

2010

Air Quality Data Summary

April 2012

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The 2010 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 6 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 (particles 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 broadly defined by Washington State and the Agency to include hundreds of chemicals and compounds that are associated with a broad range of adverse health effects, including cancer.¹ Many air toxics are a component of either particulate matter or volatile organic compounds (a precursor to ozone). Therefore, both particulate matter and gaseous air toxics data are used.

The Agency and the Washington State Department of Ecology (Ecology) work together to monitor air quality within the Puget Sound region.² The Agency's jurisdiction includes King, Snohomish, Pierce, and Kitsap counties. Real-time air monitoring data are available for some pollutants on the Internet at <http://www.pscleanair.org/airq/aqi.aspx>. To find more extensive air quality data, educational materials, and discussions of current topics, visit the Agency's website at <http://www.pscleanair.org/default.aspx>. 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 Newslines, 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 Action Network. Subscribers receive the latest on air quality news and updates on projects that affect local communities in the Puget Sound region. Other e-mail lists offered at the same web site provide 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 Monitoring Program via e-mail to Mary Hoffman at maryh@pscleanair.org or at 206-689-4006.

¹Washington Administrative Code 173-460. See Table of Toxic Air Pollutants, WAC 173-425-150.
<http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150>

²The Agency's jurisdiction covers King, Kitsap, Pierce, and Snohomish Counties in Washington State.

EXECUTIVE SUMMARY

The Agency and Ecology continued to monitor the region's air quality in 2010. Over the last two decades, many pollutant levels have declined, and air quality has generally improved.

While air quality is improving, we face new challenges. The Environmental Protection Agency (EPA) is required to review and revise national ambient air quality standards to protect public health. EPA substantially strengthened the standards for both fine particles and ozone in 2006 and 2008 reviews.

Elevated fine particle levels are the most important air quality challenge in our jurisdiction. In 2009, EPA designated much of Tacoma and surrounding Pierce County areas as nonattainment for fine particles. Fine particle concentrations at the South L Street Tacoma monitoring site, located in the South End of Tacoma, continued to violate EPA's daily PM_{2.5} standard in 2010. The Agency is collaborating with partners to reduce fine particle pollution in Tacoma and Pierce County. Further, fine particle concentrations at monitoring sites in Snohomish County were close to EPA's daily PM_{2.5} standard. 2010 data indicated that Snohomish county areas were in attainment, but since the pollution levels were so close to the standard, Snohomish County could slip into non-attainment in the future. Finally, sites in all four counties (King, Kitsap, Pierce, and Snohomish) continued to exceed the Agency's more stringent local PM_{2.5} health goal.

Ozone levels remained a concern in our region. Over the last decade, ozone concentrations have not decreased as significantly as other pollutants. EPA strengthened its 8-hour ozone standard in March 2008. The 2010 ozone levels shown in this report met EPA's 2008 standard, but future levels may not meet the standard if EPA further strengthens it.

Air toxics were present in our air at levels that posed adverse health effects.^{3,4} These health effects include, but are not limited to, increased cancer risk and respiratory effects. The Agency collaborated with the University of Washington and the Department of Ecology to complete an extensive monitoring and analysis effort to better understand health risks of toxic air pollutants in Tacoma, and to better understand methods of source apportionment using both particulate matter and gaseous air toxics sampling. The results of these studies are found in two key EPA reports:

http://www.epa.gov/ttnamti1/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf

http://www.epa.gov/ttnamti1/files/20072008csatam/PSCAA_Methods_FR.pdf

Many of the same emission sources that produce criteria and toxic air pollutants also generate greenhouse gases. The Agency collaborates with public and private partners to reduce greenhouse gases.⁵ Unlike the criteria pollutants and air toxics included in this summary, we do not monitor greenhouse gas levels in the ambient air. For more information, see <http://www.pscleanair.org/programs/climate/default.aspx>.

³Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

⁴Tacoma and Seattle Air Toxics Evaluation, 2010; http://www.pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf.

⁵Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound; <http://www.pscleanair.org/programs/climate/rptfin.pdf>.

The Agency is taking action with many partners to face these air quality challenges. 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 EPA for the criteria pollutants. The AQI is used to report daily air quality. “Good” AQI days continued to dominate our air quality in 2010. However, air quality degraded into “moderate” approximately one tenth of the time and to “unhealthy for sensitive groups” for brief periods.

Table 1 shows the AQI breakdown by percentage in each category for 2010. King County registered the highest daily AQI value of 104 on August 17, which was ozone. PM_{2.5} normally determines the AQI in the Puget Sound area on days considered unhealthy for sensitive groups.

Table 1: AQI Ratings for 2010

County	AQI Rating (% of year)				Highest AQI
	Unhealthy for				
	Good	Moderate	Sensitive Groups	Unhealthy	
Snohomish	88.8%	11.2%	0.0%	0.0%	98
King	87.7%	12.1%	0.3%	0.0%	104
Pierce	88.8%	11.2%	0.0%	0.0%	83
Kitsap	91.2%	8.8%	0.0%	0.0%	88

IMPAIRED AIR QUALITY – BURN BANS

The Agency issues temporary bans on indoor and outdoor burning when air inversions trap, close to ground level, fine particle pollution emitted from our chimneys, cars, trucks, and other activities. 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 two burn bans in 2010. The dates were Jan 28–31, and Dec 30–Jan 4, 2011.

CRITERIA AIR POLLUTANTS AND VISIBILITY

The Agency jurisdiction is currently in attainment for carbon monoxide, ozone, and PM₁₀, and has maintenance plans in place for these pollutants. EPA has announced the development and release of a more stringent nitrogen dioxide federal standard. EPA is developing the monitoring rules associated with these standards. The Agency is developing monitoring plans with Ecology to prepare for the monitoring that will be required to investigate compliance with the new standard.

EPA designated the Tacoma South L Street monitor and surrounding area as nonattainment for fine particles in December 2009. Concentrations continued to violate the daily standard in 2010. Levels at the Marysville and Darrington monitors, both in Snohomish County, remained close to the daily standard in 2010. Concentrations at monitors in all four counties continued to exceed our more stringent, local health goal.

The Enumclaw Mud Mountain 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

Ecology began monitoring air toxics at the Seattle Beacon Hill site in 2000, as part of EPA's National Air Toxics Trends Stations network.

Carbon tetrachloride, a chemically persistent air toxic banned in 1995, presented the highest potential cancer risk from air toxics monitored in 2010 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 and 2010 evaluation showed that diesel particulate matter presents the majority of potential air toxics cancer health risk in our area.^{6,7}

Unfortunately, there is no direct monitoring method to measure diesel particulate matter.

⁶Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

⁷Tacoma and Seattle Area Air Toxics Evaluation, 2010; http://www.pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf.

AIR QUALITY INDEX

The air quality index (AQI) is reported according to a 500-point scale for five of the six criteria air pollutants: ozone, particulate matter (both PM_{2.5} and PM₁₀), carbon monoxide, nitrogen dioxide, and sulfur dioxide. The highest pollutant determines the daily ranking. For example, if an area has a carbon monoxide index 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. Pollution concentration breakpoints are shown in Table 5.

- **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.

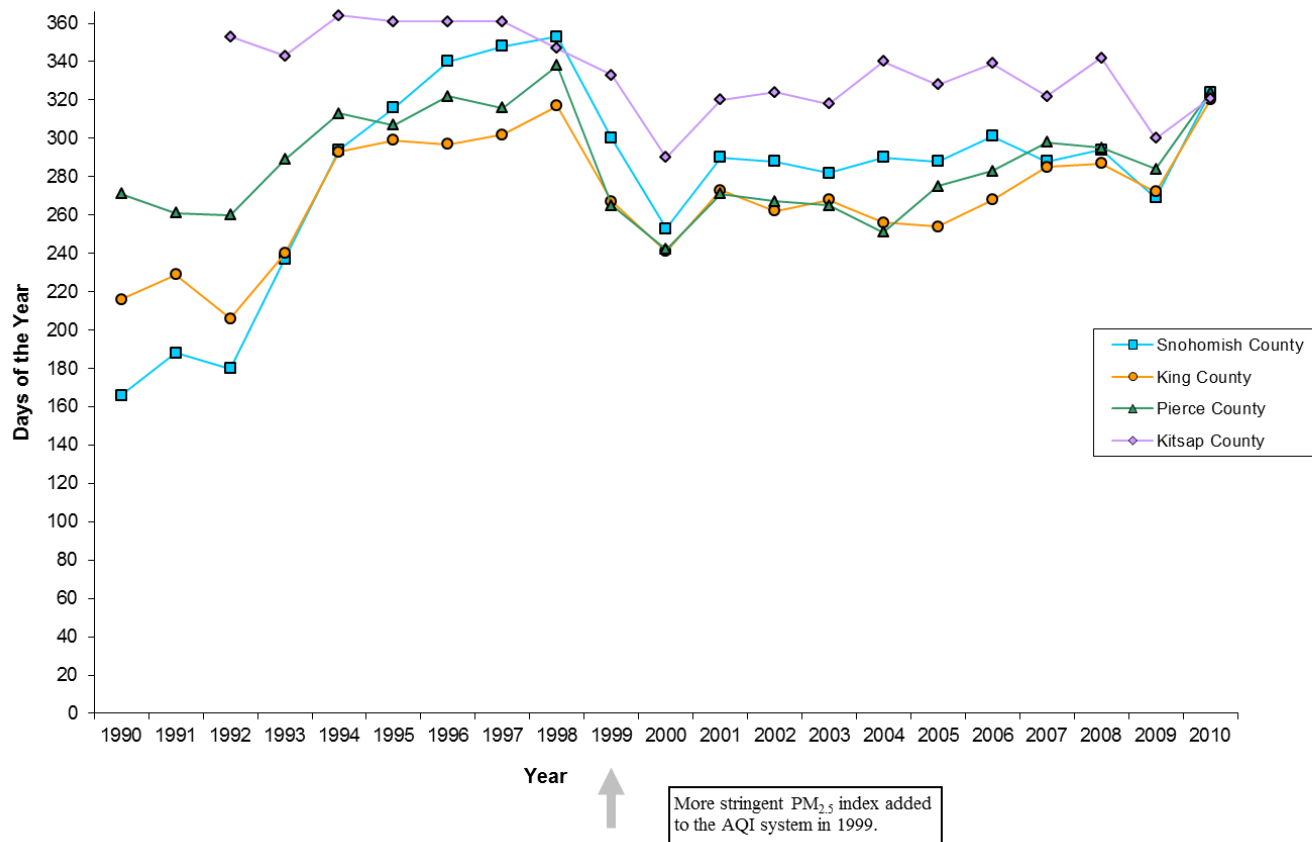
The AQI is a national index, so the reported values and colors used to show local air quality and the associated level of health concern will be the same throughout the United States. Current and archived AQI values for Puget Sound can be found on our website at www.pscleanair.org.

“Good” air quality days continue 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 revised ozone standard. Although EPA changed the PM_{2.5} standard in 2006, EPA has not yet revised the AQI breakpoints to reflect the revised PM_{2.5} daily standard. On January 15, 2010, EPA proposed to change the AQI to be reflective of the levels of the federal standard (that is, the “unhealthy for sensitive groups” category will start at 35.4 $\mu\text{g}/\text{m}^3$, instead of the current 40.4 $\mu\text{g}/\text{m}^3$). As a result, we amended the AQI to reflect the proposed change.

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. The number of “good” days now cannot be directly compared with the number 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 1990 to 2010.

Figure 2: Air Quality for King County

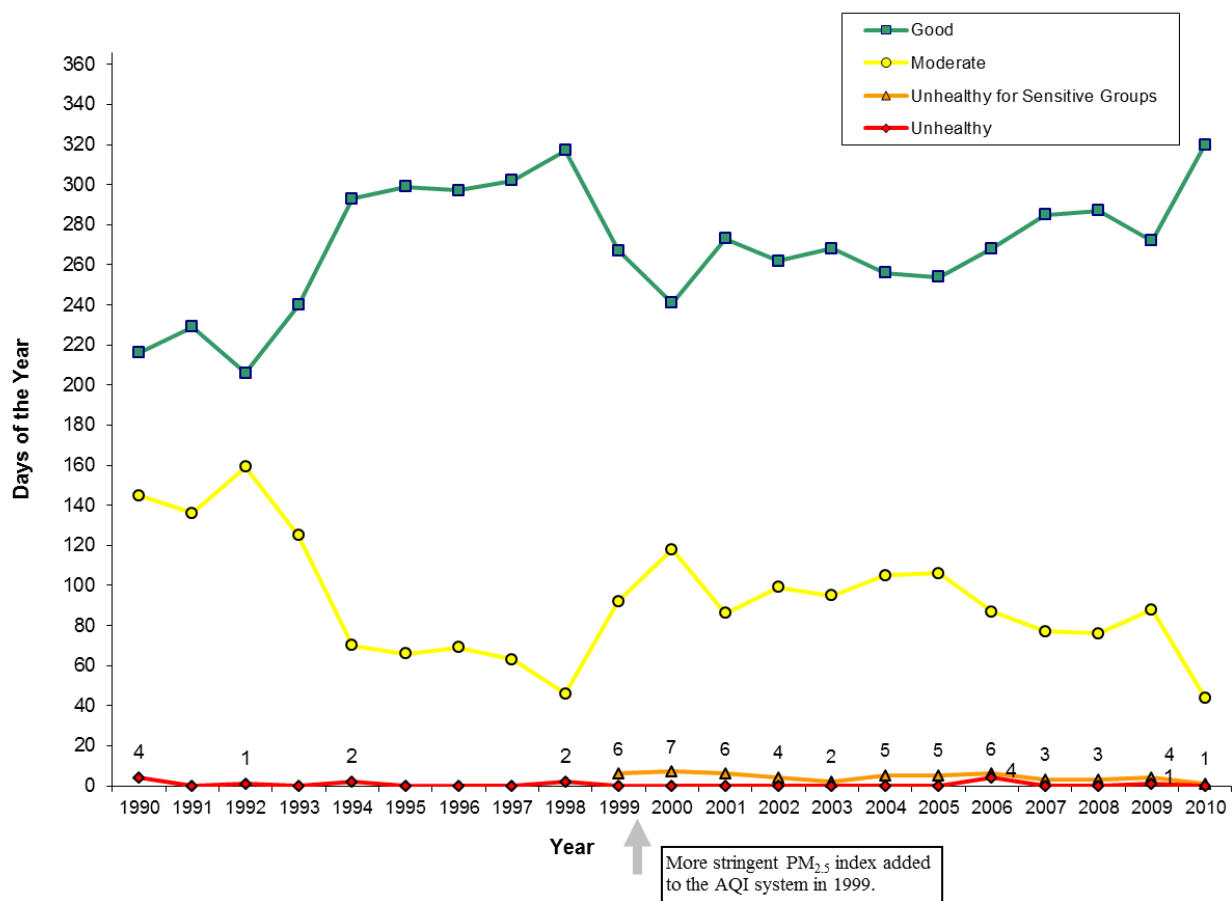


Figure 3: Air Quality for Kitsap County

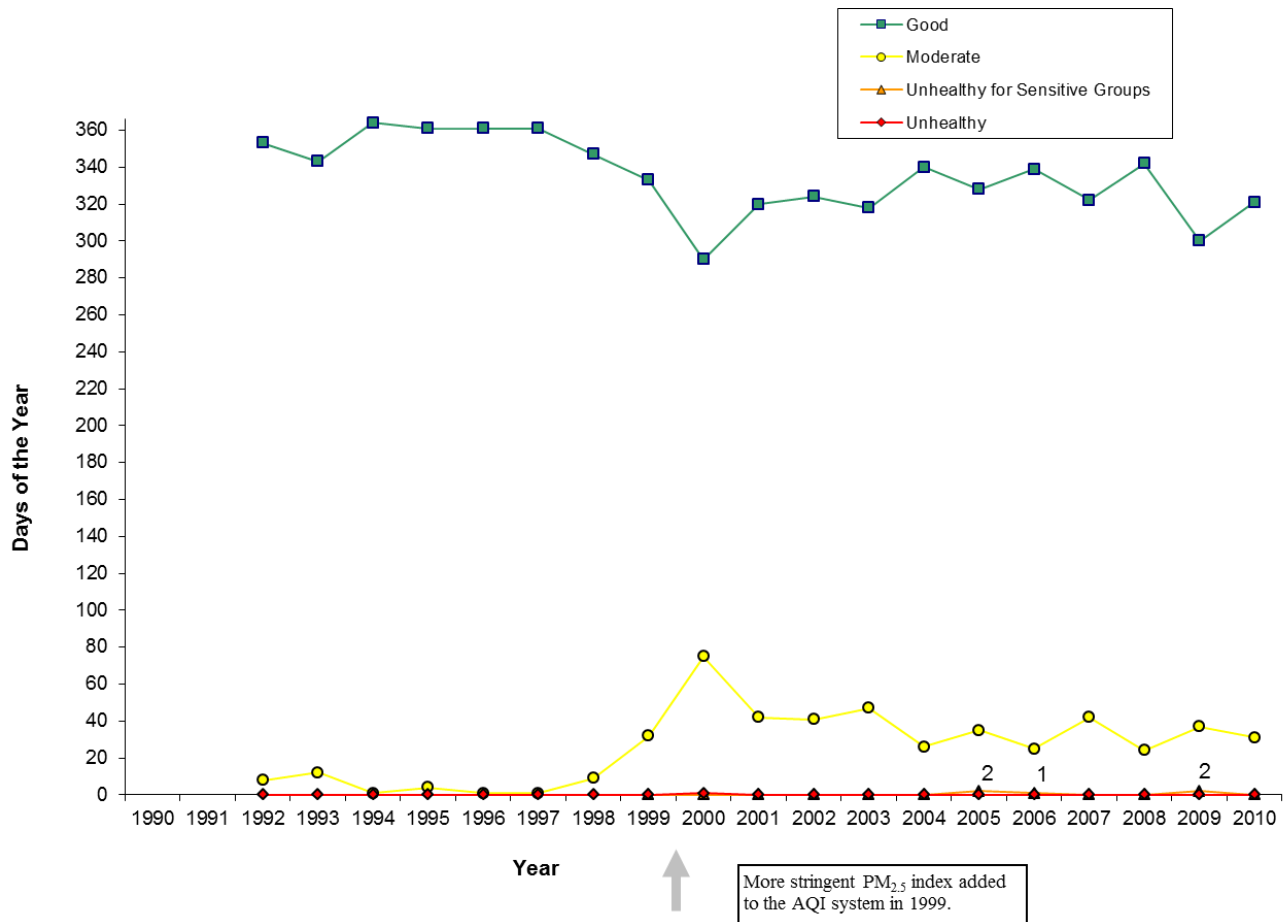


Figure 4: Air Quality for Pierce County

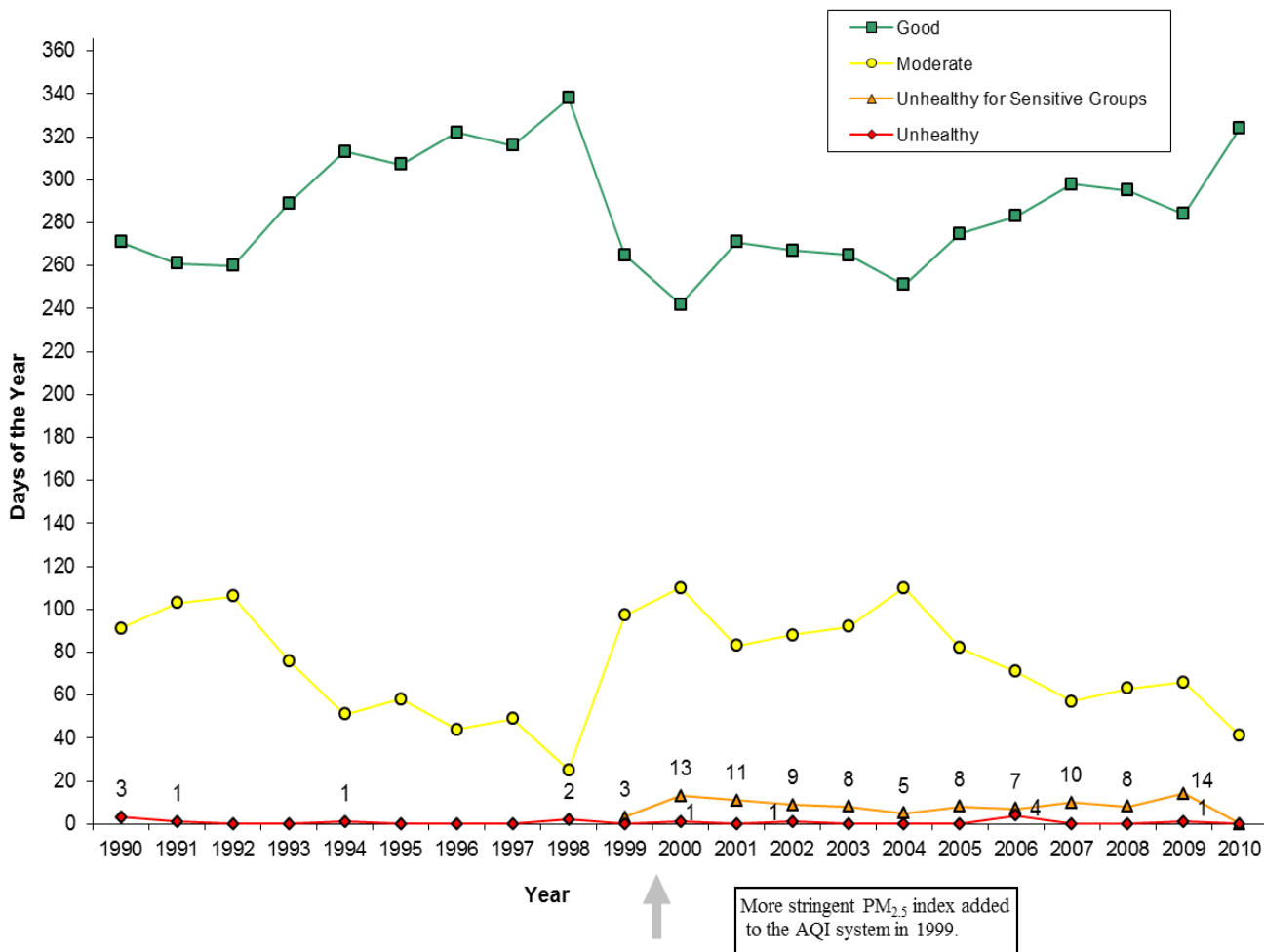
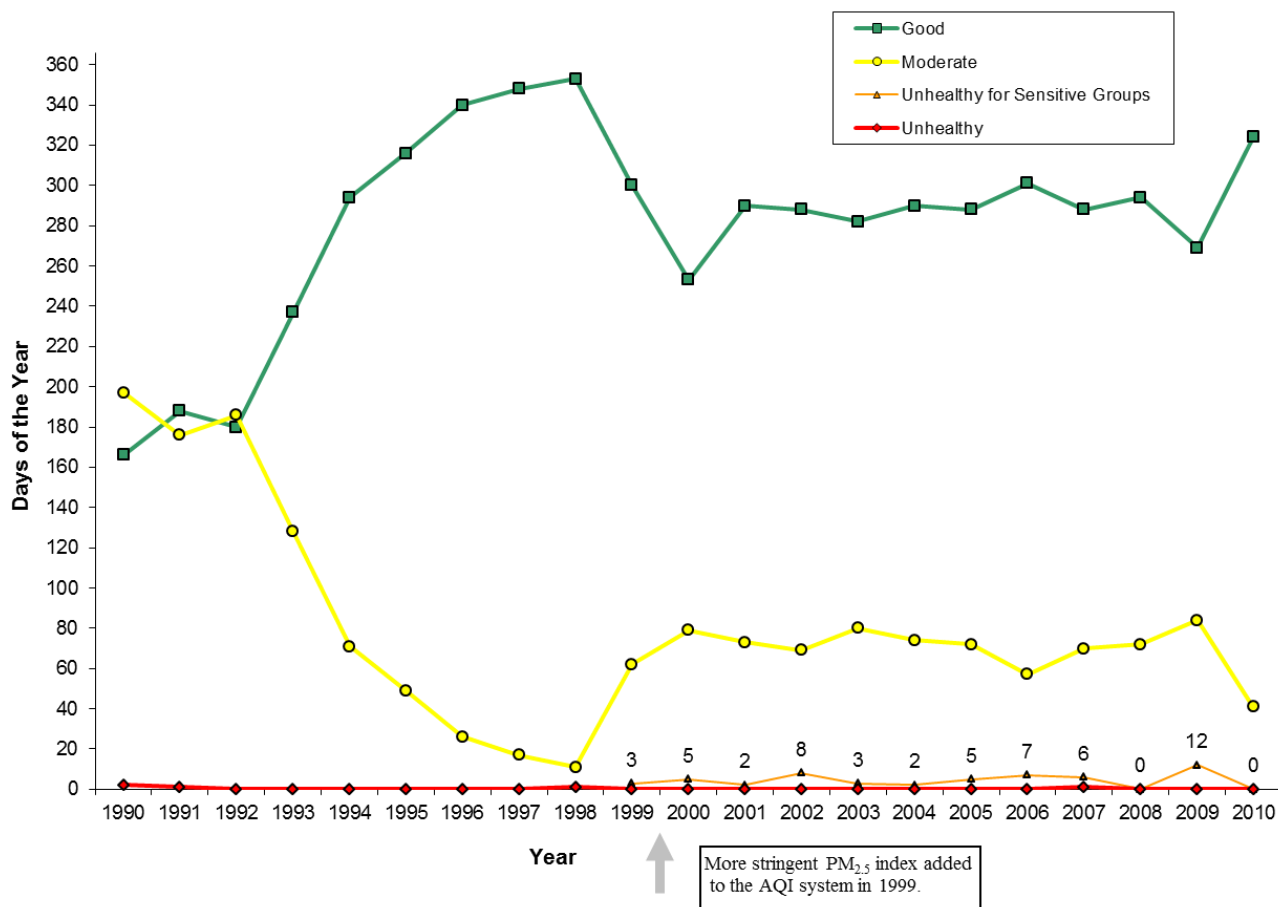


Figure 5: Air Quality for Snohomish County



MONITORING NETWORK

The Agency and Ecology operate the Puget Sound region's monitoring network, comprised of both meteorological and pollutant-specific equipment. Data from the network are normally collected automatically via the Ecology data network, or in some cases, collected manually by field staff.

