrations provided below this value are estimates.

Trichloroethylene is shaded because greater than 75% of its samples were below limits of detection. Statistics are shown, but a graph in the main text is not presented because of the level of uncertainty in quantification.

2008 Beacon Hill Air Toxics Statistical Summary for PM_{10} Metals (units in nanograms per cubic meter)

	Arsenic	Beryllium	Cadmium	Chromium	Cr+6 TSP	Lead	Manganese	Nickel
2008 count	60	60	60	60	61	60	60	60
NDs (reported as	0	13	0	0	10	0	0	0
Median (ng/m3)	0.607	0.001	0.102	2.715	0.027	3.075	7.770	1.415
Mean (ng/m3)	0.6946	0.002	0.124	2.798	0.035	4.066	11.028	2.195
95%tile (ng/m3)	1.596	0.006	0.277	4.295	0.092	9.063	29.720	5.854
Max (ng/m3)	2.310	0.018	0.552	5.470	0.130	31.700	46.600	9.510
MDL (ng/m3)	0.009	0.012	0.008	0.142	0.007	0.107	0.021	0.011
# below MDL	0	59	1	0	13	0	0	0
% below MDL	0%	98%	2%	0%	21%	0%	0%	0%

Beryllium is shaded because greater than 75% of its samples were below limits of detection.

Estimates of Air Toxics Risk

2008 Air Toxics Unit Risk Factors

Potential cancer risk is estimated by multiplying the concentration of a pollutant by its unit risk factor (URF), a constant that takes into account its cancer potency. This is shown in the equation below:

*Potential cancer risk = ambient concentration ($\mu g/m^3$) * unit risk factor (risk/$\mu g/m^3$)*

Unit risk factors are often based on epidemiological studies (studies of diseases occurring in human populations) and are also extrapolated from laboratory animal studies. Unit risk factors are typically based on an assumed 70-year (lifetime) exposure interval, and are available from multiple sources. Two main sources include EPA's Integrated Risk Information System (IRIS) as well as California EPA's Office of Environmental Health and Hazard Assessment (OEHHA). Both of these sources are based on peer-reviewed literature and extensive review.[1,2] We present potential cancer risk estimates based on both IRIS and California EPA values. It should be noted that, if a comprehensive risk assessment were to be performed, it may be preferable to use the most protective unit risk factor in order to be as protective of human health as possible. Available unit risk factors from both IRIS and California EPA are presented in the table below. The cancer rating refers to its "weight of evidence" ranking: A = known carcinogen, B1 = probable carcinogen, based on incomplete human data, B2 = probable carcinogen, based on adequate animal data.[3]

2008 Air Toxics Unit Risk Factors

Air Toxic	IRIS[4] Unit Risk Factor Risk/$\mu g/m^3$	OEHHA[5] URF Risk/$\mu g/m^3$	Cancer Rating[6]
Formaldehyde	1.3E-05	6E-06	B1
Benzene	7.8E-06	2.9E-05	A
Carbon Tetrachloride	1.5E-05	4.2E-05	B2
Chromium (Hexavalent) (M)	1.2E-02	1.5E-01	A
Chloroform	2.3E-05	5.3E-06	B2
Arsenic (M)	4.3E-03	3.3E-03	A

[1]US EPA, Integrated Risk Information System (IRIS); http://cfpub.epa.gov/ncea/iris/index.cfm.
[2]California EPA, Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values, June 25, 2008; http://www.arb.ca.gov/toxics/healthval/healthval.htm.
[3]International Agency for Research on Cancer; http://monographs.iarc.fr/.
[4]Integrated Risk Information System, EPA; http://www.epa.gov/iris/.
[5]California EPA, Consolidated Table of OEHHA/ARB Approved Risk Assessment Values, June 25, 2008; http://www.arb.ca.gov/toxics/healthval/healthval.htm.
[6]Ratings per 1986 EPA guidelines.

Air Toxic	IRIS[4] Unit Risk Factor Risk/μg/m^3	OEHHA[5] URF Risk/μg/m^3	Cancer Rating[6]
1,3-Butadiene	3E-05	1.7E-04	A
Acetaldehyde	2.2E-06	2.7E-06	B2
Nickel (Subsulfide) (M)	4.8E-04	2.6E-04	A
Tetrachloroethylene	not assessed	5.9E-06	B2
Trichloroethylene	not assessed	2E-06	B2
Cadmium (M)	1.8E-03	4.2E-03	B1
Lead (M)	not assessed	1.2E-05	B2
Beryllium (M)	2.4E-03	2.4E-03	B1
Dichloromethane	4.7E-07	1E-06	B2
Vinyl Chloride	8.8E-6	7.8E-05	A

2008 Beacon Hill Potential Cancer Risk Estimates per 1,000,000 – 95th Percentile
Percentage of samples greater than cancer screen value

AIR TOXIC	**RISK BASED ON 95TH PERCENTILE CONCENTRATIONS IRIS**	**RISK BASED ON 95TH PERCENTILE CONCENTRATIONS OEHHA**	**RANGE**	**% OF SAMPLES> IRIS SCREEN**	**% OF SAMPLES> OEHHA SCREEN**
Benzene	12	43	12-43	100%	100%
1,3-Butadiene	5	27	5-27	84%	97%
Carbon Tetrachloride	18	51	18-51	100%	100%
Formaldehyde	25	11	11-25	100%	100%
Chromium 6 (M)	1	14	1-14	2%	79%
Arsenic (M)	7	5	5-7	93%	83%
Chloroform	4	1	1-4	100%	16%
Acetaldehyde	5	6	5-6	76%	81%
Nickel (M)	3	2	2-3	38%	18%
Tetrachloroethylene	NA	2	2	NA	30%
Trichloroethylene	NA	<1	<1	NA	0%
Cadmium (M)	<1	1	<1	0%	15%
Lead (M)	NA	<1	<1	NA	0%
Beryllium (M)	<1	<1	<1	0%	0%
Dichloromethane	<1	1	<1	0%	3%

Shaded air toxics have >75% of samples with estimated concentrations (values below the reported laboratory detection limit).Screening value used is concentration equivalent to an estimated 1 in a million potential cancer risk.

Non-cancer Reference Concentrations (RfC) and Hazard Indices

Air toxic	Non Cancer RfC (ug/m3)	Mean Hazard Index
Benzene	60	0.013
1,3-butadiene	20	0.003
Carbon tetrachloride	40	0.022
Chloroform	300	0.0005
Dichloromethane	400	0.001
Tetrachloroethylene	35	0.004
Trichloroethylene	600	0.0001
Acrolein*	0.35	1.124
Acetaldehyde*	140	0.006
Formaldehyde*	9	0.082
Arsenic*	0.015	0.046
Beryllium	0.007	0.000
Cadmium	0.02	0.006
Manganese*	0.09	0.123
Nickel	0.05	0.044
CR+6 TSP	0.2	0.0002

Reference concentrations are based on chronic values from California Air Resources Board (OEHHA)

Mean hazard index is based on HQ=1, HI = mean concentration/reference concentration

Acrolein is only air toxic that fails screen with hazard index greater than 1.

* denotes a change in reference concentration from 2007 air quality data summary (OEHHA updated reference concentrations in February 2009, before publication of this report[7])

[7] California Air Resources Board. February 2009 Changes to the Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values. http://www.arb.ca.gov/toxics/healthval/changes.pdf.