The Agency conducted monitoring as early as 1965. Table 2 presents a summary of the monitoring stations and parameters monitored from 1999 through 2010. Some parameters were monitored for only part of this period. Shaded stations in the table operated in 2010. Similarly, a filled circle denotes a pollutant that was monitored in 2010. An “x” denotes a pollutant that was no longer monitored in 2010. The network changes because the Agency and Ecology regularly re-evaluate monitoring resources to measure and report on the pollutants that are most relevant to public health. Access or logistics issues can 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 17 shows monitoring stations that were active in 2010.

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 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 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 methods, the Agency measures particulate matter using continuous 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 is shown 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. EPA considers the federal reference method (FRM) to be the most accurate way to

determine PM_{2.5} concentrations. The FRM does not provide continuous or rapid turnaround information. The EPA has determined that PM_{2.5} can also be measured with a continuous device that is considered a Federal Equivalent Method (FEM).

The Agency uses the FRM, the FEM, and another continuous method to provide more time-relevant data. These methods determine fine particulate matter concentration differently:

- The FRM 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.
- The tapered element oscillating microbalance (TEOM-FDMS) method measures mass and uses a filter dynamic measurement system to eliminate moisture measurements from the sample, allowing the mass to be converted. This is a Federal Equivalent Method (FEM) for PM_{2.5}.
- The nephelometer uses scattering of light.

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”. The method provides our best estimate for continuous PM_{2.5} values using nephelometers. In 2010, the standard TEOM continuous devices were all retired, and no longer used. In their place, the Agency installed a converted TEOM-FDMS device. The TEOM-FDMS device was tested by EPA, and achieved the FEM standards. The Agency and Ecology worked together to evaluate the technology as compared to the reference method, and started reporting the data to EPA as full equivalent method data starting at the beginning of 2011.

The Agency also uses instruments to measure organic components of fine particulate matter, called aethalometers. These instruments measure light absorption, and a standard algorithm provides results in PM_{2.5} mass of Black Carbon.

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 Mar 31, 2003)												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 4 th 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							●	●					●	●	●		●	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)							X						X	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 133 rd 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
CZ	Aquatic Center, 601 143 rd Ave NE, Bellevue (ended May 31, 2006)						X	X						X				X	b, f
DA	South Park, 8025 10 th Ave S, Seattle (ended Dec 31, 2002)	X			X			X						X	X			X	b, e, 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
DB	17171 Bothell Way NE, Lake Forest Park	X	X		●		●	●	●					●	●	●		●	b, d, f
DC●	305 Bellevue Way NE, Bellevue				X			●						●				●	a, d
DD	South Park, 8201 10 th Ave S, Seattle							●						●				●	b, e, f
DE●	City Hall, 15670 NE 85 th 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 148 th Ave NE, Bellevue												●						b, d
DK●	43407 212 th 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 56 th , 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 11 th 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 SPECIATION SITE	X	X	X	X		X	●			X			●	●	●		●	a, e
ER	South Hill, 9616 128 th St E, Puyallup	X	X		X	X		●						●	●	●		●	b, f
ES	7802 South L St, Tacoma SPECIATION SITE				●		●	●	●					●	●	●		●	b, f
FF●	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma														●	●			b, f
FG●	Mt Rainier National Park, Jackson Visitor Center									●									c

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
FH⊙	Charles L Pack Forest, La Grande									●									c, f
FL⊙	1101 Pacific Ave, Tacoma (ended Jun 30, 2006)												X						a, d
ID	Hoyt Ave & 26th St, Everett (ended Feb 29, 2000)										x				X				a, e, d
IG	Marysville JHS, 1605 7 th St, Marysville SPECIATION SITE	X	X		●		●	●	●					●	●	●		●	b, d
IH	20935 59 th Place West, Lynnwood (ended Jun 8, 1999)	X		X										X	X			X	a, d
II	6120 212 th St SW, Lynnwood				X	X	●	●						●	●	●		●	b, d
JN⊙	5810 196 th 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 & 196 th 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
QG	Fire Station #51, 10955 Silverdale Way, Silverdale (ended September 4, 2008)					X		X						X	X	X		X	a, d
RV⊙	Yelm N Pacific Road, 931 Northern Pacific Rd SE, Yelm									●									c, f
UB⊙	71 E Campus Dr, Belfair (ended Sep 30, 2004)									X									c
VK⊙	Fire Station, 709 Mill Road SE, Yelm (ended Oct 2005)									X									c, f

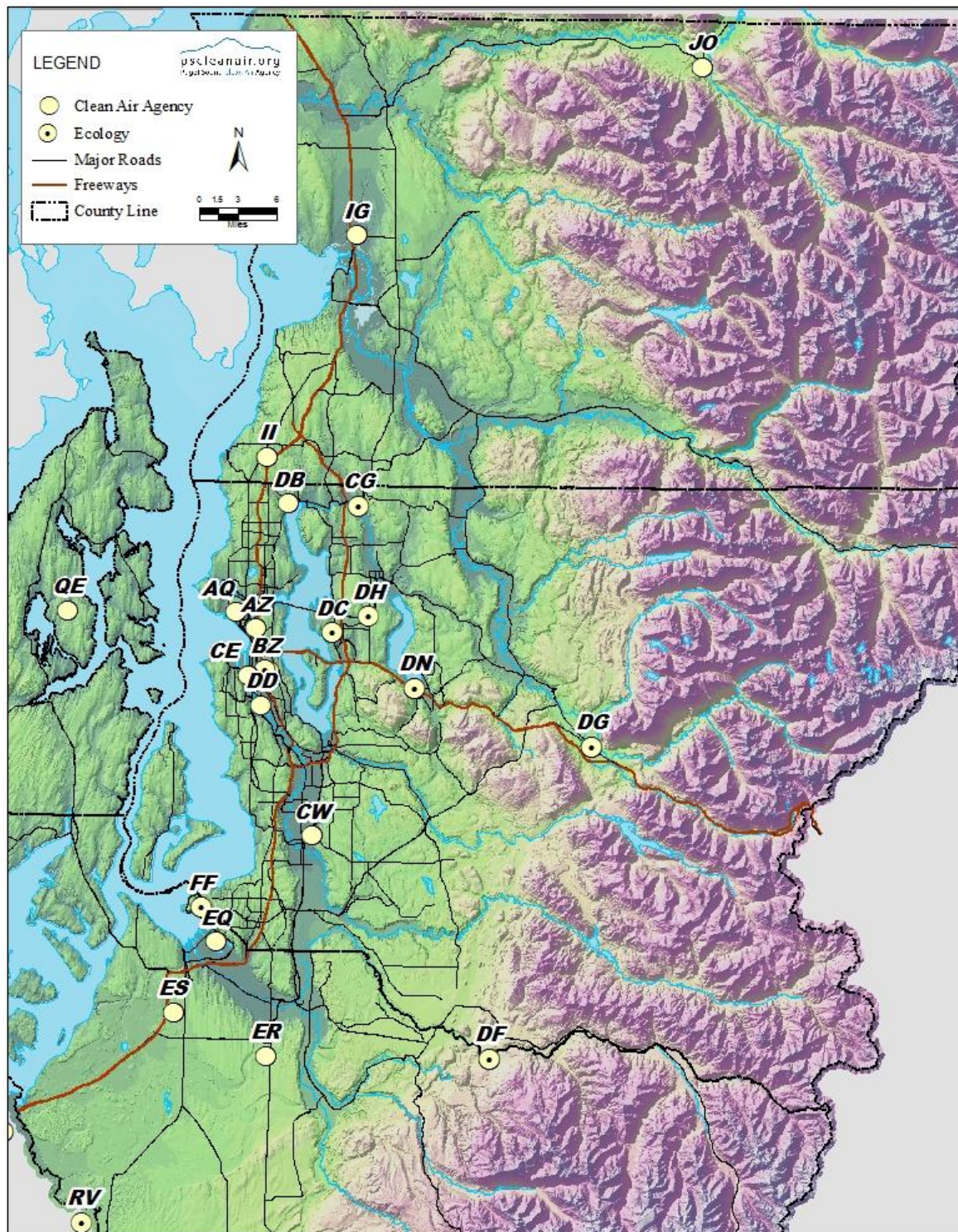
⊙ Station operated by Ecology

SO₂

Sulfur Dioxide

RV	Shading indicates station functioning	NO_x	Nitrogen Oxide
●	Indicates parameter currently monitored	CO	Carbon Monoxide
X	Indicates parameter previously monitored	b_{sp}	Light scattering by atmospheric particles
PM₁₀ ref	Particulate matter <10 micrometers (reference)	Wind	Wind direction and speed
PM₁₀ bam	Particulate matter <10 micrometers (beta attenuation continuous)	Temp	Air temperature (relative humidity also measured at BW)
PM₁₀ teom	Particulate matter <10 micrometers (teom continuous)	AT	Air Toxics
PM_{2.5} ref	Particulate matter <2.5 micrometers (reference)	VSBY	Visual range (light scattering by atmospheric
PM_{2.5} bam	Particulate matter <2.5 micrometers (beta attenuation continuous)	PHOTO	Visibility (camera)
PM_{2.5} teom	Particulate matter <2.5 micrometers (teom-fdms continuous)	O₃	Ozone (May through September)
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)		
Location			
a	Urban Center		
b	Suburban		
c	Rural		
d	Commercial		
e	Industrial		
f	Residential		

Map 1: Active Air Monitoring Network for 2010



Two Ozone sites (FG & FH) located in Mount Rainier National Park are not shown on this map.

IMPAIRED AIR QUALITY – BURN BANS AND SMOG ALERTS

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 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. The compliance department enforces burn bans.

There are two stages of the indoor burn bans. For a Stage 1 burn ban, residential burning in fireplaces and uncertified wood stoves is prohibited (unless a wood-burning device is the only adequate source of heat).⁸ For a Stage 2 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 Stage 1 burn ban could be declared by the Agency when $PM_{2.5}$ levels reached $35 \mu g/m^3$ (24-hour average). A Stage 2 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 federal $PM_{2.5}$ standard. Under the revised statute, a Stage 1 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 Stage 2 burn ban is triggered when the following three things have happened:

- 1) A Stage 1 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.

The Agency communicates with the public, news media, meteorologists, and local agencies during burn bans to spread the word.

The Agency called two burn bans in 2010. The dates (and counties-highest stage reached) were: Jan 28–31 (Snohomish-1, Kitsap-2), and Dec 30–Jan 1 (2011) (Pierce-1, Snohomish-1). The second burn ban was elevated to Stage 2, and added counties on Jan 1, 2011.

Monitoring data from the first burn ban is shown in Figure 6. The 24-hour average $PM_{2.5}$ concentrations from two Snohomish county sites and from one Kitsap site are plotted along with the Air Quality Index (AQI) category and the federal daily standard ($35 \mu g/m^3$). The 24-hour average values are a running mean of the previous 12 and future 12 hourly values.

⁸Uncertified 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} at Three Monitoring Sites during the Jan 28-31, 2010 Burn Ban

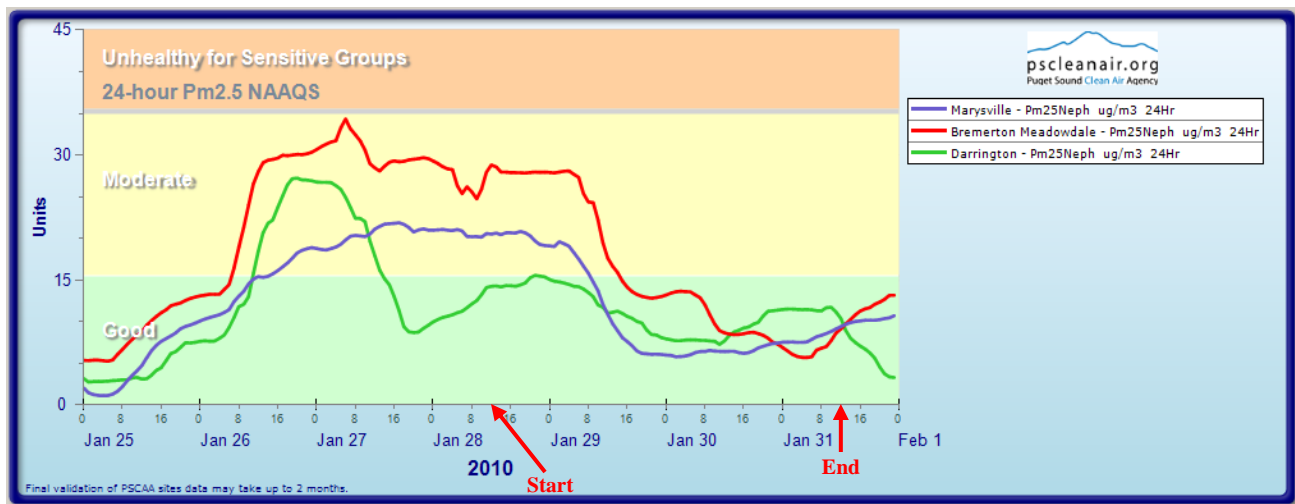
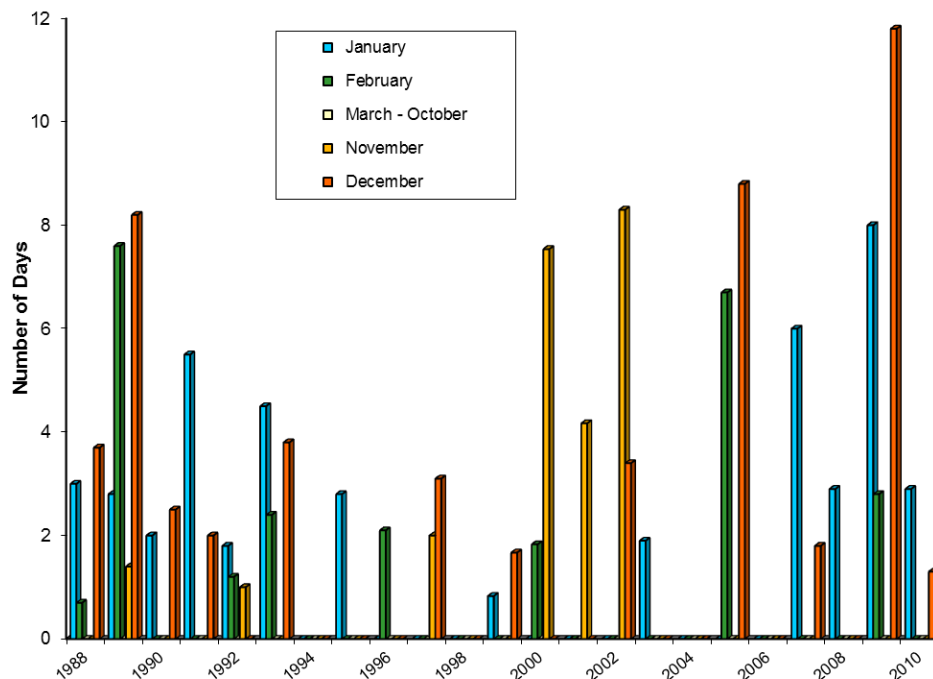


Figure 7: Number of Days with Indoor Burning Bans in the Puget Sound Region



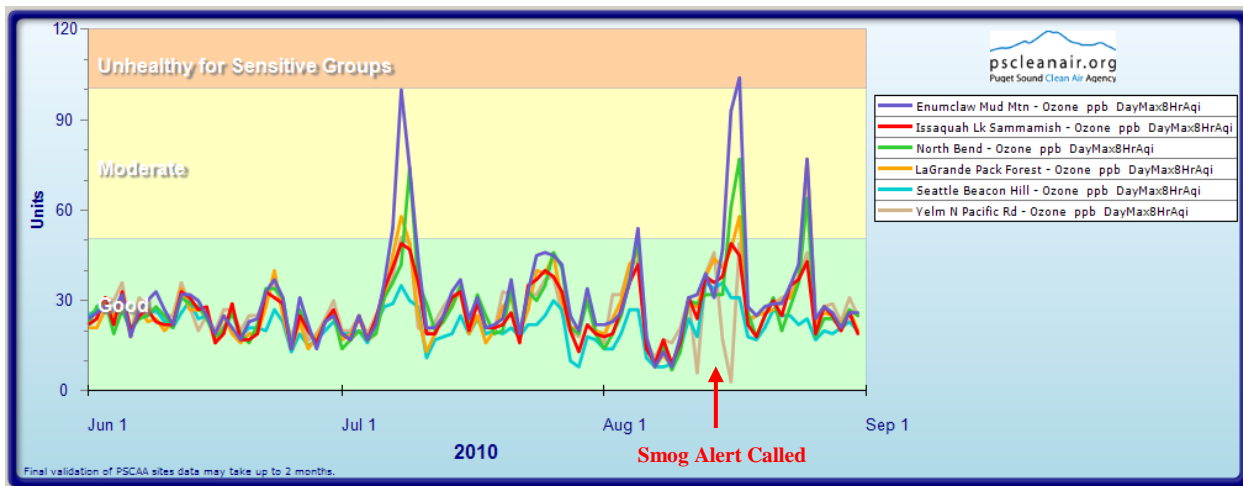
SMOG FORECASTS

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 issued a smog alert on August 13, 2010 for the days ahead. The 8-hour ozone daily maximum air quality index from June through August is shown in Figure 8. The stations plotted include Enumclaw, Beacon Hill, Lake Sammamish, Pack Forest, North Bend, and Yelm. 8-hour ozone concentrations are shown on page A-12 of the Appendix.

Figure 8: Smog Forecast Event



AIR QUALITY STANDARDS AND HEALTH GOALS

National Ambient Air Quality Standards (NAAQS)

The [Clean Air Act](#), which was last amended in 1990, requires EPA to set [National Ambient Air Quality Standards](#) (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. **Primary standards** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. **Secondary standards** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

EPA has set National Ambient Air Quality Standards for six principal pollutants, called "criteria" pollutants (listed below). Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$).

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. 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>.⁹ The air quality standards that apply to the Puget Sound air shed are summarized in Table 3.

In addition to air quality standards, the Agency has developed an air quality health goal for daily $\text{PM}_{2.5}$ concentrations. The Agency convened a Particulate Matter Health Committee, comprised of local health professionals, who examined the fine particulate health research.¹⁰ 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 $25\mu\text{g}/\text{m}^3$ for a daily average, more protective than the current federal standard of $35\mu\text{g}/\text{m}^3$. 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.^{11,12} 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 $\text{PM}_{2.5}$ average.

⁹Washington Administrative Code chapters 173-470, 173-474, and 173-475.

¹⁰Puget Sound Clean Air Agency. Final Report of the Puget Sound Clean Air Agency $\text{PM}_{2.5}$ Stakeholder Group; http://www.pscleanair.org/news/library/reports/pm2_5_report.pdf.

¹¹American Lung Association; <http://www.lungusa.org/assets/documents/publications/state-of-the-air/state-of-the-air-report-2006.pdf>.

¹²EPA Clean Air Science Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; <http://www.epa.gov/sab/panels/casacpmpanel.html>.

Table 3: Puget Sound Region Air Quality Standards for Criteria Pollutants for 2010

Pollutant [final rule cite]	Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]	primary	8-hour 1-hour	9 ppm 35 ppm	Not to be exceeded more than once per year
Lead [73 FR 66964, Nov 12, 2008]	primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽¹⁾	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]	primary	1-hour	100 ppb	98th percentile, averaged over 3 years
	primary and secondary	Annual	53 ppb ⁽²⁾	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]	primary and secondary	8-hour	0.075 ppm ⁽³⁾	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution [71 FR 61144, Oct 17, 2006]	PM _{2.5}	Annual	15 µg/m ³	annual mean, averaged over 3 years
		24-hour	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	24-hour	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]	primary	1-hour	75 ppb ⁽⁴⁾	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

as of October 2011

(1) Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m³ as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

(2) The official level of the annual NO₂ standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

(3) Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

(4) Final rule signed June 2, 2010. The 1971 annual and 24-hour SO₂ standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

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.¹³ The Agency ceased all PM_{10} monitoring in 2006 and 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, 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.^{14,15,16,17} Children, older adults, and people with some illnesses are more sensitive and more likely to develop heart or lung problems associated with $PM_{2.5}$.^{18,19} 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 strengthened the $PM_{2.5}$ NAAQS.²⁰ EPA designated the Tacoma/Pierce County fine particle nonattainment area on December 14, 2009. The South L Tacoma monitor located at the south end of Tacoma, in Pierce County continued to violate the standard based on 2008, 2009, and 2010 data. Ecology and our Agency are working together to bring the area back into attainment.

¹³U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; <http://www.epa.gov/particles/actions.html>.

¹⁴Pope 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.

¹⁵Gauderman 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.

¹⁶Kunzli 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>.

¹⁷U.S. Environmental Protection Agency. 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.

¹⁸Park 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>.

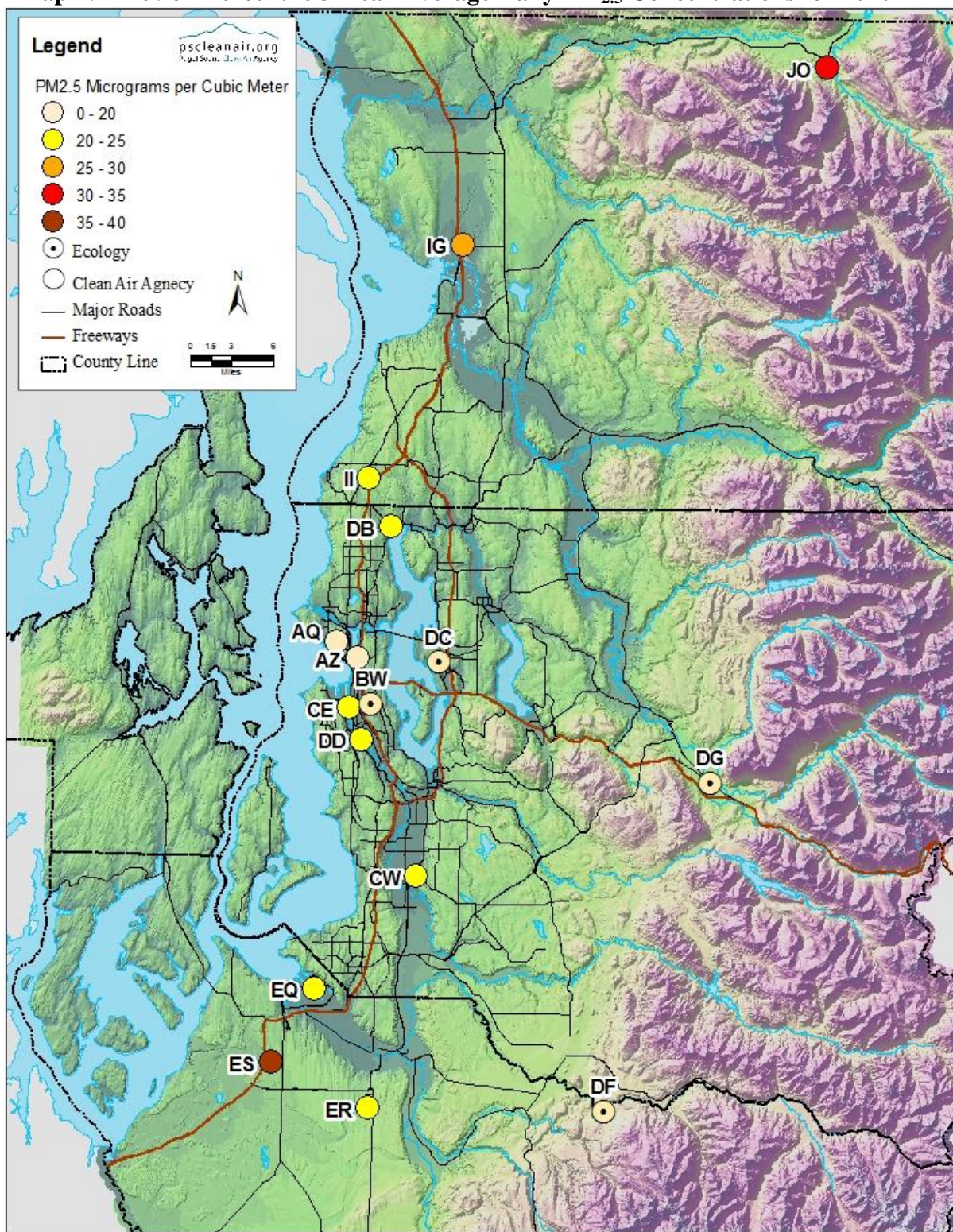
¹⁹Goss et al. Effect of Ambient Air Pollution on Pulmonary Exacerbations and Lung Function in Cystic Fibrosis. *American Journal of Respiratory Critical Care Medicine*. Volume 169: pp 816-821. January 12, 2004.

²⁰U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; <http://www.epa.gov/particles/actions.html>.

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 $25 \mu\text{g}/\text{m}^3$ during the winter season.

Map 2 shows the 98th percentile of the 3-year average of daily $\text{PM}_{2.5}$ concentrations. The map includes only those monitoring sites with three years of complete data from 2008 to 2010.

Map 2: The 98th Percentile 3-Year Average Daily PM_{2.5} Concentrations for 2010*



* 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 2010 is the average of the 98th percentile daily concentration for 2008, 2009, and 2010. Concentrations for King, Pierce, and Snohomish Counties were measured using the FRM, except where noted.²¹ Concentrations for Kitsap County were measured using continuous methods.²²

Figure 10 does not include 2010 data for Kitsap County. The monitoring at the Silverdale site was discontinued, and the Bremerton site had equipment problems for portion of 2008, resulting in an incomplete dataset. Kitsap County data shows that PM_{2.5} levels are below the federal standard.

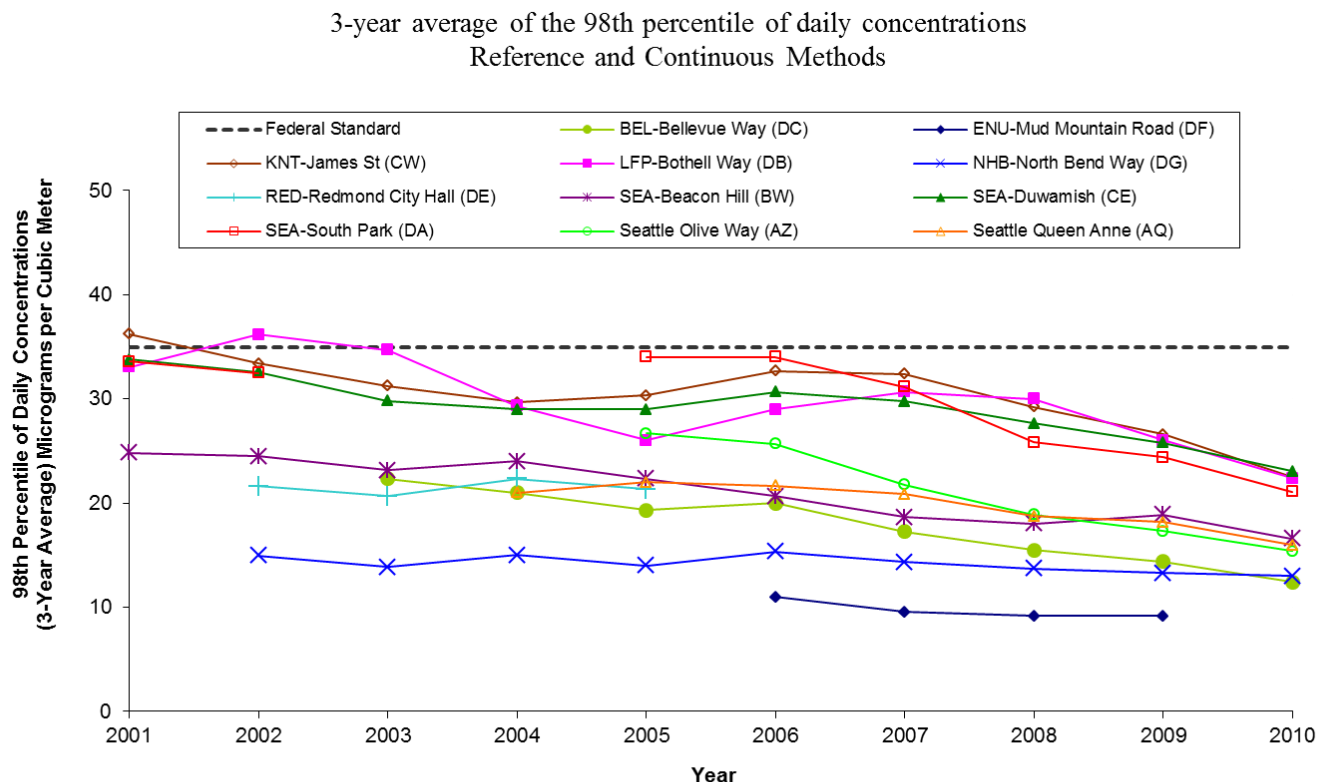
Figure 11 shows that the Tacoma South L Site, located in the Tacoma South End neighborhood, continues to violate the federal standard of 35 $\mu\text{g}/\text{m}^3$. Concentrations at the Darrington and Marysville monitors in Snohomish County, and the Tacoma Tideflats monitor in Pierce County and are the next highest range of concentrations at 29 and 30 $\mu\text{g}/\text{m}^3$.

Statistical summaries for 98th percentile daily concentrations for 2010 data are provided on page A-7 through A-9 of the Appendix.

²¹Where 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”.

²²Continuous 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) data are FRM from 1999-2009, nephelometer 2010. Beacon Hill (BW) data are FRM from 1999-2010. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-10. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2010). Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-10. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2010. Olive Way (AZ) data are neph from 2003-2010. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2010. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010. Enumclaw (DF) data are from neph in 2000-2010.

Figure 10: Daily PM_{2.5} for Kitsap County

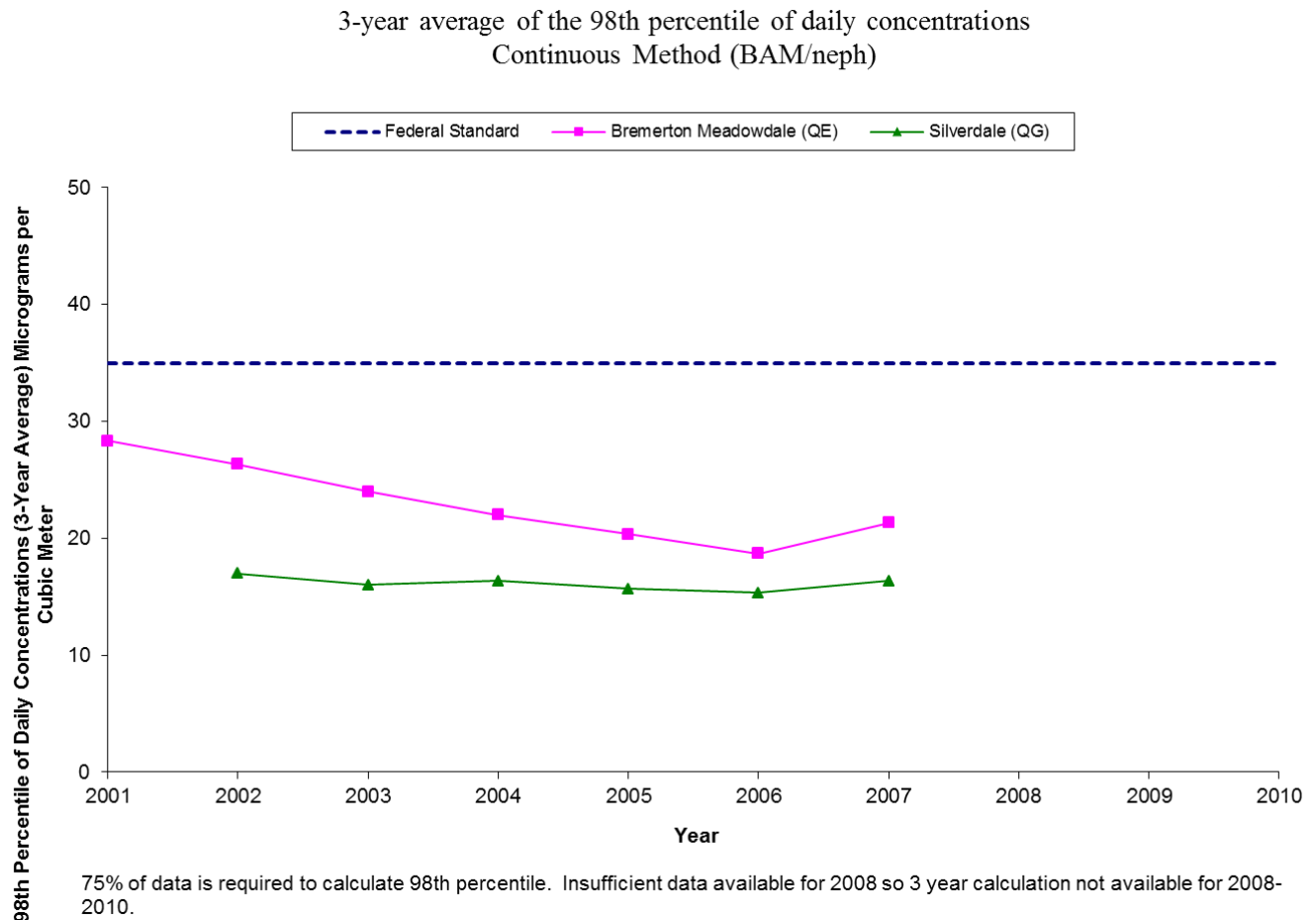
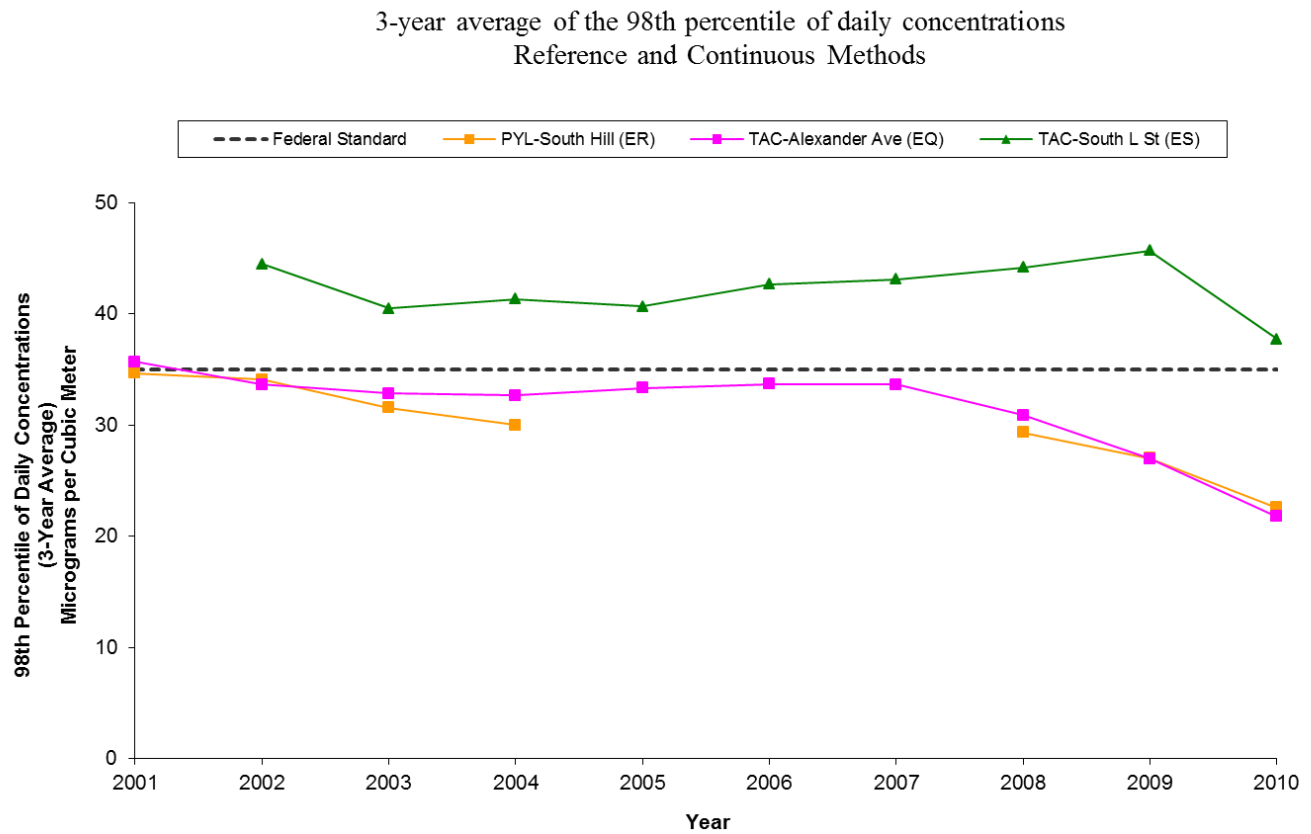
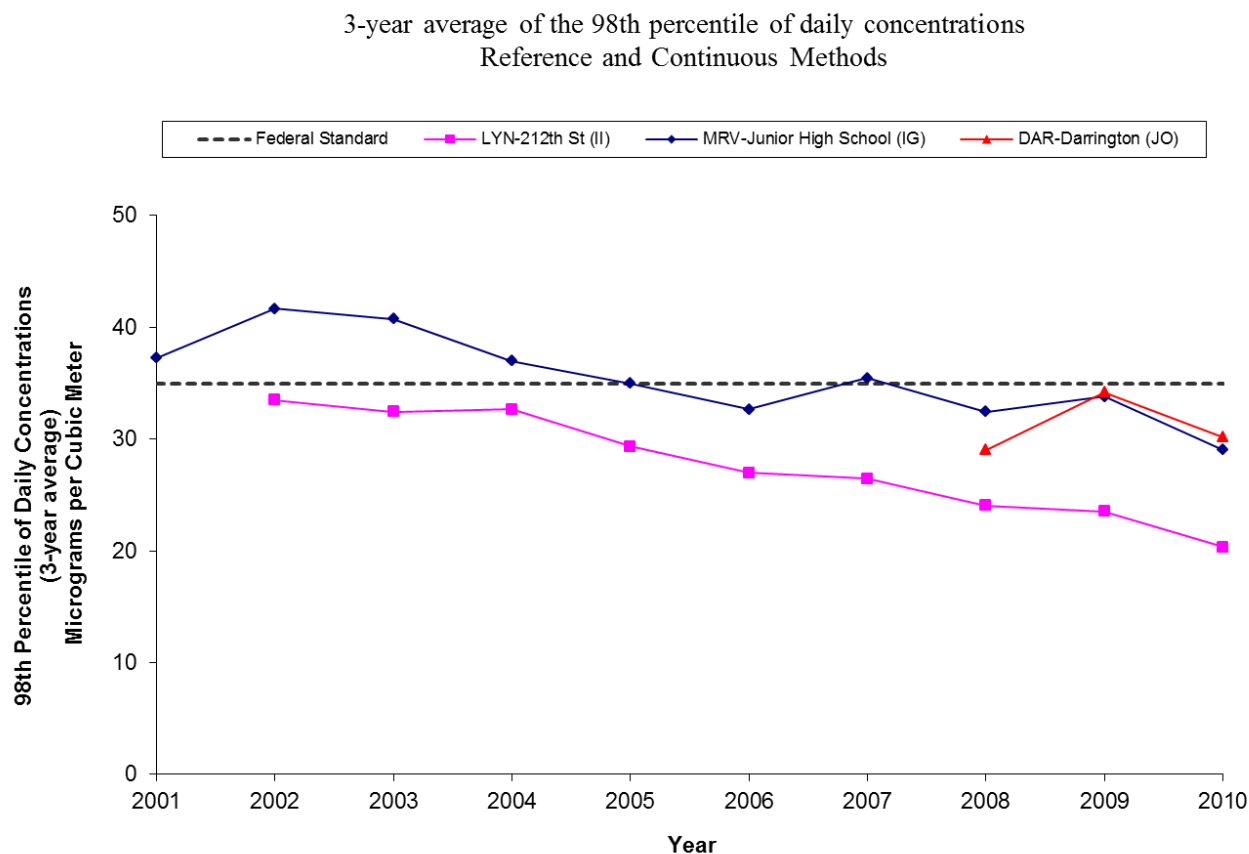


Figure 11: Daily PM_{2.5} for Pierce County



Note: All South L data are FRM from 2000- 2010. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2010.
South Hill data are FRM from 1999-2002 and nephelometer from 2003-2004; incomplete nephelometer data was collected from South Hill in 2005.

Figure 12: Daily PM_{2.5} for Snohomish County

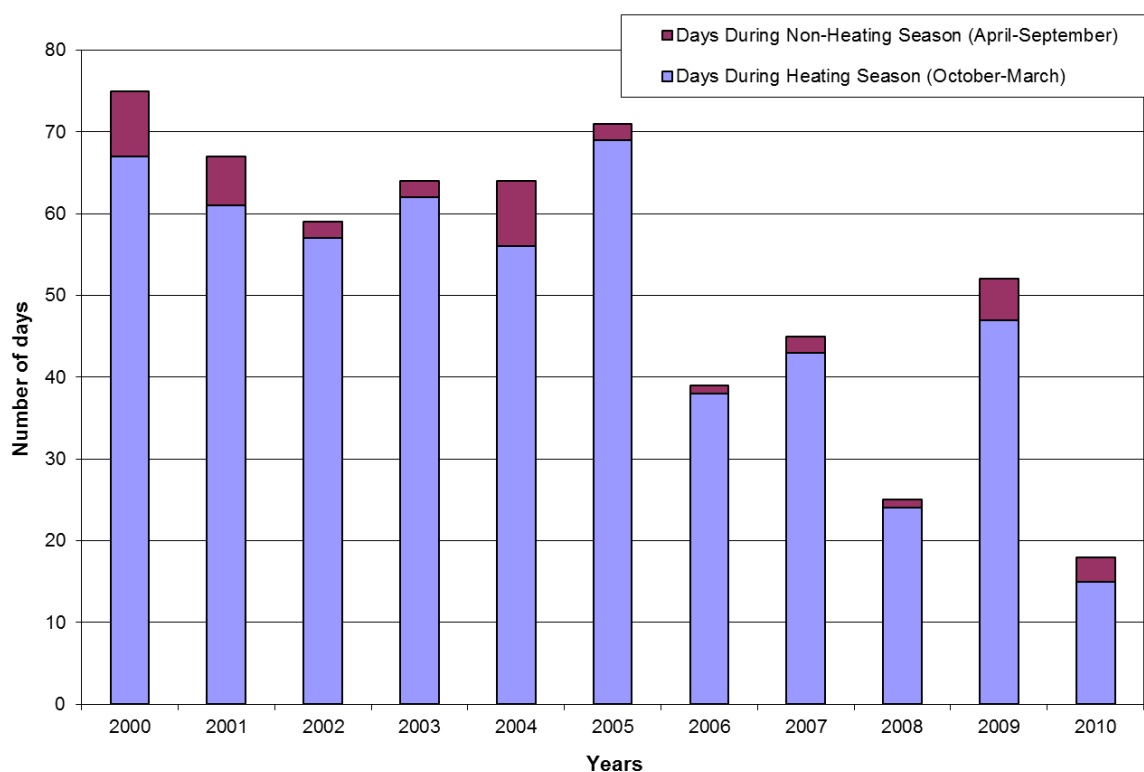


Note: Marysville data are FRM from 1999-2010. Lynnwood (II) data are FRM except 2004, 2007-2010 which were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007-2010.

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 $25 \mu\text{g}/\text{m}^3$ 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 was exceeded annually in the region, from 2000 to 2010. The shading demonstrates that our highest fine particulate days overwhelmingly take place during the winter wood heating months. While the graph indicates that we have made 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



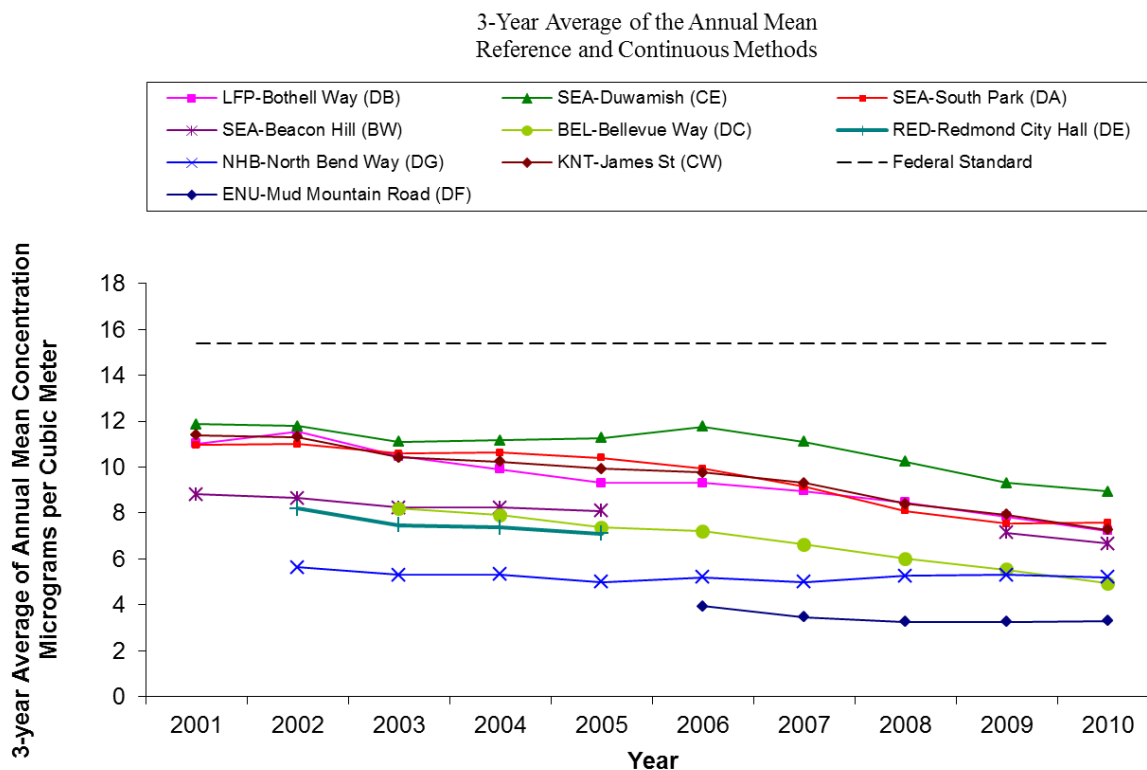
Includes data from all sites in King, Kitsap, Pierce, and Snohomish counties, both daily and continuous methods. The Darrington monitor was added in 2004.

PM_{2.5} ANNUAL FEDERAL STANDARD

The Puget Sound air shed has attained the annual PM_{2.5} standard. Figures 14 through 17 show annual averages at each monitoring station for King, Kitsap, Pierce, and Snohomish Counties. Figure 15 does not show any 2008, 2009, or 2010 data for Kitsap County. This is because monitoring at the Silverdale site was discontinued, and the Bremerton site had equipment problems for a portion of 2008, resulting in an incomplete dataset. Figures 14 through 17 show data from 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 2010 is the average of the annual averages for 2008, 2009, and 2010.

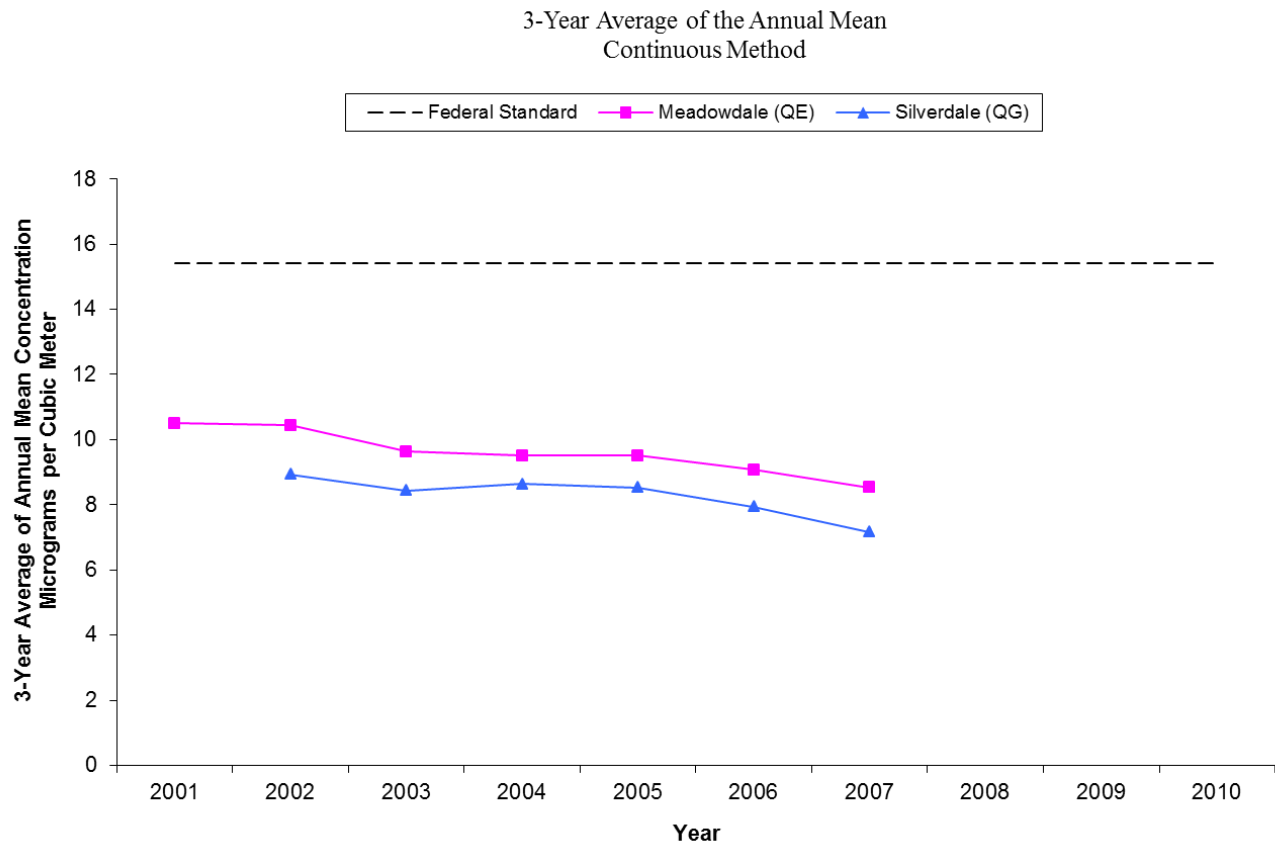
The Agency's Particulate Matter Health Committee did not recommend an annual PM_{2.5} health goal lower than the federal annual standard (15 $\mu\text{g}/\text{m}^3$).

Figure 14: Annual PM_{2.5} for King County



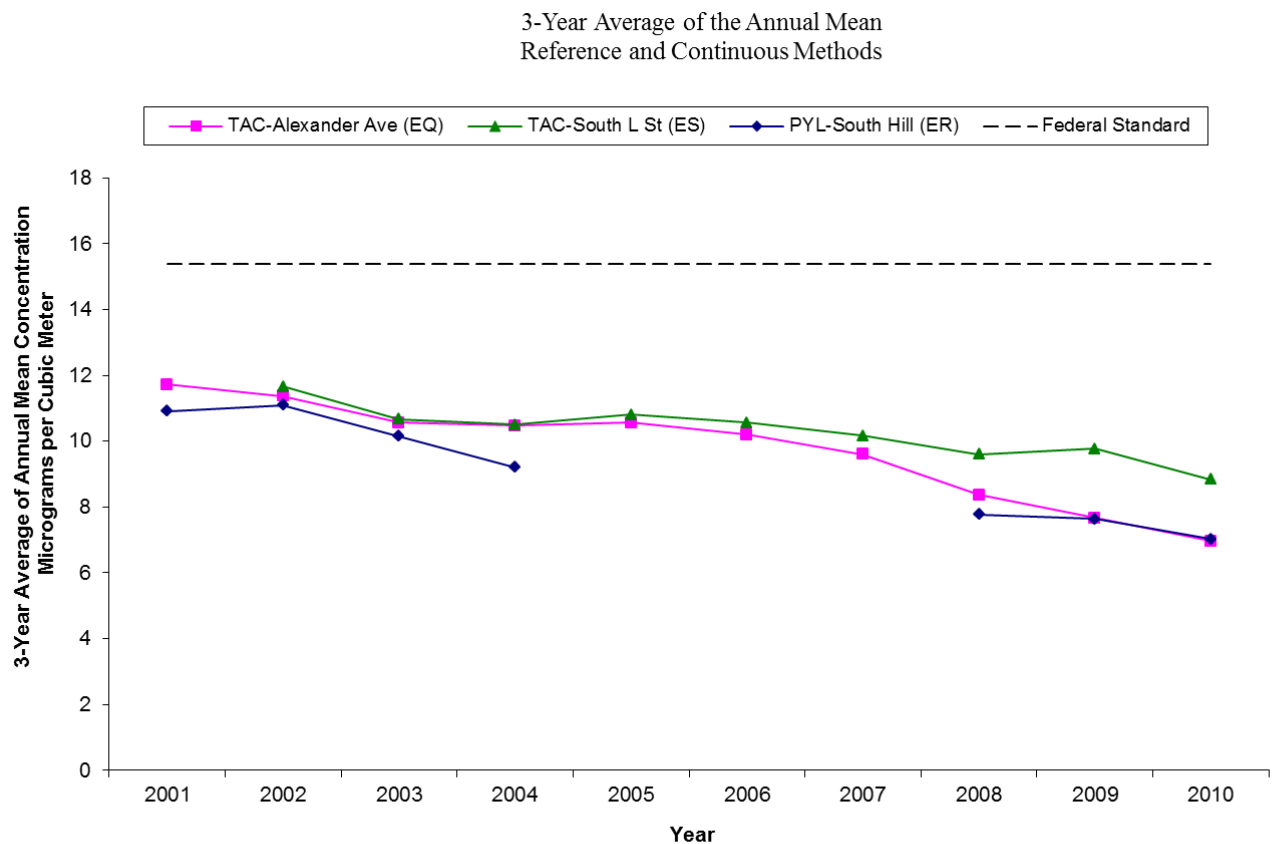
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2010. Beacon Hill (BW) data are FRM from 1999-2010. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2010. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2010. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2010. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2010.

Figure 15: Annual PM_{2.5} for Kitsap County



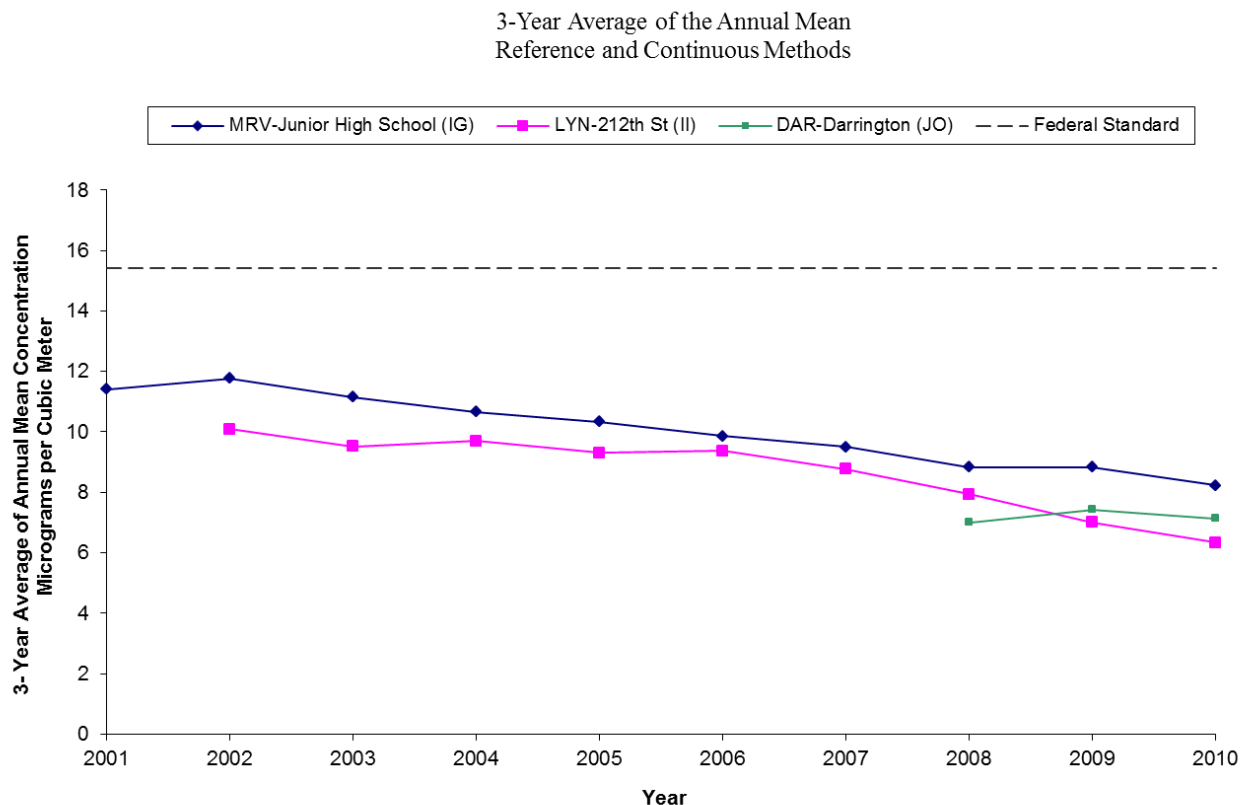
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010. Insufficient data in 2008 resulted in the inability to calculate a 3 year average for 2008, 2009, 2010.

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, 2008-2010 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002. Alexander Ave (EQ) data 2003-2010 was measured with a nephelometer.

Figure 17: Annual PM_{2.5} for Snohomish County



Note: Marysville (IG) data are FRM from 1999-2010. Lynnwood (II) data are FRM except 2004, 2007-2010. The 2004, 2007-2010 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2010.

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 of interest.

PARTICULATE MATTER – PM_{2.5} SPECIATION AND AETHALOMETERS

The methods described above show the total amount of fine particulate matter, but do not give us more specific data. 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.^{23,24,25}

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 40 species are measured at speciation monitors in the area. Each species and its annual average concentration are shown on page A-10 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 pollution sources, and then estimate how much each source is contributing at each site.

Our Agency and Ecology conducted speciation monitoring at five monitoring sites in the Puget Sound region in 2010:

- Seattle Beacon Hill – typical urban impacts, mixture of sources (speciation samples collected every third day, operated by Ecology)
- Seattle Duwamish – urban industrial area, impacts from industrial sources and diesel emissions (speciation samples collected every sixth day, operated by PSCAA)
- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day, operated by Ecology)
- Tacoma Tideflats – urban industrial area, impacts from industrial sources and diesel emissions (speciation samples collected every sixth day, operated by PSCAA)
- Marysville – residential area, impacts from wood combustion (speciation samples collected every sixth day, operated by Ecology)

Many scientific and health researchers have analyzed speciation data from these sites. In addition to using speciation data for concentrations of specific species 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

²³Puget Sound Air Toxics Evaluation, October 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

²⁴Tacoma and Seattle Air Toxics Evaluation, October 2010:
http://www.epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf.

²⁵Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley PM_{2.5} Nonattainment Area". PublicationNumber 10-02-009.

contributors to mass when fine particle levels are highest, and compare sites.^{26,27} Major constituents of fine particulate matter in our region include:

- Organic and Elemental Carbon – Largely from combustion sources.
- Sulfate and Nitrates – 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, diesel and heavy fuels). Large industrial sources also contribute substantially to SO_x (about 20%). Voluntary and regulatory programs are reducing the sulfur content in fuels and 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 27 show simplified, major contributors at the speciation sites for the 2010 samples (annual average), as well as on the highest concentration days. Because speciation samples are collected on either every third or sixth day schedules, not all of the most elevated concentration days (for samples >15 µg/m³) are captured. This schedule results in only a handful of samples represented in the ‘highest concentration’ pie charts below (five samples for Tacoma South L, three for Tacoma Tideflats, one for Seattle Duwamish, one for Seattle Beacon Hill, and three for Marysville).

All the sites show organic carbon as the main contributor to PM_{2.5} mass, with an increase in carbon on the most elevated fine particulate days. Organic carbon comes from combustion sources, and most notably from wood smoke. Highest percentages of organic carbon come from sites where wood smoke is more prominent, especially the Tacoma South L site. The Seattle Beacon Hill site is an exception as the only sample over 15 µg/m³ was in May, which is not within the typical wood burning season.

²⁶Brook, Dann, and Burnett. The Relationship Among TSP, PM₁₀, 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.

²⁷Jeffrey 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.

Figure 18: Tacoma South L Average Contributions 2010

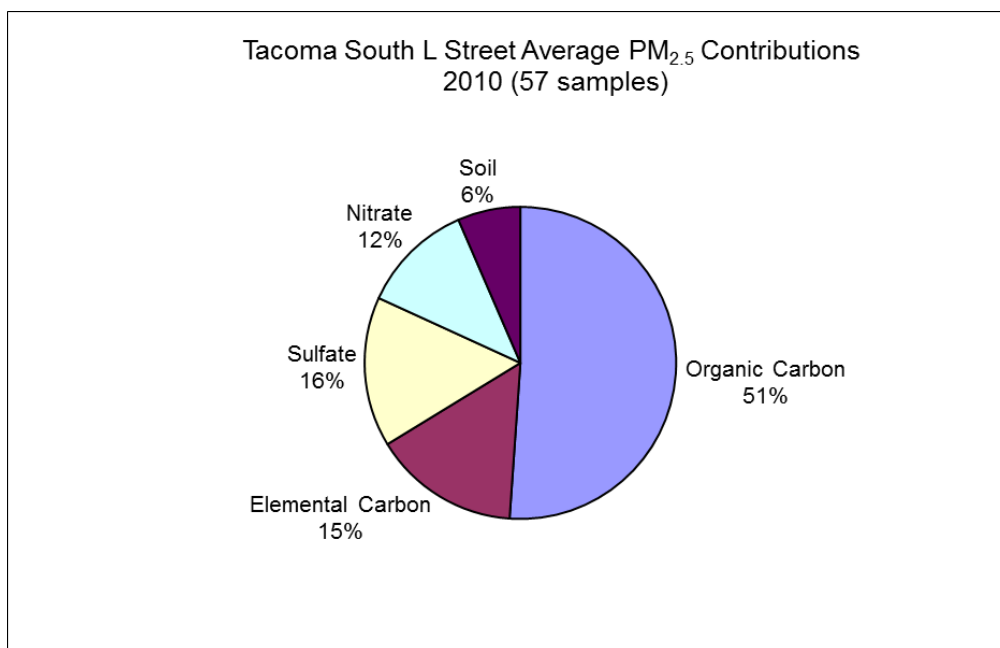


Figure 19: Tacoma South L Contributions on Highest Days 2010 (5 samples over 15 $\mu\text{g}/\text{m}^3$)

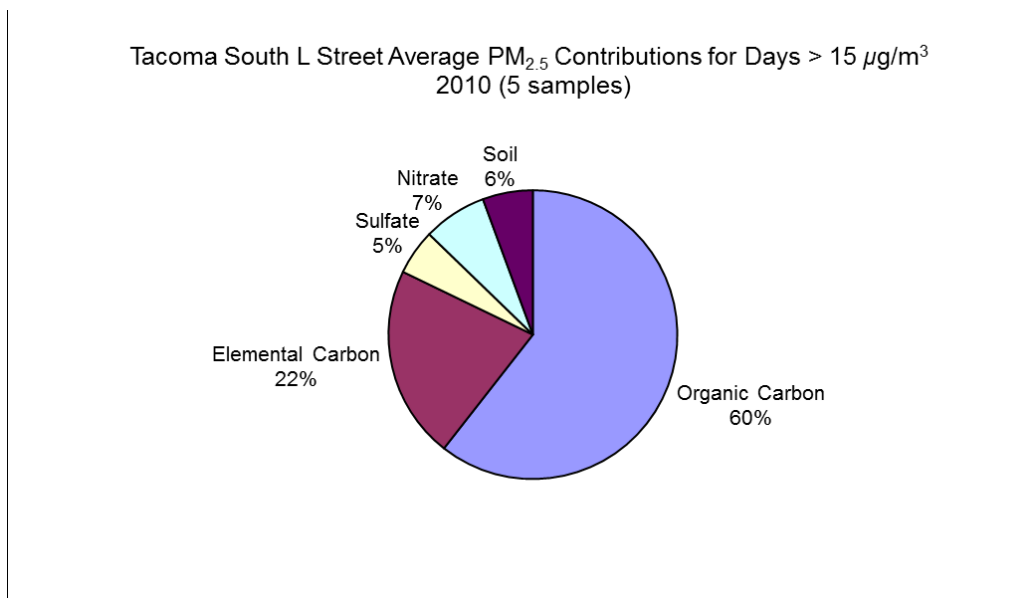


Figure 20: Tacoma Tideflats Average Contributions 2010

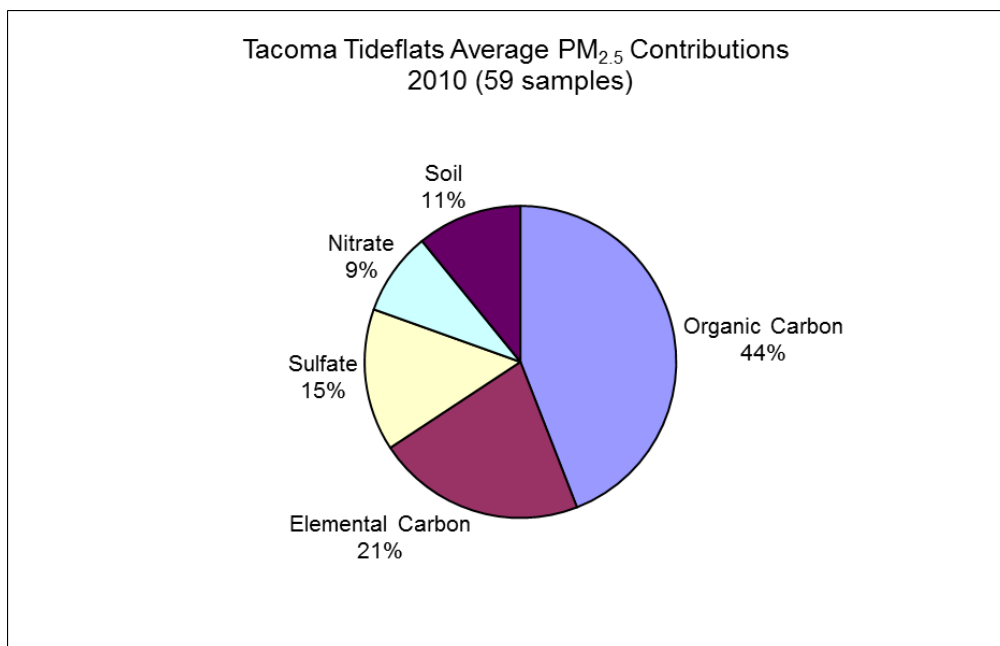


Figure 21: Tacoma Tideflats Contributions on Highest Days 2010 (3 samples over 15 $\mu\text{g}/\text{m}^3$)

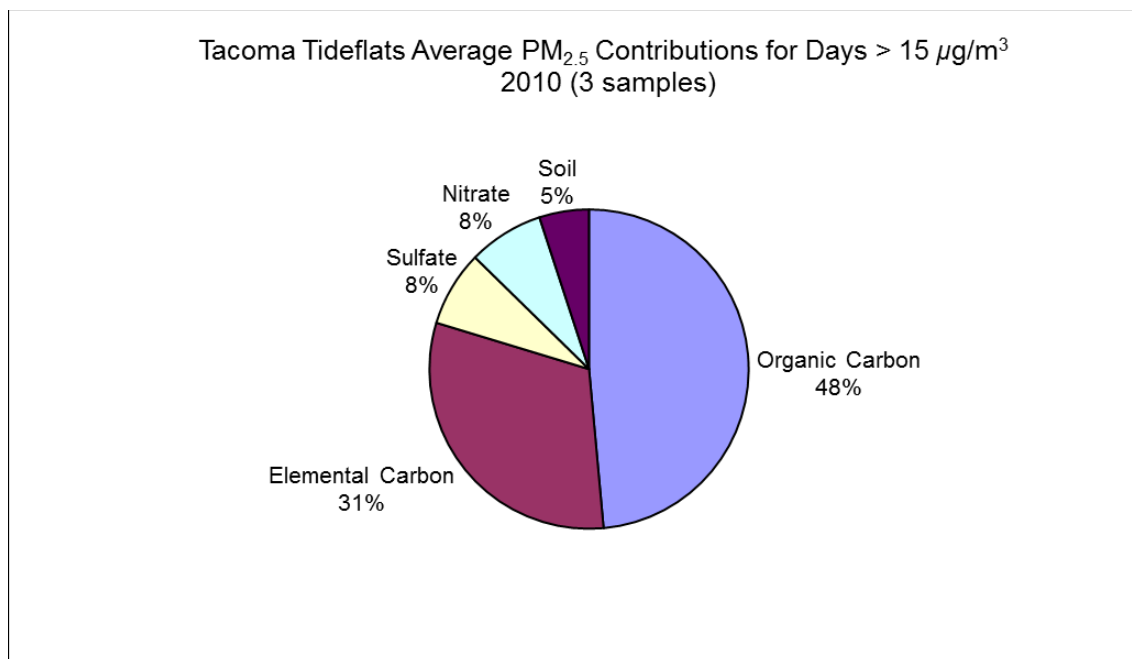


Figure 22: Seattle Duwamish Average Contributions 2010

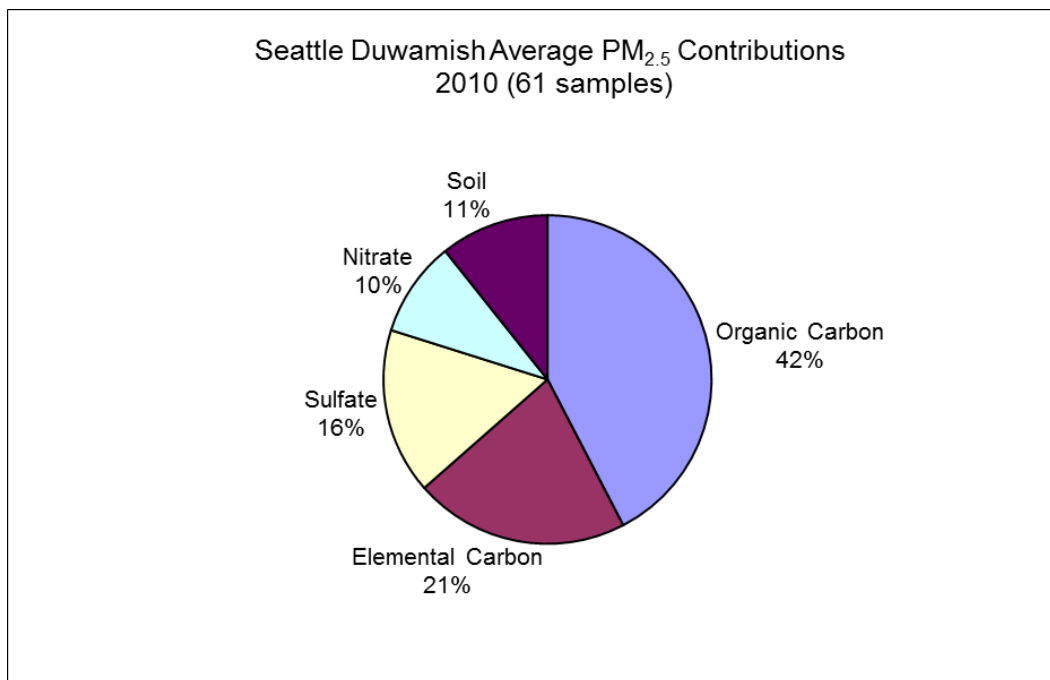


Figure 23: Seattle Duwamish Contributions on Highest Days 2010 (1 sample over 15 $\mu\text{g}/\text{m}^3$)

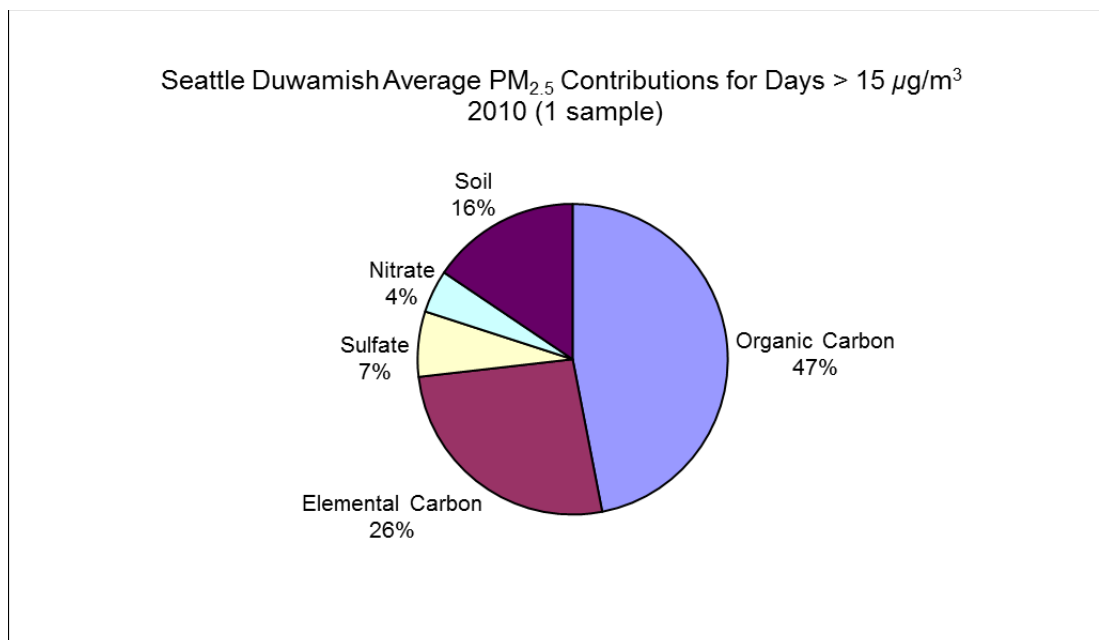


Figure 24: Seattle Beacon Hill Average Contributions 2010

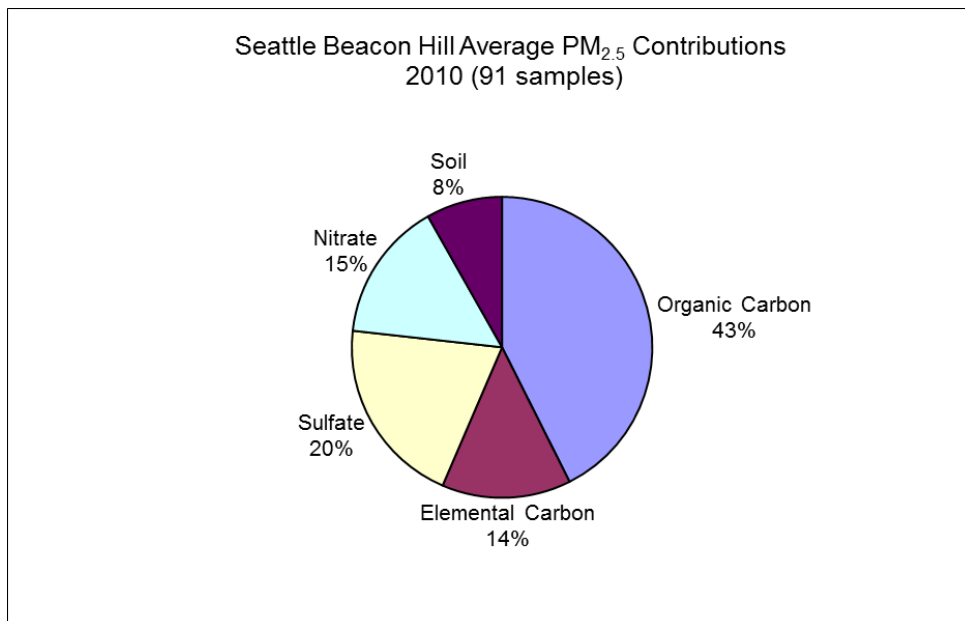
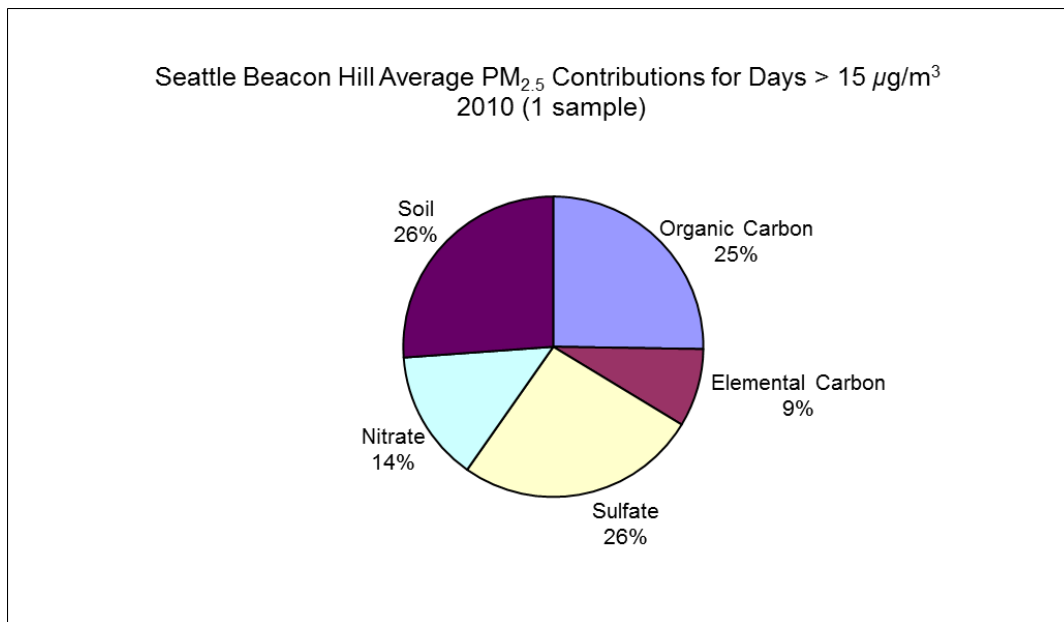


Figure 25: Seattle Beacon Hill Contributions on Highest Day 2010 (1 sample over 15 $\mu\text{g}/\text{m}^3$)



*Sample occurred on 5/12/2010.

Figure 26: Marysville Average Contributions 2010

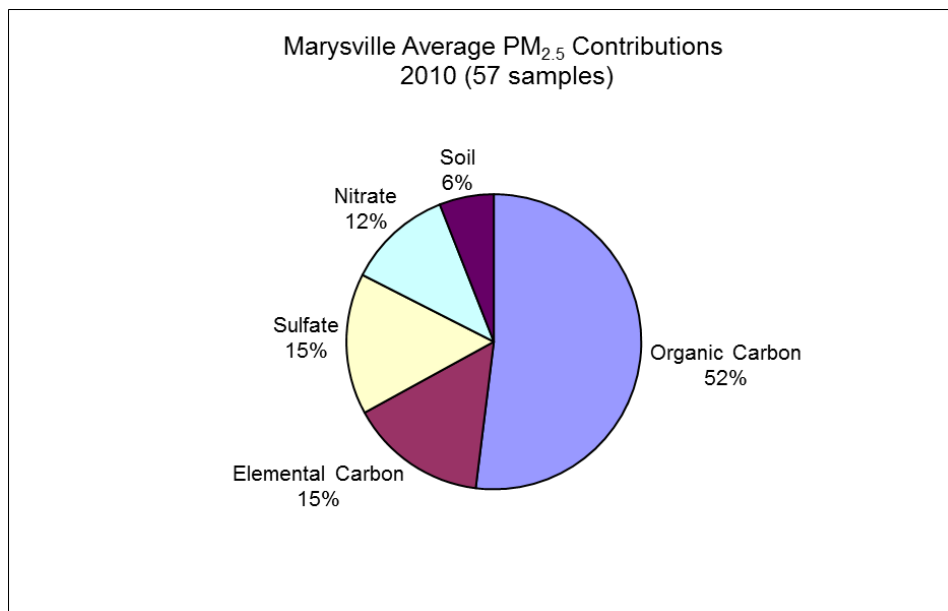
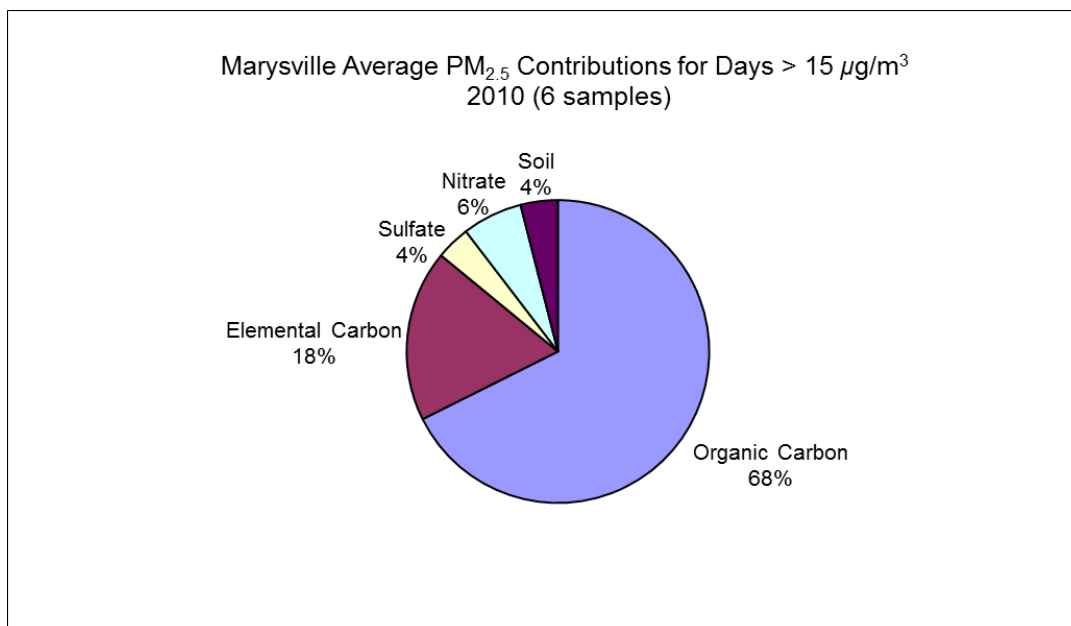


Figure 27: Marysville Contributions on Highest Days 2010 (6 samples over 15 $\mu\text{g}/\text{m}^3$)



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 correlate 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 carbons are related to diesel particulate, wood smoke particulate, and particulate from other combustion sources.²⁸ 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-11 of the Appendix.

²⁸Urban 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 in our region 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 (biogenic). Ozone levels are usually highest in the afternoon because of the intense sunlight and the time required for ozone to form in the atmosphere. The Washington State Department of Ecology currently monitors ozone from May through September, as this is the 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 harmful ultraviolet 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.²⁹ Ozone has also been linked to immune system impairment.³⁰ 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 forests and agricultural crops, interfering with their ability to grow and produce food.³¹

Most ozone monitoring stations are located in rural areas 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. Precursors have typically been transported 10 to 30 miles downwind from their source by the time the highest ozone 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).

²⁹EPA, Air Quality Index: A Guide to Air Quality and Your Health; http://www.epa.gov/airnow/aiq_brochure_08-09.pdf.

³⁰EPA Health and Environmental Effects of Ground Level Ozone; <http://www.epa.gov/ttn/oarpg/naaqsfm/o3health.html>.

³¹EPA Health and Environmental Effects of Ground Level Ozone; <http://www.epa.gov/ttn/oarpg/naaqsfm/o3health.html>.

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2010

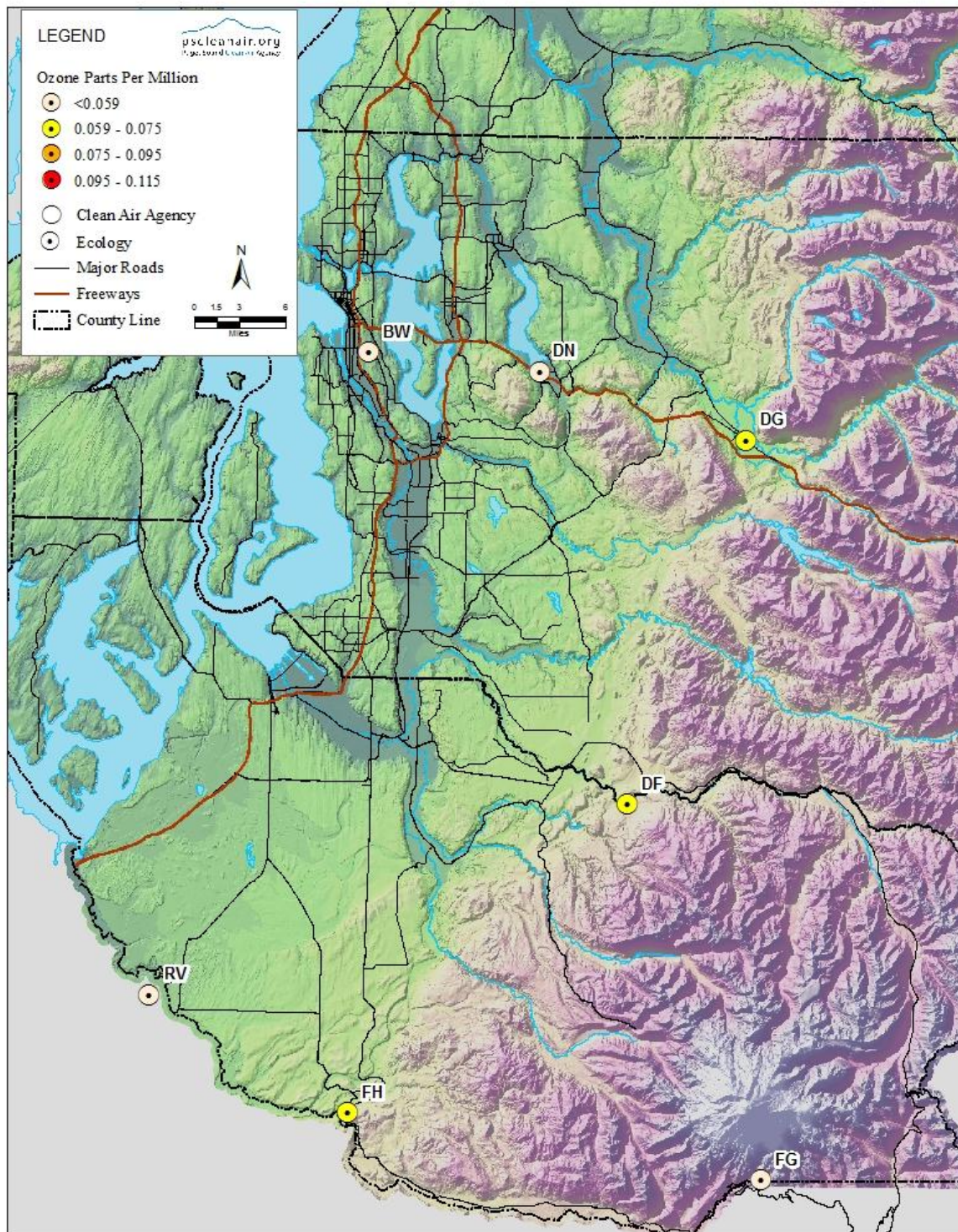


Figure 28 presents data for each monitoring station and the 8-hour federal standard. EPA revised its 8-hour standard from 0.08 parts per million (ppm) to 0.075 ppm in March 2008. EPA has expressed intent to reconsider the standard in 2013.³²

Figure 28 shows that the Enumclaw Mud Mountain monitor violated the 2008 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 2010 design value is 0.073 ppm, which does not violate the 2008 standard. The highest 2010 8-hour ozone concentration of 0.077 ppm was recorded at the Enumclaw Mud Mountain monitor.

As of the publication of this report, the Puget Sound area will be designated in attainment under the (2008) 0.075 ppm standard.

Figure 29 presents 8-hour average data for the months of May through September, the months when ozone levels are greatest in the Puget Sound.

Statistical summaries for 8-hour average ozone data are provided on page A-12 of the Appendix.

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

³²EPA. Ground-Level Ozone Regulatory Actions; <http://www.epa.gov/air/ozonepollution/actions.html>.

Figure 28: Ozone for Puget Sound Region

3-Year Average of the 4th Highest Daily Maximum 8-hour Annual Concentration vs Standard

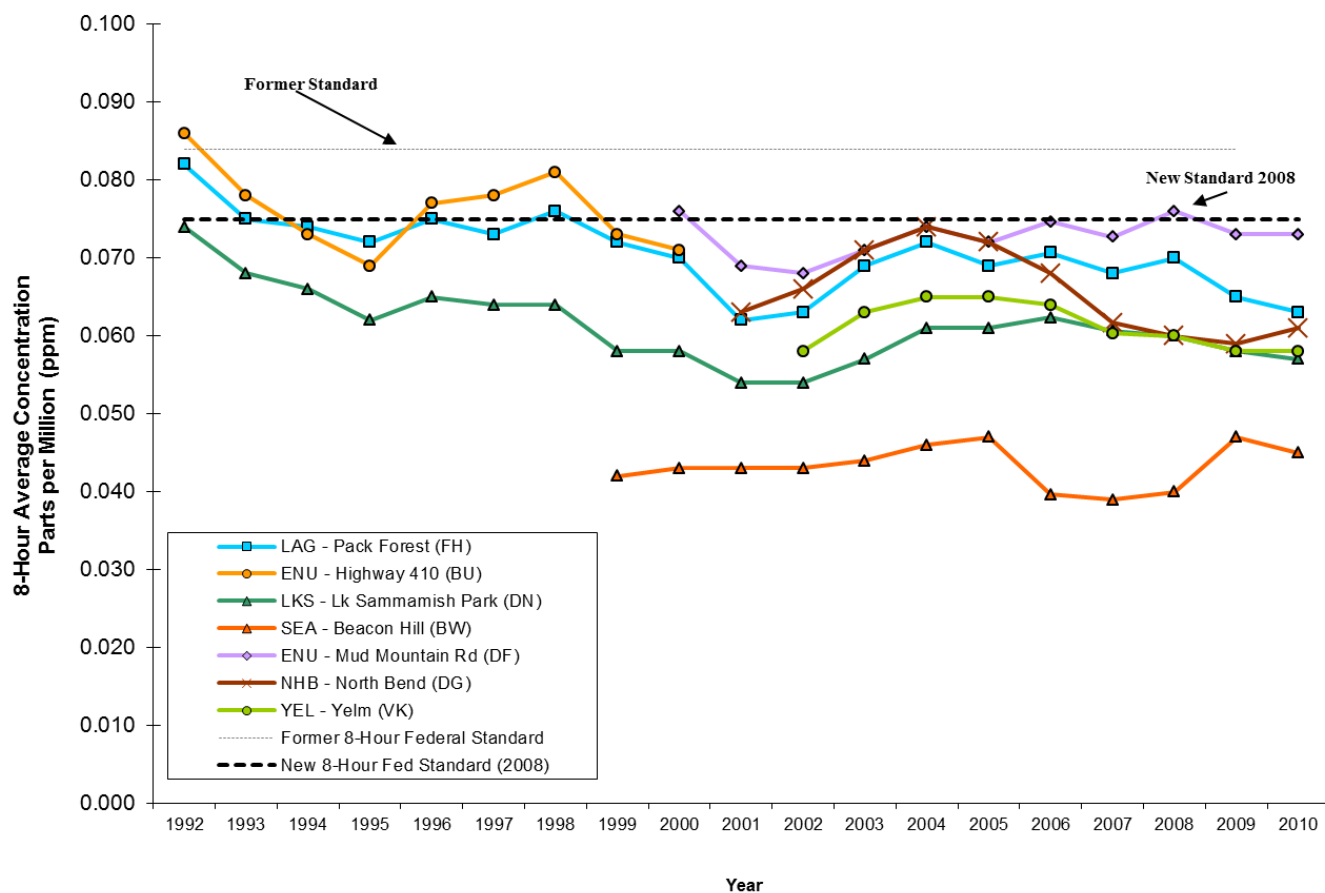
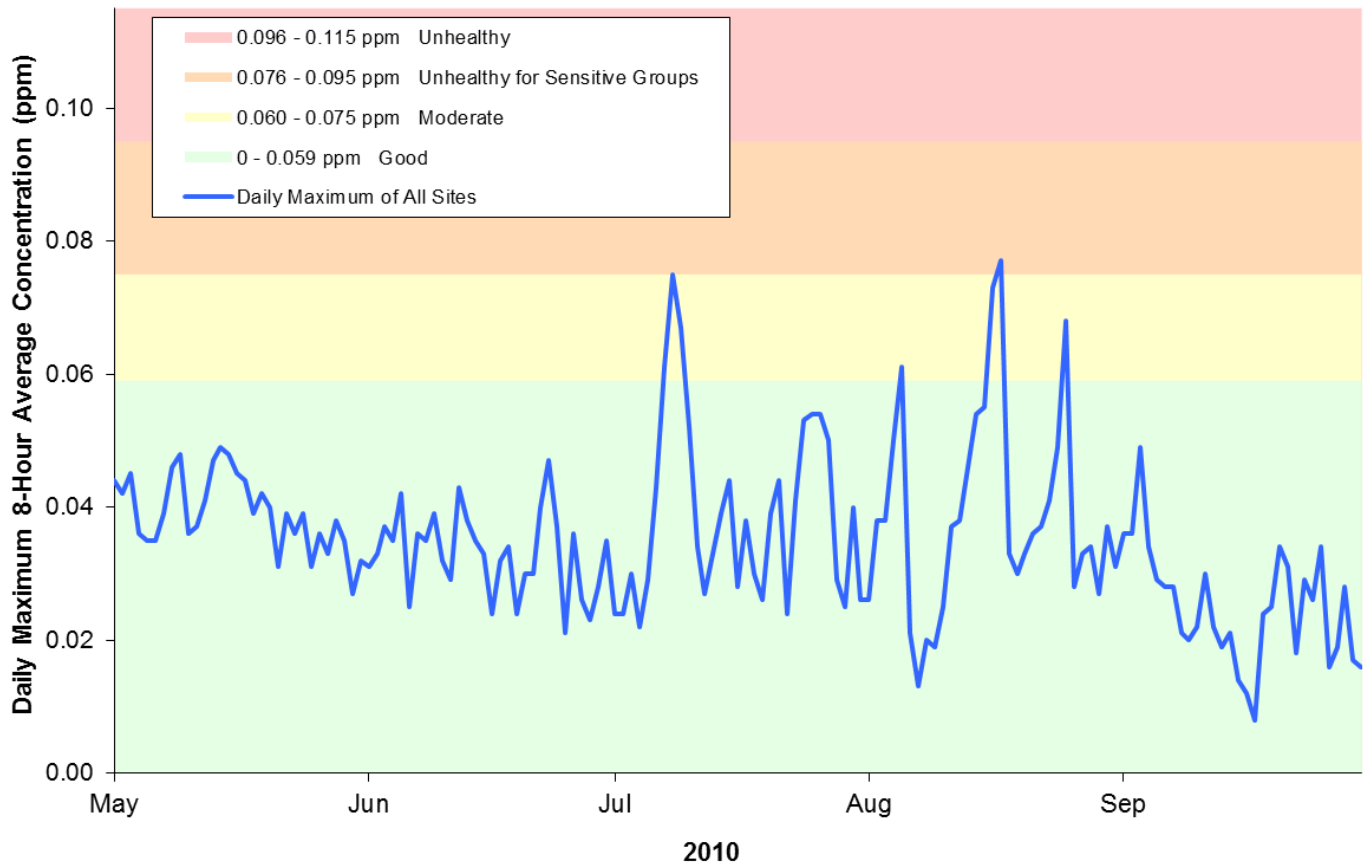


Figure 29: Ozone (O₃) for Puget Sound Region May-September 2010



NITROGEN DIOXIDE

Nitrogen dioxide (NO₂) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and hydroperoxy (HO₂) and alkylperoxy (RO₂) free radicals in the atmosphere. NO₂ can cause coughing, wheezing, and shortness of breath in people with respiratory diseases such as asthma.³³ Long-term exposure can lead to respiratory infections.

The term “NO_x” is defined as NO + NO₂. NO_x participates in a complex chemical cycle with volatile organic compounds (VOCs) which can result in the production of ozone. NO_x can also be oxidized to form nitrates, which are an important component of fine particulate matter. On-road vehicles such as trucks and automobiles and off-road vehicles such as construction equipment, marine vessels, 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 been reduced dramatically since the 1970s. NO₂ 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.

Ecology maintains one monitoring site for nitrogen dioxide at the Beacon Hill station. In 2007, the monitoring technique and equipment changed to record NO_y instead of NO_x, in order to observe all reactive nitrogen compounds. NO_y is NO_x plus all other reactive nitrogen oxides present in the atmosphere. NO_y components such as nitric acid (HNO₃) and PAN can be important contributors to the formation of ozone and fine particulate matter. The additional nitroxy compounds are generally present in much lower concentrations than NO₂ (or NO_x). Figure 30 shows NO₂ concentrations through 2005. In 2006, no data were recorded due to the relocation of the Beacon Hill monitor to a different location on the same property. From 2007 onward, the concentration of NO₂ is represented as NO_y – NO, since NO₂ is no longer directly recorded, and NO_y = NO + NO₂ + other nitroxy compounds. The annual average for each year has consistently been less than half of the 2010 federal standard, as shown in Figure 30 and in the statistical summary on page A-13 of the Appendix.

The maximum 1-hour average of NO_y – NO, measured in 2010, was 0.052 ppm on both July 9 and August 16. Visit www.epa.gov/air/nitrogenoxides/ for additional information on NO₂.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010.³⁴ The new 1-hour standard is 100 ppb. The design value is calculated by following the procedures in the Federal Register. EPA retained the current annual health-based standard for nitrogen dioxide of 53 ppb (0.053 ppm). Nitrogen dioxide levels in the Puget Sound region, as currently monitored by Ecology, are typically below (cleaner than) the levels in the new standard. The new standard is depicted in Figure 31 with historical data since 1998.

³³EPA, Airnow, NO_x Chief Causes for Concern; <http://epa.gov/air/nitrogenoxides/>

³⁴EPA. New 1-hour National Ambient Air Quality Standards for Nitrogen Dioxide; <http://www.epa.gov/air/nitrogenoxides/actions.html#jan10>, accessed September, 2010.

Figure 30: Annual Nitrogen Dioxide (NO₂) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-2010)

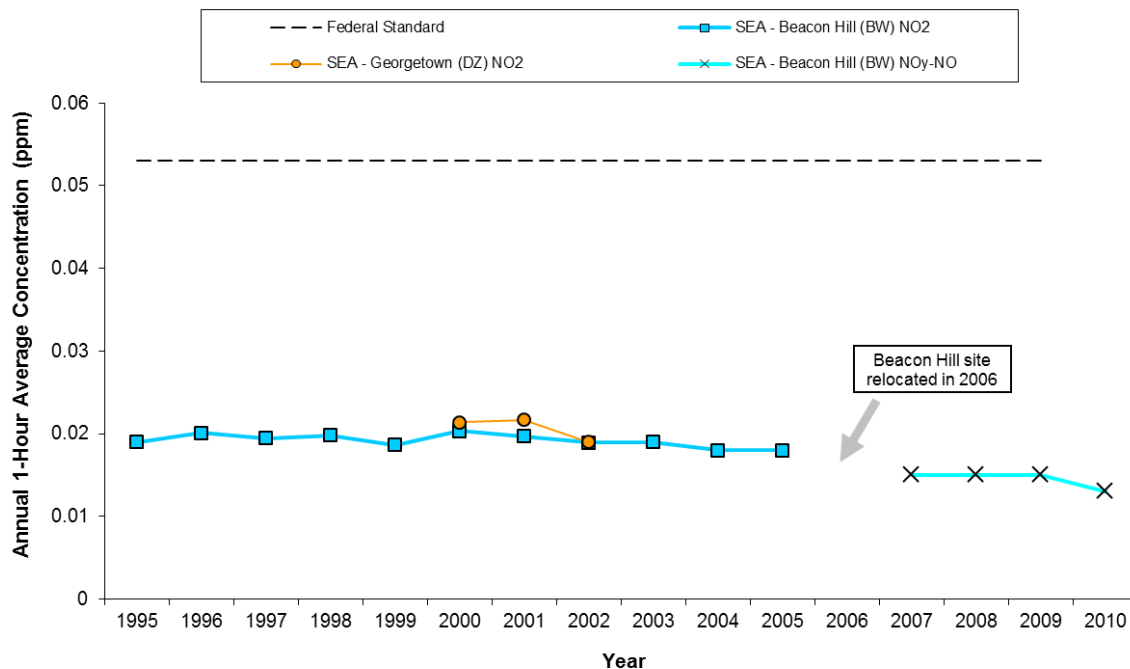
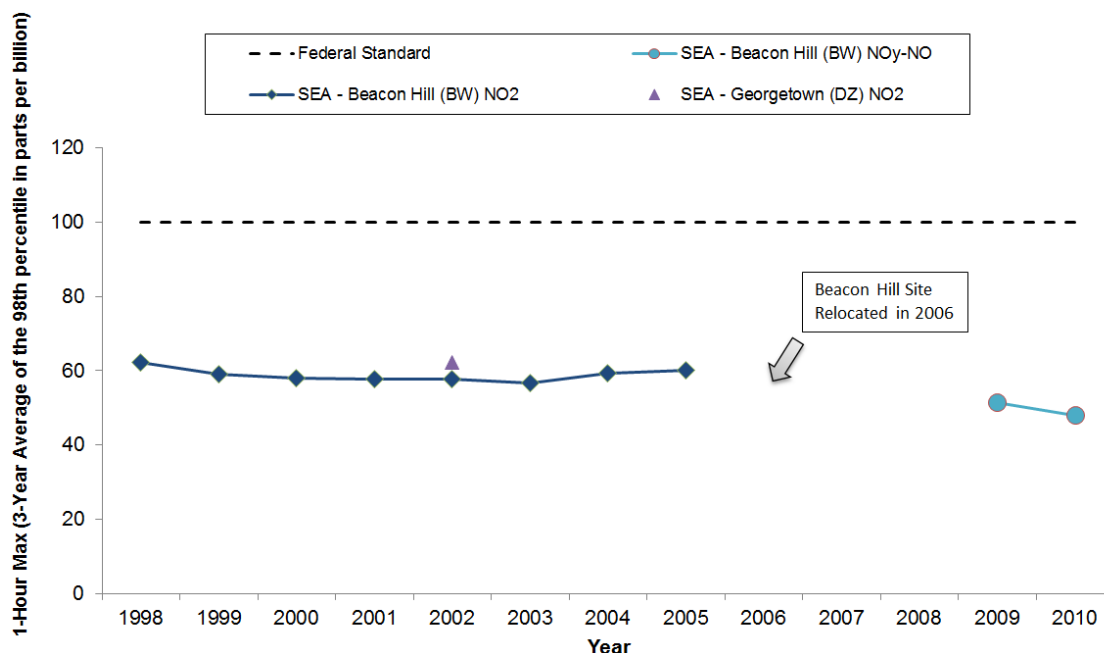


Figure 31: New 1-Hour Maximum Standard for Nitrogen Dioxide (NO₂) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-2010)



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 does not burn completely. The vast majority of CO emissions come from motor vehicles.

Elevated levels of CO in ambient air occur more frequently in areas with heavy traffic and during the colder months of the year when temperature inversions are more common. 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.

Ecology conducts all 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 emissions controls on car engines. EPA designated the Puget Sound region as a CO attainment area in 1996. Ecology has substantially reduced its CO monitoring network, and only the Bellevue 148th Ave site and the Beacon Hill site ran during 2010.

The CO national ambient air quality standard is based on the 2nd highest 8-hour average. Figure 32 shows the 2nd 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.

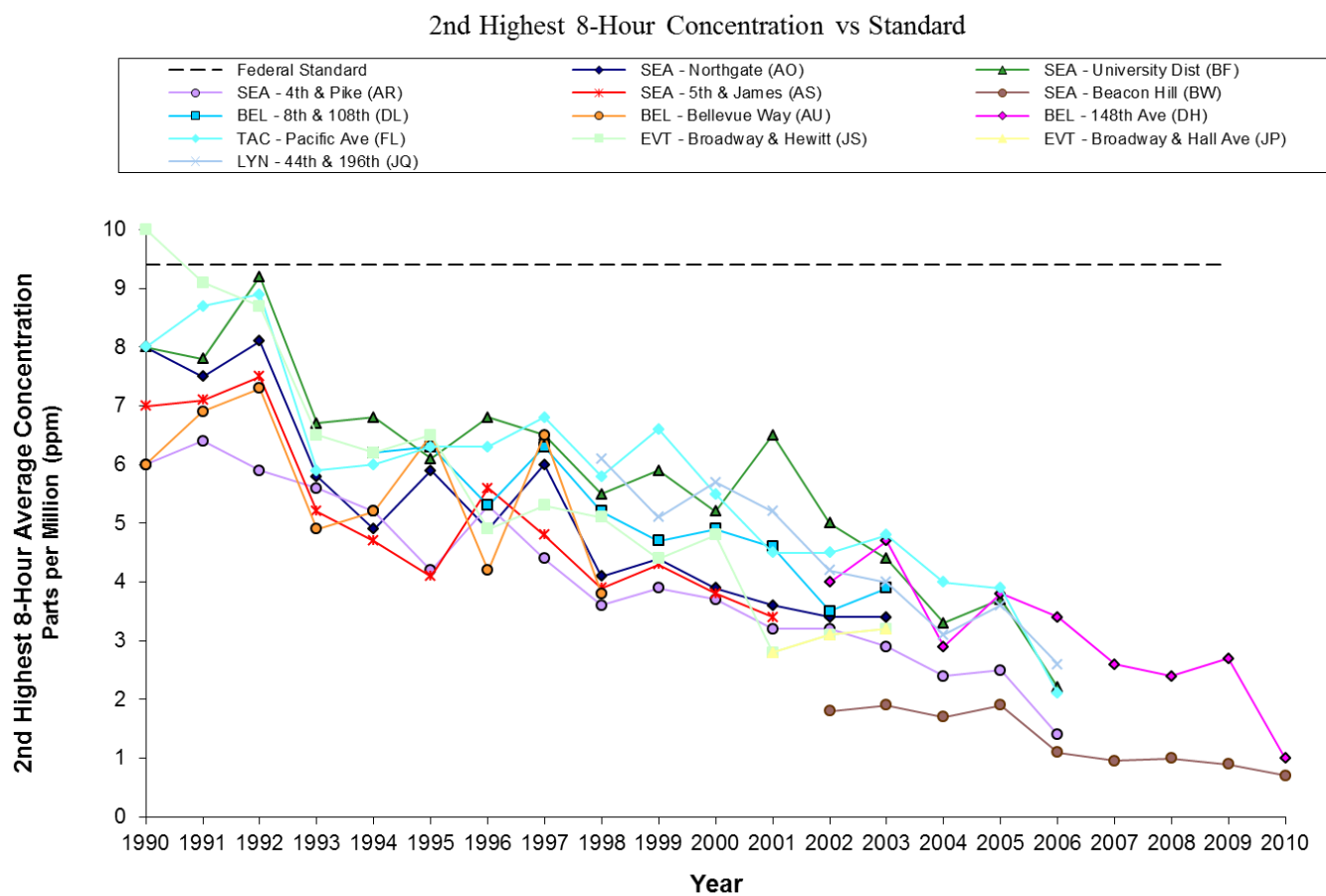
The maximum 8-hour concentration for CO in 2010 was 1.1 parts per million (ppm) and occurred on January 4 at the Bellevue site.

The EPA 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.

In 2011, EPA completed a NAAQS review for carbon monoxide, and left the standards unchanged, although required monitoring locations will be modified.

Statistical summaries for 8-hour average CO data are provided on page A-14 of the Appendix. For additional information on CO, visit www.epa.gov/air/urbanair/co/index.html.

Figure 32: Carbon Monoxide (CO): 2nd Highest Annual 8-hour Value for Puget Sound Region



SULFUR DIOXIDE

Sulfur dioxide (SO₂) 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 SO₂ 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). Marine vessels, on-road vehicles and diesel construction equipment are the main contributors to SO₂ emissions today.

SO₂ may cause people with asthma who are active outdoors to experience bronchial constriction, where symptoms include wheezing, shortness of breath, and tightening of the chest. People should limit outdoor exertion if SO₂ levels are high. SO₂ can also form sulfates in the atmosphere, a component of fine particulate matter.

The Puget Sound area has experienced a significant decrease in SO₂ 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 SO₂ in 1999 because of these decreases. Monitoring sites for SO₂ were historically sited in or near former industrial areas. Ecology monitored SO₂ at the Beacon Hill site from 2000-2005. In 2006, the SO₂ 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.

EPA changed the SO₂ standard in June of 2010. The annual and 1-hour average standard were both revoked as the new standard is more restrictive and also there was no evidence of health effects of SO₂ from long term exposure.

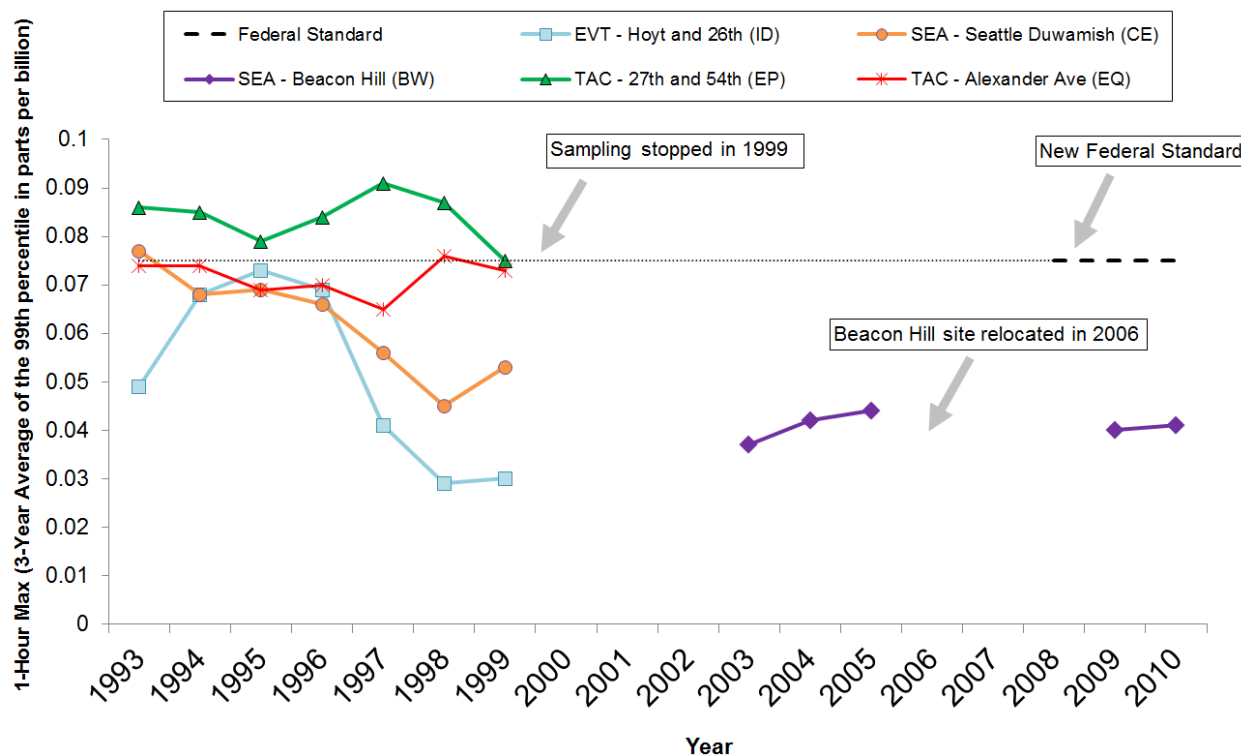
The new standard is a 3-year average of the 99th percentile of the daily 1-hour maximum concentrations. Levels must be below 0.075 ppm. Demonstration of attainment is determined from the 2008-2010 data. The Seattle Beacon Hill site is below the new standard.

Figure 33 shows the maximum 3-year average of the 99th percentile of 1-hour maximum concentrations at individual monitoring sites. The maximum measured SO₂ concentrations in 2010 were below all federal and regional standards.

Statistical summaries for SO₂ data from the Beacon Hill site are available on page A-15 of the Appendix.

Additional information on SO₂ is available at <http://www.epa.gov/air/sulfurdioxide/>.

Figure 33: Sulfur Dioxide (SO₂) 1-Hour Maximum Concentrations (3-Year Average of the 99th Percentile) for the 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. Lead from aviation gasoline used in small aircraft is also of concern nationally.

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 have decreased substantially. For a historic look at the Puget Sound region's lead levels, please see page 87 of the 2007 Air Quality Data Summary located at <http://www.pscleanair.org/news/library/reports/2007AQDSFinal.pdf>.

In October 2008, EPA strengthened the lead standard from 1.5 $\mu\text{g}/\text{m}^3$ to 0.15 $\mu\text{g}/\text{m}^3$ (rolling three-month average).³⁶ As part of this rulemaking, EPA initiated a pilot lead monitoring program that focuses on lead from aviation gasoline at small airports, including two in our region. For additional information on lead, visit www.epa.gov/air/lead.

³⁵Lead 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 $\text{PM}_{2.5}$ is measured at speciation monitors.

³⁶US EPA, National Ambient Air Quality Standard for Lead, Final Rule. Federal Register, November 12, 2008; <http://www.epa.gov/fedrgstr/EPA-AIR/2008/November/Day-12/a25654.pdf>.

VISIBILITY

There are no separate 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 present near the ground, can be 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.

Figures 34 through 38 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 (b_{sp}), and this value is converted into miles, which is more intuitive. The nephelometer cannot account for meteorological effects on visibility such as cloudiness, so the visibility in these graphs is only 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. The large fluctuations are due to seasonal variability. The summer months typically have better visibility while the winters are usually worse. The blue line shows the average of the previous 12-months. This moving average reduces seasonal variation and allows longer-term trends to be observed. The moving average shows that the visibility for the Puget Sound area has steadily increased (improved) over the last decade with some year-to-year variability caused by meteorology. For the 20-year period from December 1990 through December 2010, the 12-month moving average increased from 49 miles to 84 miles.

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

Figure 34: Puget Sound Visibility

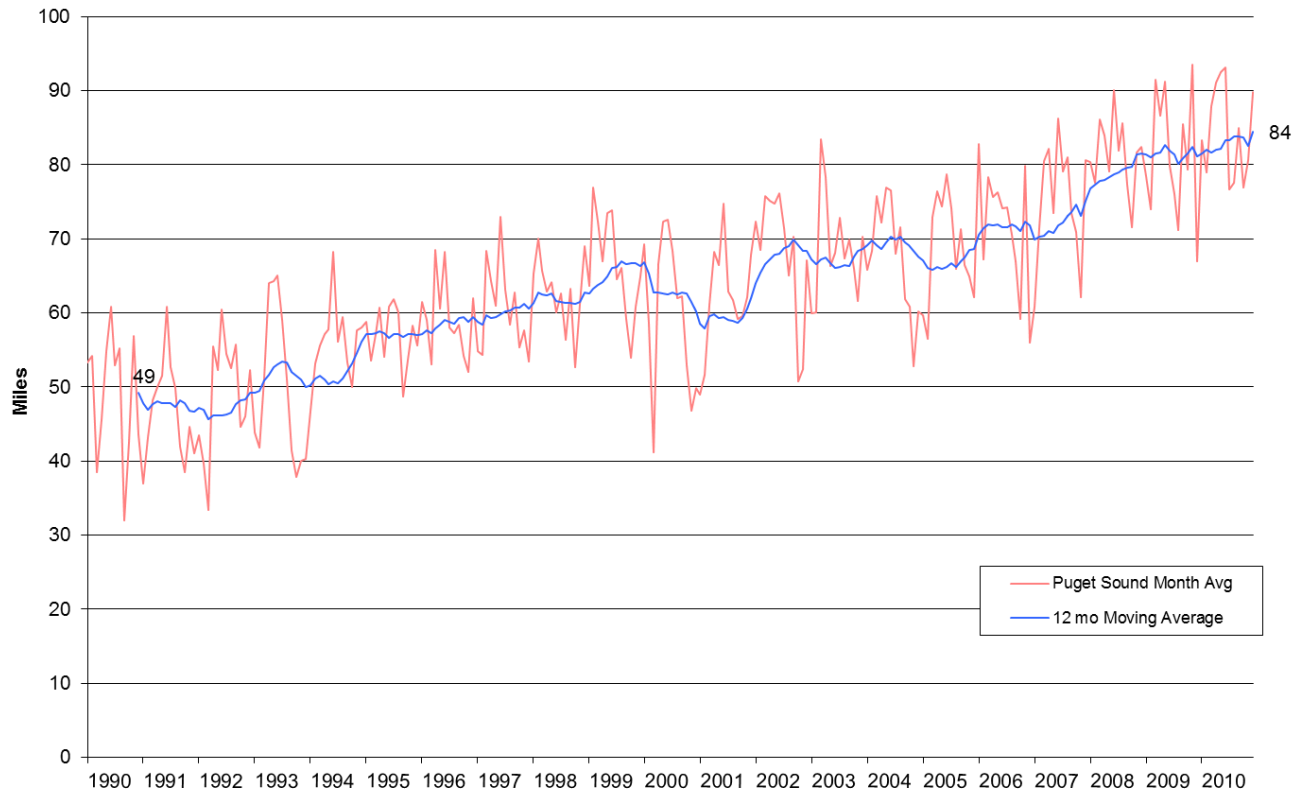


Figure 35: King County Visibility

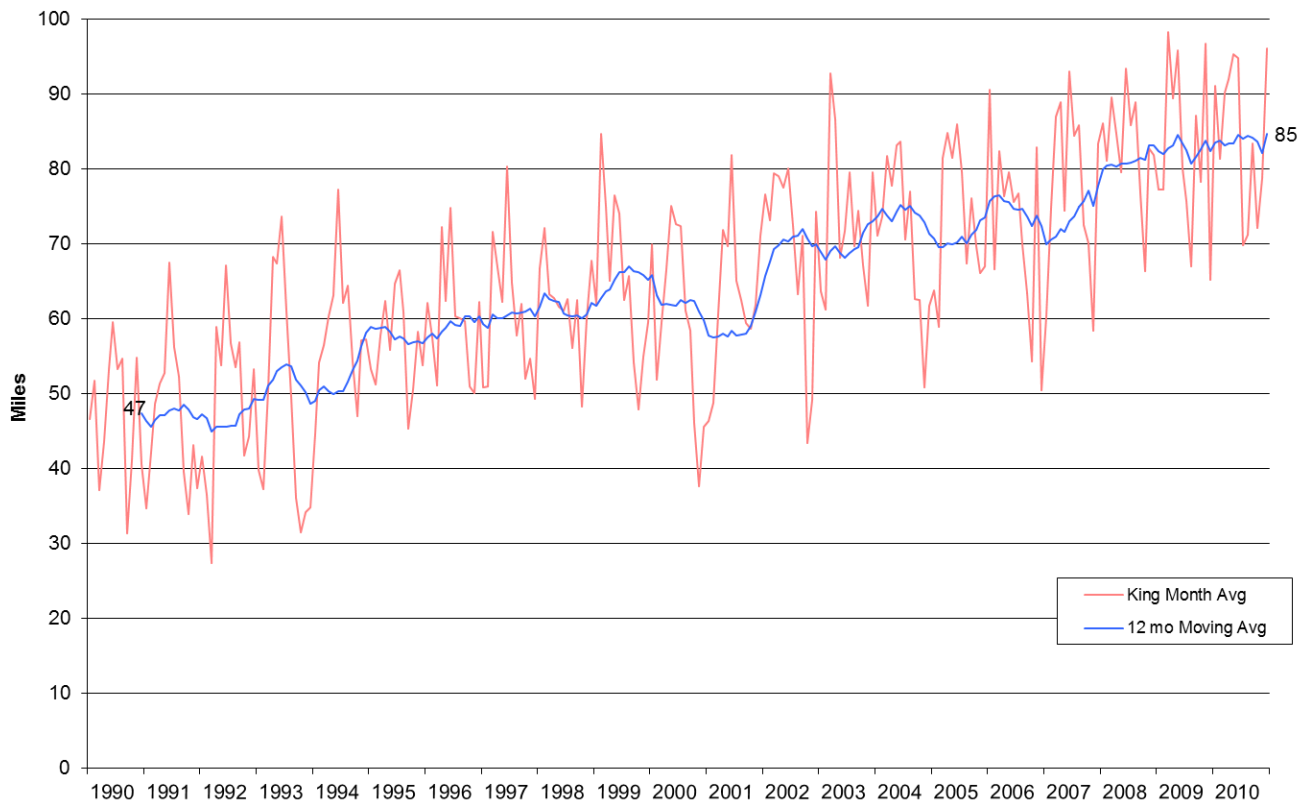


Figure 36: Kitsap County Visibility

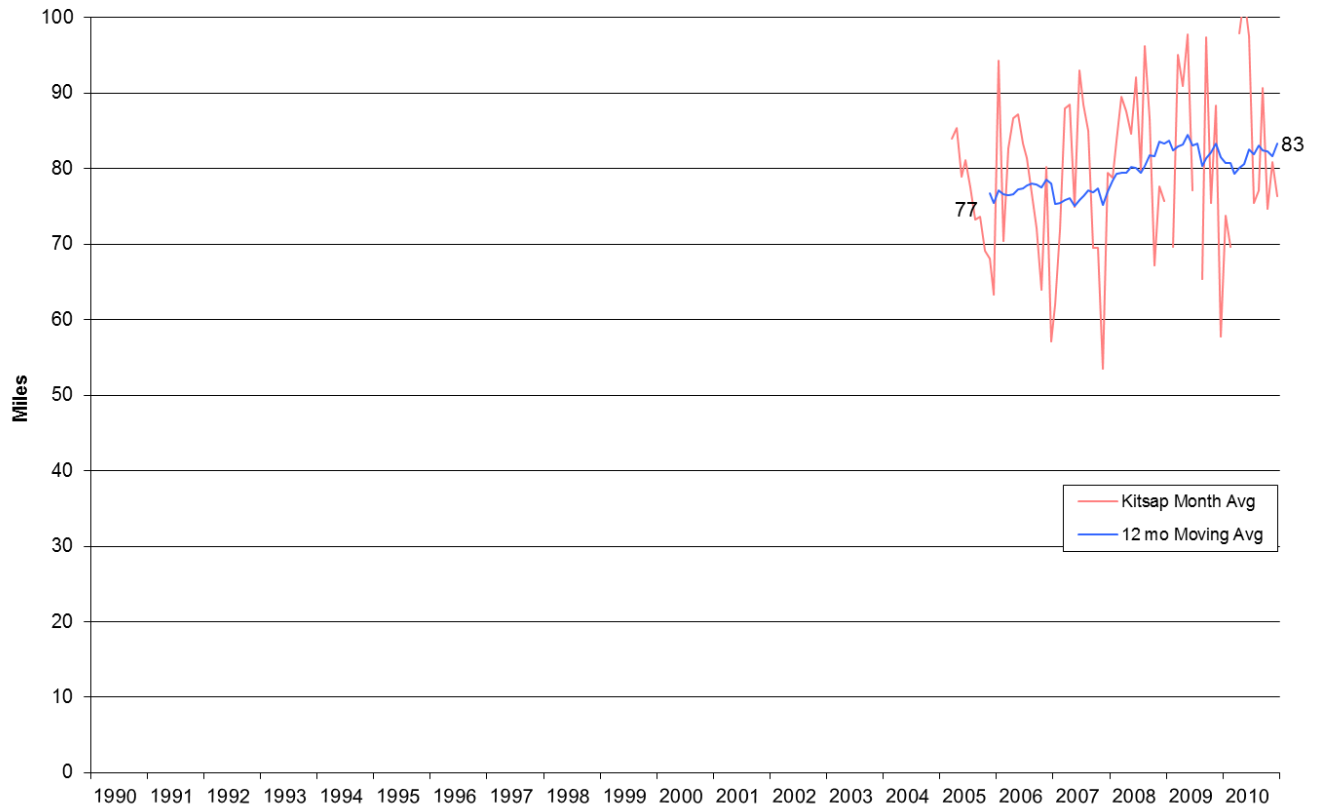


Figure 37: Pierce County Visibility

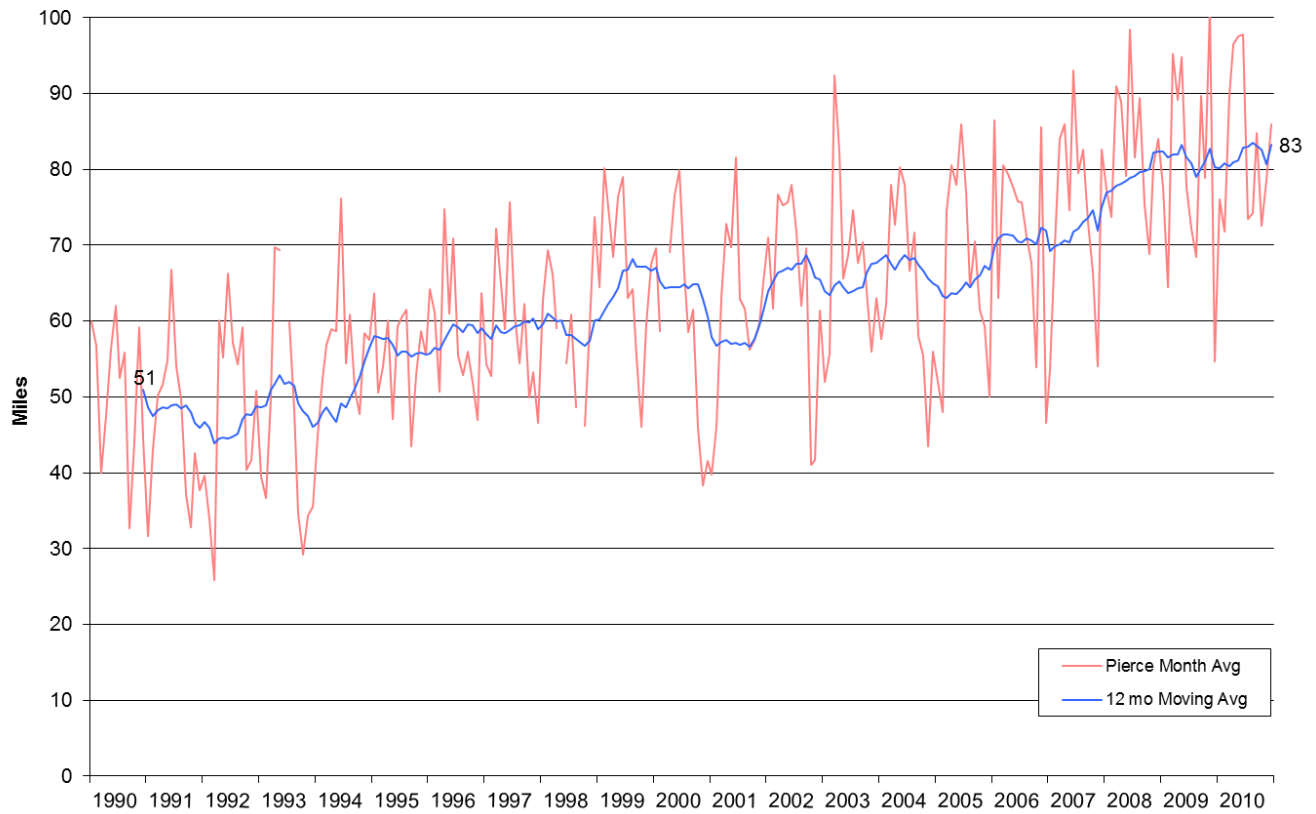
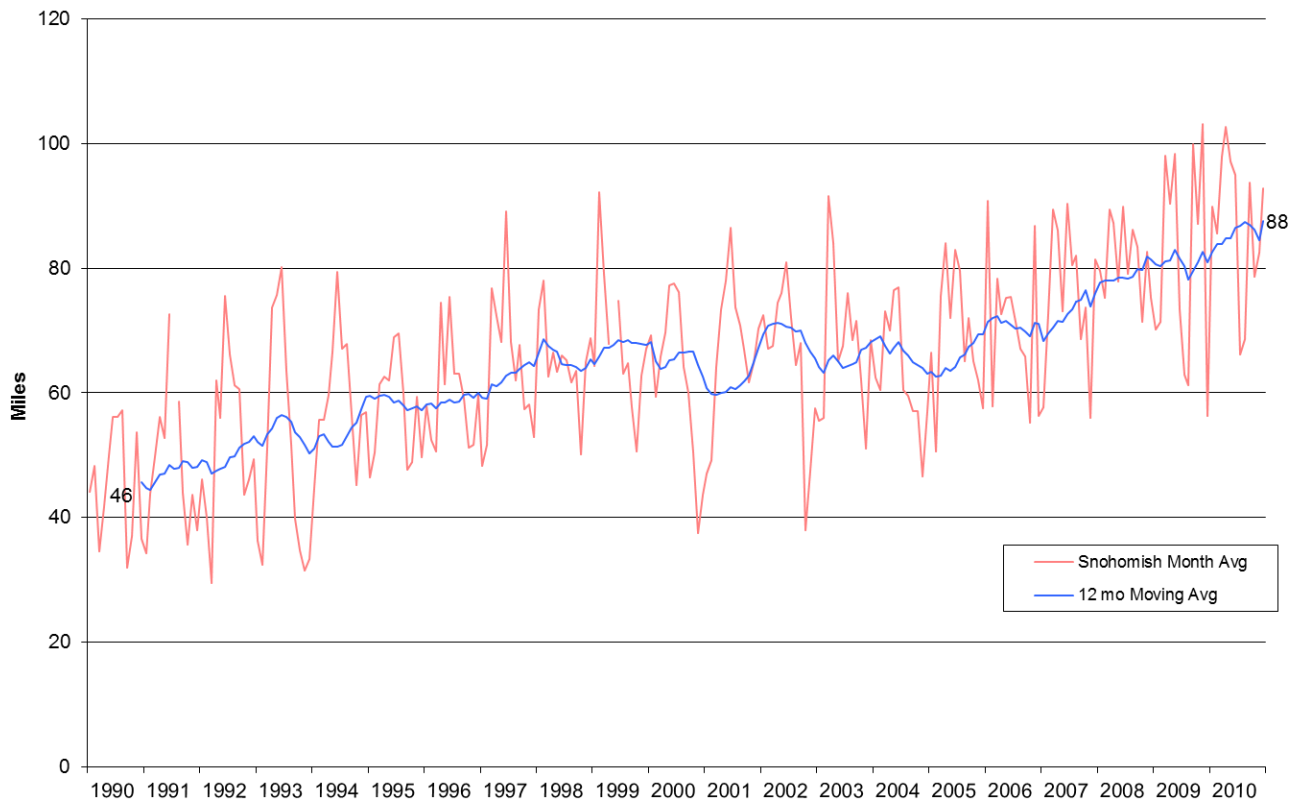


Figure 38: Snohomish County Visibility



AIR TOXICS

Air toxics are broadly defined as over 400 pollutants that the Agency considers potentially harmful to human health and the environment. Washington State Department of Ecology (Ecology) monitored for air toxics in 2010 at the Seattle Beacon Hill site. The Beacon Hill site is part of an EPA-sponsored network of National Air Toxic 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). We provide a short description of health effects associated with each air toxic and their sources.

From November 2008 to October 2009, we sampled for air toxics at four additional sites in Seattle and Tacoma as part of an EPA-funded air toxics study. For more details, see our report at http://www.pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.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-16 of the Appendix.

RELATIVE RANKING BASED ON CANCER RISK & UNIT RISK FACTORS

Table 4 ranks 2010 air toxics from the Beacon Hill monitoring site according to mean potential cancer risk per million. It shows monitored pollutants ranked from highest concern/risk (#1) to lowest, based on ambient concentrations multiplied by unit risk factors. A unit risk factor takes into account how toxic a pollutant is. Potential cancer risk estimates are shown here to provide a meaningful basis of comparison between pollutants, and are not intended to represent any one community or individual 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 over a lifetime (set at 70 years). 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 pages A-17 and A-18 in the Appendix.

Risks presented in this table are based on annual average ambient (outside) concentrations. Risks based on 95th percentile concentrations (a more protective statistic than presented in Table 4) are presented on page A-18 of the Appendix. Page A-18 also lists the frequency (percentage) of samples that were over the cancer screening level of one-in-a-million risk.

³⁷US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, February 2006; http://www.epa.gov/region4/air/airtoxic/Screening_111610_KMEL.pdf

Table 4: 2010 Beacon Hill Air Toxics Ranking
(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk*
Carbon Tetrachloride	1	30
Benzene	2	20
1,3-Butadiene	3	11
Chromium VI (TSP)	4	4
Formaldehyde	5	4
Chloroform	6	3
Dichloromethane	7	3
Acetaldehyde	8	2
Naphthalene	9	2
Arsenic (PM ₁₀)	10	2
Nickel (PM ₁₀)	11	1
Tetrachloroethylene	12	< 1
Cadmium (PM ₁₀)	13	< 1
Manganese (PM ₁₀)	14	< 1
Lead (PM ₁₀)	15	< 1

*Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level (WAC 173-460-150)³⁸

M = metal

PM₁₀ = fine particles less than 10 micrometers in diameter

TSP = total suspended particulate

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.

³⁸Washington State Administrative Code WAC 173-460-150, <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150>

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 risks, 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.³⁹ 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-19 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 2010 at Beacon Hill. An 11-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 2010. 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.

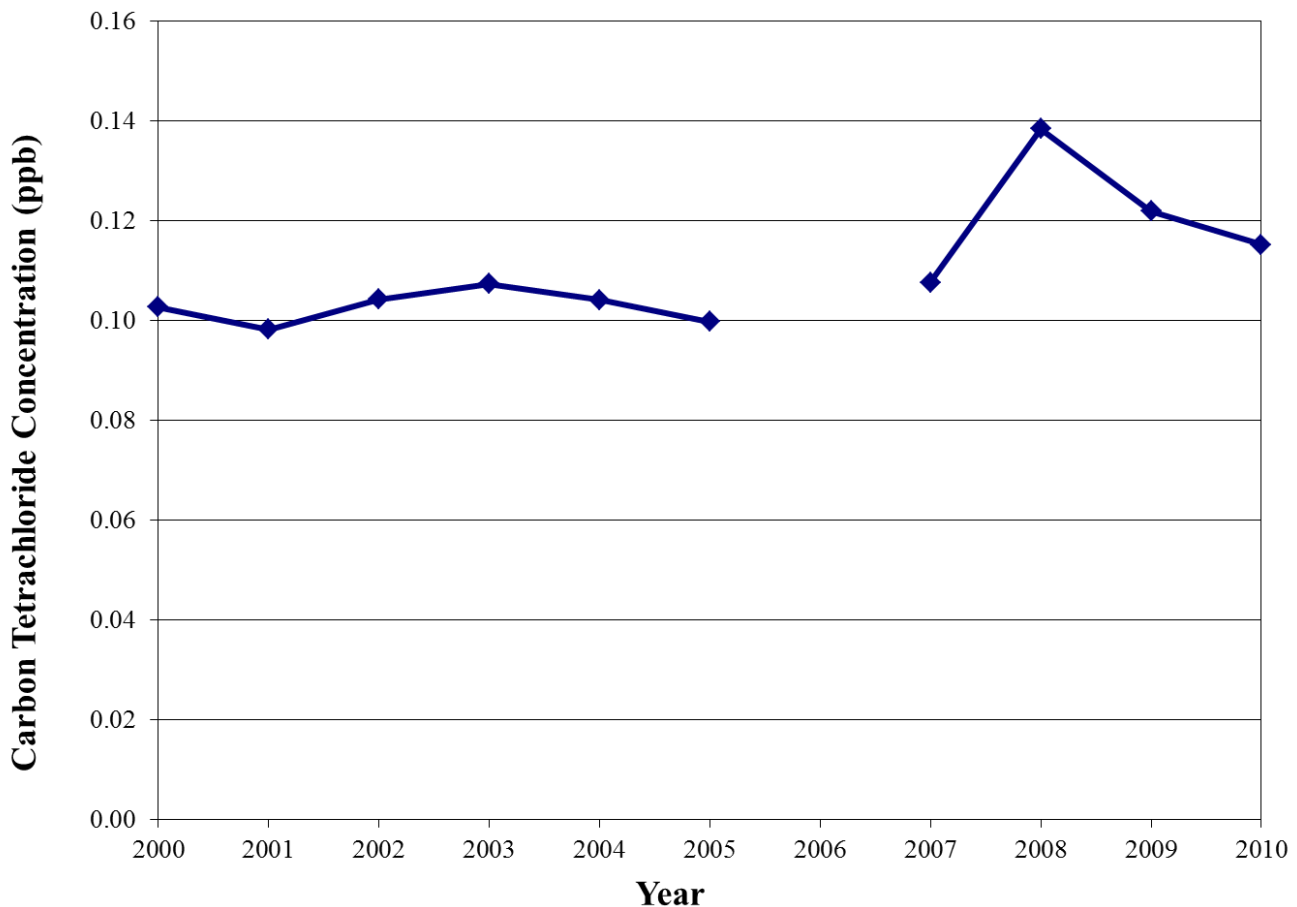
³⁹EPA, Acrolein Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/acrolein.html>.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.⁴⁰ It was widely used as a solvent for both industry and consumer users, and was banned from consumer use in 1995. Trace amounts are still emitted by local sewage treatment plants. Carbon tetrachloride is relatively ubiquitous and has a long half-life, and concentrations are similar in urban and rural areas. Carbon tetrachloride's 2010 average potential cancer risk range estimate at Beacon Hill was 30 in a million.

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

Figure 39: Carbon Tetrachloride Annual Average Concentrations at Beacon Hill, 2000-2010



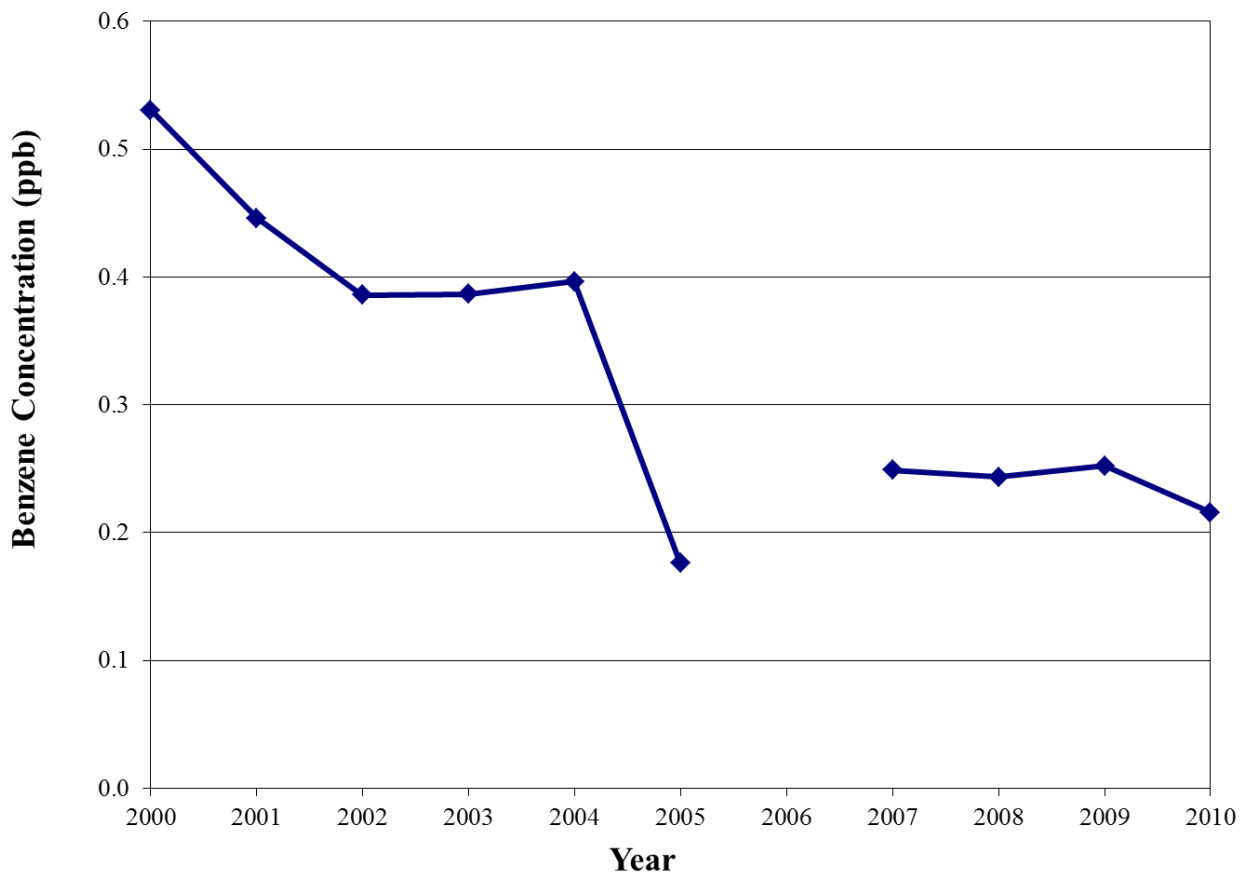
⁴⁰EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/carbonte.html>.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune, and nervous system disorders.⁴¹ This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvents, and other combustion. Benzene's 2010 average potential cancer risk range estimate at Beacon Hill was 20 in a million.

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

Figure 40: Benzene Annual Average Concentrations at Beacon Hill, 2000-2010



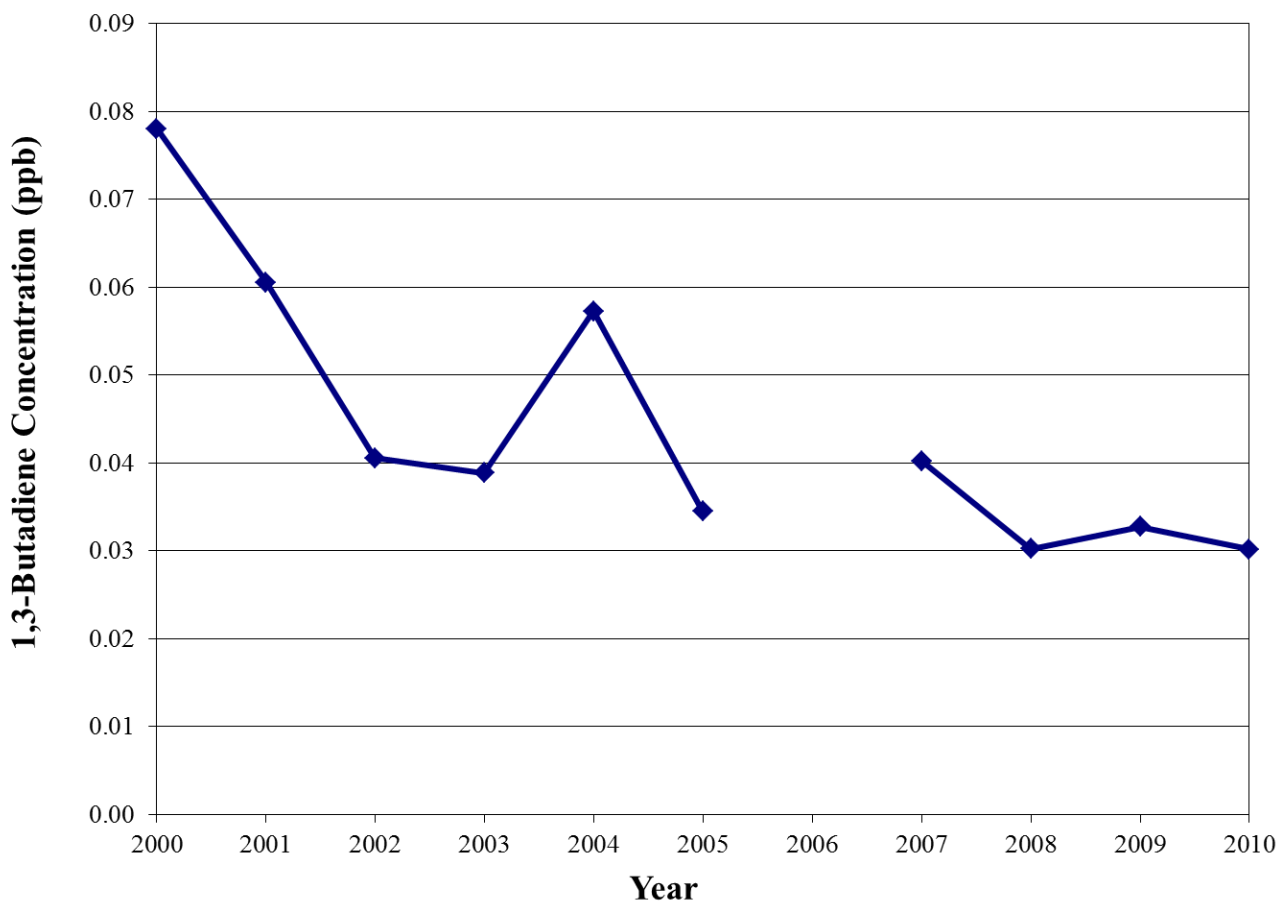
⁴¹EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/benzene.html>.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.⁴² Primary sources of 1,3-butadiene include cars, trucks, buses, and wood burning. 1,3-butadiene's 2010 average potential cancer risk estimate at Beacon Hill was 11 in a million.

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

Figure 41: 1,3-Butadiene Annual Average Concentrations at Beacon Hill, 2000-2010



⁴²EPA Hazard Summary; <http://www.epa.gov/ttnatw01/hlthef/butadien.html>.

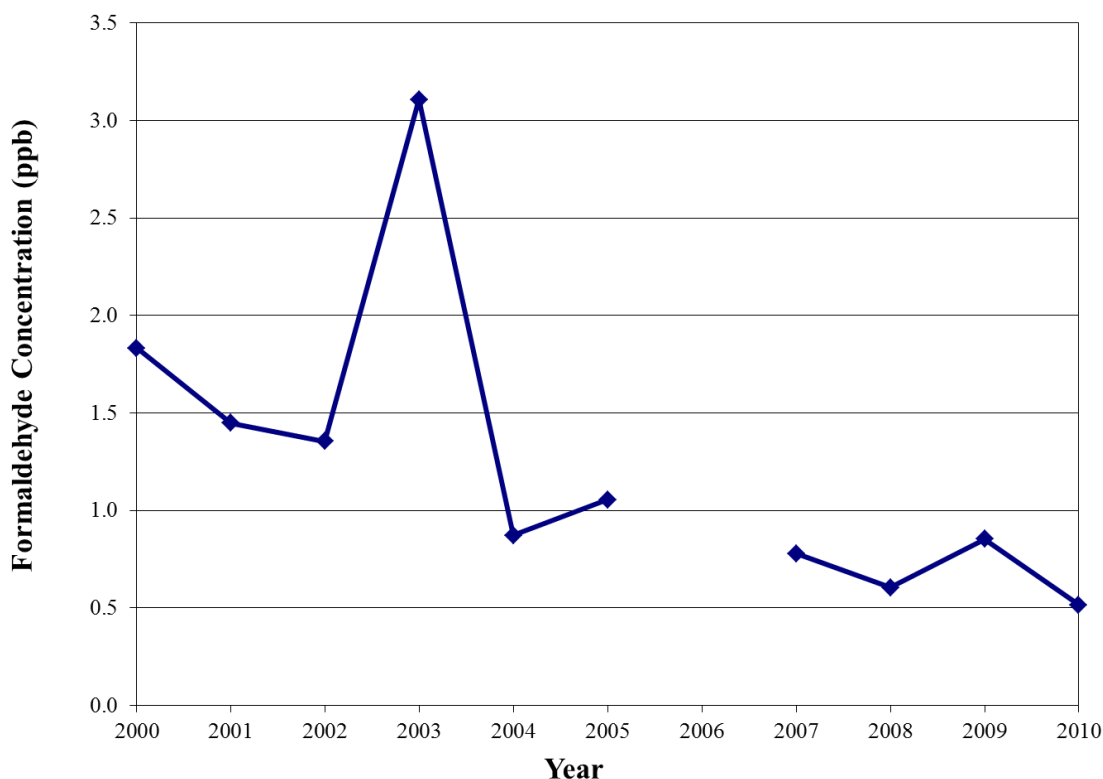
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat, and lung irritation.⁴³ Sources of ambient formaldehyde include automobiles, trucks, wood burning, and other combustion. Formaldehyde's 2010 average potential cancer risk range estimate at Beacon Hill was 4 in a million.

The increase in formaldehyde 2003 concentrations is due to 9 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 42: Formaldehyde Annual Average Concentrations at Beacon Hill, 2000-2010



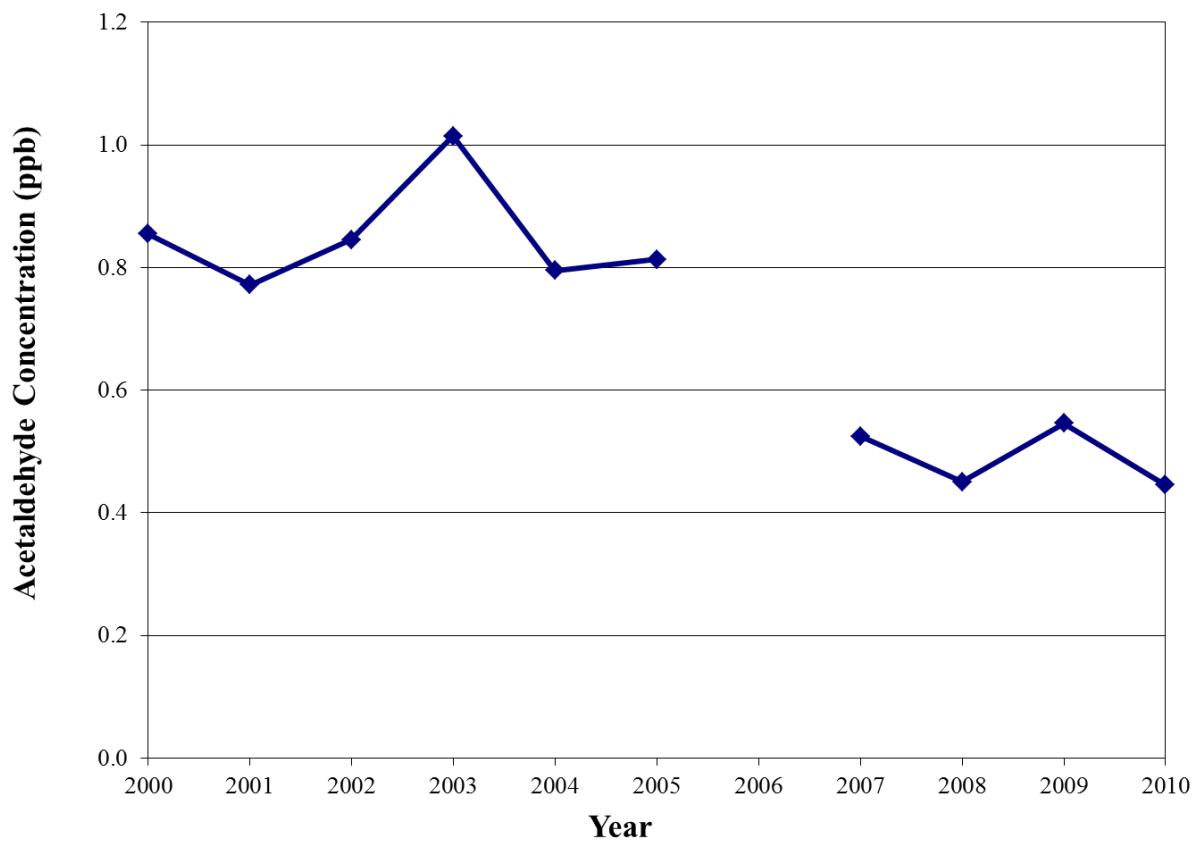
⁴³EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/formalde.html>.

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.⁴⁴ Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2010 average potential cancer risk estimate at Beacon Hill was 3 in a million.

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

Figure 43: Acetaldehyde Annual Average Concentrations at Beacon Hill, 2000-2010



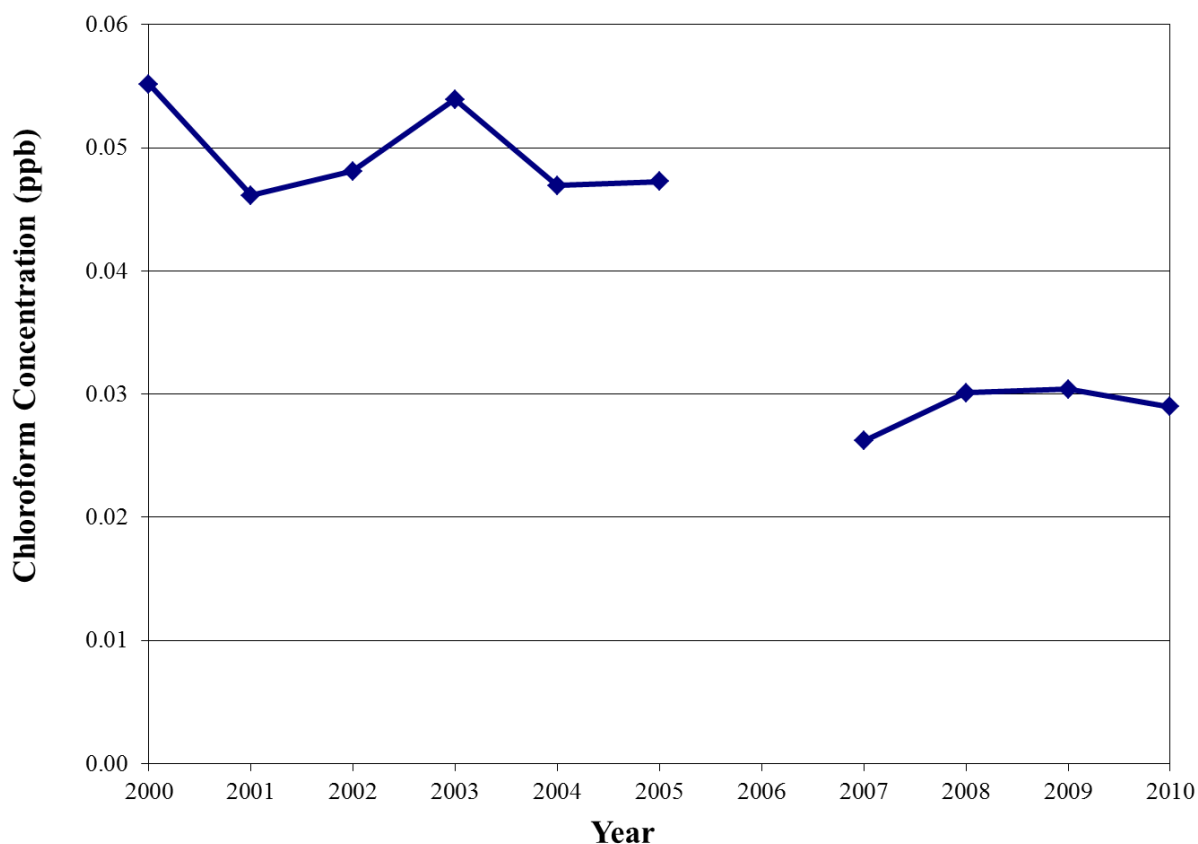
⁴⁴EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/acetalde.html>.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.⁴⁵ Main sources of chloroform are water treatment plants and reservoirs. Since the Beacon Hill monitoring site is located at the Beacon Hill reservoir, the chloroform data may be biased high. However, it is still useful to calculate and assess the long-term trend and potential risk. Chloroform's 2010 average potential cancer risk range estimate at Beacon Hill was 3 in a million.

The Agency does not prioritize efforts to reduce chloroform emissions, as it does not likely present risk in areas other than those directly adjacent to reservoirs.⁴⁶

Figure 44: Chloroform Annual Average Concentrations at Beacon Hill, 2000-2010



⁴⁵EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/chlorofo.html>.

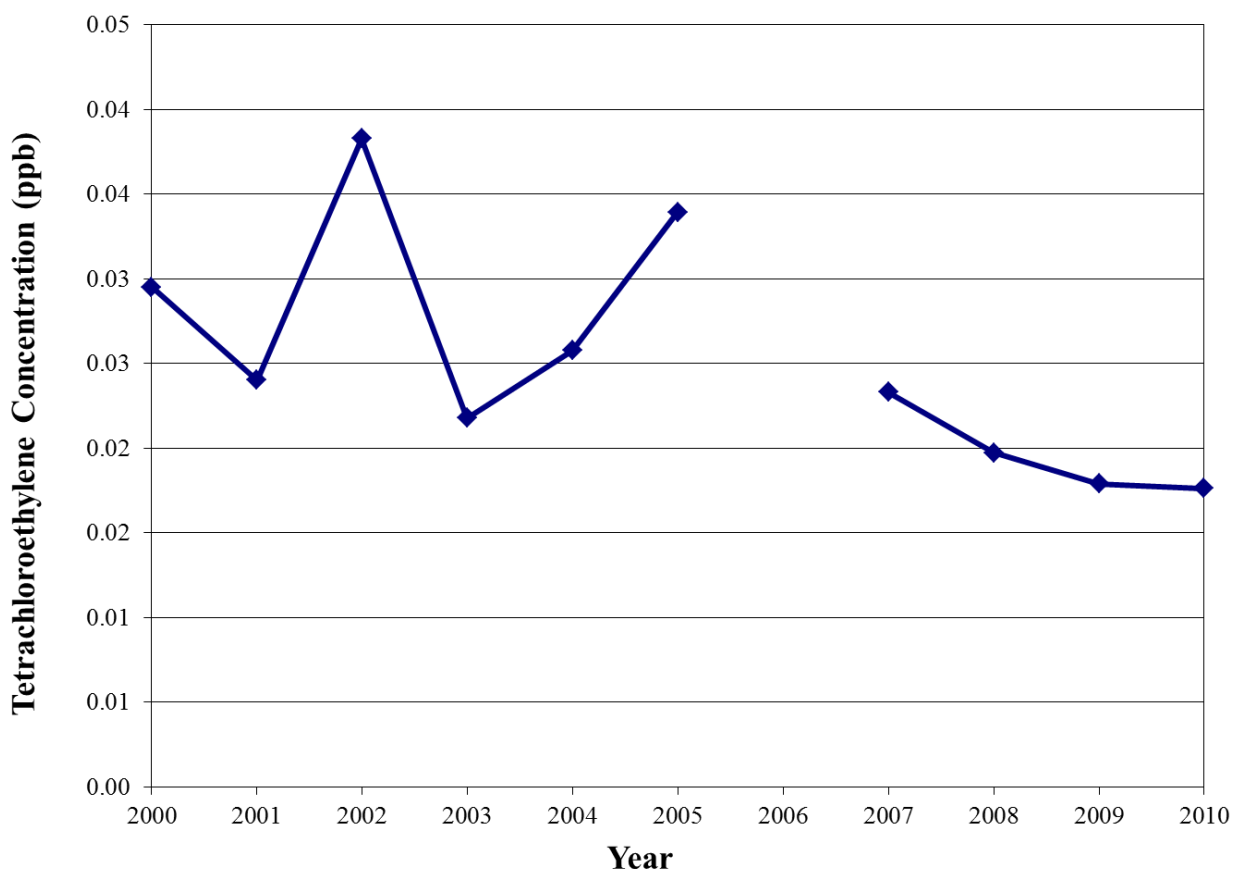
⁴⁶Seattle Public Utilities. 2008 Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/stellent/groups/public/@spu/@fom/documents/webcontent/spu01_003889.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform; http://www.ci.seattle.wa.us/util/About_SPU/Water_System/Water_Quality/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.⁴⁷ Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene’s 2010 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.⁴⁸

Figure 45: Tetrachloroethylene Annual Average Concentrations at Beacon Hill, 2000-2010



⁴⁷EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html>.

⁴⁸Agency Regulation III, Section 3.03; <http://www.pscleanair.org/regulated/businesses/regulations.aspx>.

Dichloromethane

EPA lists dichloromethane as a probable human carcinogen. Dichloromethane is also associated with central nervous system effects.⁴⁹ Local sources of dichloromethane include solvents used in paint stripping and cleaning. Dichloromethane's 2010 average potential cancer risk estimate at Beacon Hill was 3 in a million. The Agency works with and regulates solvent-using businesses to reduce dichloromethane emissions.

Naphthalene

EPA lists naphthalene as a possible human carcinogen. Naphthalene is similarly associated with repertory effects and retina damage.⁵⁰ Local sources of naphthalene include the manufacturing of mothballs, coal-tar production, and a general byproduct of combustion of wood and heavy fuels. Naphthalene's 2010 average potential cancer risk estimate at Beacon Hill was 3 in a million. Since naphthalene is below one-in-a-million cancer risk most other years, no graph of estimated concentrations is presented.

The Agency works with and regulates wood burning through burn bans and wood stove replacement programs to reduce naphthalene emissions.

METALS

Table 4 (2010 Beacon Hill Air Toxics Ranking), shown previously in this section, includes estimated potential cancer risks for several PM₁₀ 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-19).

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 (trivalent and hexavalent) in our air. 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.⁵¹ 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 4 in a million.

⁴⁹EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/methylen.html>.

⁵⁰EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/naphthal.html>.

⁵¹EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/chromium.html>.

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

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation, and liver and kidney damage.⁵² Arsenic is used to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2010 average potential cancer risk range estimate at Beacon Hill was 2 in a million.

Nickel

EPA lists nickel as a known human carcinogen. Nickel is also associated with dermatitis and respiratory effects.⁵³ Combustion of gasoline and diesel fuels (car, truck, and bus exhaust) is a main source of nickel in the Puget Sound area. Nickel's 2010 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.⁵⁴ Combustion of distillate oil is a main source of cadmium in the Puget Sound area. Cadmium's 2010 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 associated with reproductive and digestive effects.⁵⁵ 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 2010 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

EPA lists lead 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 55.

⁵²EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/arsenic.html>.

⁵³EPA Hazard Summary; <http://www.epa.gov/iris/subst/0273.htm>.

⁵⁴EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/cadmium.html>.

⁵⁵EPA 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.⁵⁶ Beryllium sources include combustion of coal and fuel oil that contain beryllium, and tobacco smoke. Beryllium's 2010 average potential cancer risk estimate was less than one-in-a-million, based on estimated concentrations. More than 50% of the beryllium dataset was below the minimum detection limit.

Manganese

EPA lists manganese as “not classifiable” for cancer. Manganese exposures are primarily associated with central nervous system effects.⁵⁷ 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. 2010 manganese levels in the Puget Sound area are below levels indicating health risk, with a hazard index of less than one.

⁵⁶EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/berylliu.html>.

⁵⁷EPA National Air Toxics Assessment; <http://www.epa.gov/ttnatw01/hlthef/manganes.html>.

DEFINITIONS

GENERAL DEFINITIONS

Air Quality Index

Table 5: 2010 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
O ₃ (ppm) 8-hour	O ₃ (ppm) 1-hour ^(a)	PM _{2.5} (µg/m ³)	PM ₁₀ (µg/m ³)	CO (ppm)	SO ₂ ^(e) (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	—	15.5–35.4 ^(d)	55–154	4.5–9.4	0.035–0.074	(b)	51–100	Moderate
0.076–0.095	0.125–0.164	35.5–55.4 ^(d)	155–254	9.5–12.4	0.075–0.184	(b)	101–150	Unhealthy for sensitive groups
0.096–0.115	0.165–0.204	55.5–150.4	255–354	12.5–15.4	0.185–0.304	(b)	151–200	Unhealthy
0.116–0.374	0.205–0.404	150.5–250.4	355–424	15.5–30.4	0.305–0.804	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	
(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	Hazardous

^(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) NO₂ has no short-term National Ambient Air Quality Standard (NAAQS) and can generate an AQI only above a value of 200.

^(c) 8-hour O₃ values do not define higher AQI values (above 300). AQI values above 300 are calculated with 1-hour O₃ concentrations.

^(d) Although EPA changed the PM_{2.5} standard in 2006, EPA has not yet revised the AQI breakpoints to reflect the revised PM_{2.5} daily standard. On January 15, 2009, EPA proposed to change the AQI to be reflective of the levels of the federal standard (that is, the “unhealthy for sensitive groups” category will start at 35.4 µg/m³, instead of the current 40.4 µg/m³). As a result, we amended the AQI to reflect the proposed change. That is, the AQI for PM_{2.5} in this document may have a slight increase in the number of days in the “unhealthy for sensitive groups” range than in it may have had based on the older definition.

^(e) EPA changed the SO₂ standard on June 22, 2010 to be based on an hourly maximum instead of a 24-hour and annual average.

For more information on the AQI see <http://www.airnow.gov/index.cfm?action=aqibasics.aqi>.

Air shed

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 the 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 Agency Regulation III.

Criteria Air Pollutant (CAP)

The Clean Air Act of 1970 defined *criteria pollutants* and provided EPA the authority to establish ambient concentration standards for these criteria pollutants to protect public health. EPA periodically revises the original concentration limits and methods of measurement, most

recently in 2011. The six criteria air pollutants are: particulate matter (10 micrometers and 2.5 micrometers), ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead.

ppm, ppb (parts per million, or parts per billion)

A unit of concentration used for a many air pollutants. A ppm (ppb) means one molecule of the pollutant per million (or billion) molecules of air.

Hazardous Air Pollutant (HAP)

A *hazardous air pollutant* is an air contaminant listed in the Federal Clean Air Act, Section 112(b). EPA currently lists 188 pollutants as HAPs at <http://www.epa.gov/ttn/atw/188polls.html>.

Temperature Inversions

Air temperature usually decreases with altitude. On a sunny day, air near the surface is warmed and is free to rise. The warm surface air can rise to altitudes of 4000 feet or more and is dispersed (or mixed) into higher altitudes. In contrast, on clear nights with little wind, the surface can cool rapidly (by 10 degrees or more), which also cools the air just above the surface. The air aloft does not cool, which creates a very stable situation where the warm air aloft effectively caps the cooler air below. This limits mixing to just a few hundred feet, or less. This situation is called a temperature inversion and allows for pollutants to accumulate to high concentrations.

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.

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) a black object can be seen 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. Reduced visibility (or visual range) is caused by weather (clouds, fog, and rain) and air pollution (fine particles and gases).

Volatile Organic Compound (VOC)

An organic compound that participates in atmospheric photochemical reactions. This excludes compounds determined by EPA to have negligible photochemical reactivity.

2010

Air Quality Data Summary Appendix

April 2012

Air Quality Index 1980 – 2010

King County															
Days in Each Air Quality Category						Pollutant Determining the AQI							Highest Value		
Year	Good Moderate		Unhealthy for Sensitive Groups		Very Unhealthy	All Days				Unhealthy Days			AQI	Date	Pollutant
						PM	CO	SO ₂	O ₃	PM	CO	O ₃			
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	0	53	5	0	2	114	Nov 21	PM
2001	273	86	6	0	0	295	10	0	60	6	0	0	118	Nov 10	PM
2002	262	99	4	0	0	275	11	0	79	4	0	0	113	Nov 27	PM
2003	268	95	2	0	0	250	5	0	110	0	0	2	132	Jun 6	O ₃
2004	256	105	5	0	0	280	2	0	84	4	0	1	132	Dec 18	PM
2005	254	106	5	0	0	302	3	0	60	5	0	0	117	Dec 11	PM
2006	268	87	6	4	0	273	2	0	90	6	0	4	169	Jul 22	O ₃
2007	285	77	3	0	0	278	0	0	87	2	0	1	115	Jan 29	PM
2008	287	76	3	0	0	306	0	0	60	0	0	3	140	Jun 29	O ₃
2009	272	88	4	1	0	254	0	0	111	1	0	4	154	Jul 5	PM
2010	<u>320</u>	<u>44</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>261</u>	<u>0</u>	<u>0</u>	<u>104</u>	<u>0</u>	<u>0</u>	<u>1</u>	104	Aug 17	O ₃
Totals	6970	4184	52	111	6	5389	4723	61	1150	59	83	27			
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 (PM₁₀).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM_{2.5}) and 8-hour ozone (O₃) standards. The O₃ standard was again revised in March 2008.

Air Quality Index 1990 – 2010

Kitsap County																
Days in Each Air Quality Category						Pollutant Determining the AQI							Highest Value			
Year	Good	Moderate	Unhealthy		Very Unhealthy	All Days				Unhealthy Days			AQI	Date	Pollutant	
			for Sensitive Groups	Unhealthy		PM	CO	SO ₂	O ₃	PM	CO	O ₃				
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
2009	300	37	2	0	0	339					2			111	Dec 3	PM
2010	<u>321</u>	<u>31</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>352</u>					<u>0</u>			88	Dec 31	PM
Totals	6367	493	5	1	0	6314	552	0	0	6	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 (PM₁₀).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM_{2.5}) and 8-hour ozone (O₃) standards. The O₃ standard was again revised in March 2008.

Air Quality Index 1980 – 2010

Pierce County															
Days in Each Air Quality Category						Pollutant Determining the AQI								Highest Value	
Year	Good Moderate		Unhealthy for Sensitive Groups		Very Unhealthy	All Days				Unhealthy Days			AQI	Date	Pollutant
						PM	CO	SO ₂	O ₃	PM	CO	O ₃			
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	0	46	14	0	0	153	Dec 6	PM
2001	271	83	11	0	0	306	2	0	57	11	0	0	139	Nov 10	PM
2002	267	88	9	1	0	291	1	0	73	10	0	0	158	Nov 27	PM
2003	265	92	8	0	0	264	1	0	100	8	0	0	122	Jan 7	PM
2004	251	110	5	0	0	272	0	0	94	5	0	0	133	Nov 5	PM
2005	275	82	8	0	0	276	2	0	87	8	0	0	120	Dec 10	PM
2006	283	71	7	4	0	270	0	0	95	8	0	3	170	Dec 17	PM
2007	298	57	10	0	0	261	0	0	104	9	0	1	137	Jan 29	PM
2008	295	63	8	0	0	259	0	0	107	5	0	3	129	Aug 16	O ₃
2009	284	66	14	1	0	250	0	0	115	15	0	0	158	Jul 5	PM
2010	<u>324</u>	<u>41</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>259</u>	<u>0</u>	<u>0</u>	<u>106</u>	<u>0</u>	<u>0</u>	<u>0</u>	83	Dec 5	PM
Totals	7535	3596	96	91	5	7738	2101	293	1191	114	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 (PM₁₀).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM_{2.5}) and 8-hour ozone (O₃) standards. The O₃ standard was again revised in March 2008.

Air Quality Index 1980 – 2010

Snohomish County															
Days in Each Air Quality Category						Pollutant Determining the AQI								Highest Value	
Year			Unhealthy for Sensitive Groups		Very Unhealthy	All Days				Unhealthy Days			AQI	Date	Pollutant
						PM	CO	SO ₂	O ₃	PM	CO	SO ₂			
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	0	1	0	0	153	Dec 22	PM
1999	300	62	3	0	0	260	105	0	0	3	0	0	129	Jan 3	PM
2000	253	79	5	0	0	301	36	0	0	5	0	0	113	Jul 4	PM
2001	290	73	2	0	0	356	9	0	0	2	0	0	111	Nov 10	PM
2002	288	69	8	0	0	343	22	0	0	8	0	0	116	Nov 4	PM
2003	282	80	3	0	0	364	1	0	0	3	0	0	108	Nov 4	PM
2004	290	74	2	0	0	364	2	0	0	2	0	0	107	Nov 5	PM
2005	288	72	5	0	0	360	5	0	0	5	0	0	139	Dec 11	PM
2006	301	57	7	0	0	364	1	0	0	7	0	0	143	Dec 17	PM
2007	288	70	6	1	0	365	0	0	0	7	0	0	155	Jan 15	PM
2008	294	72	0	0	0	366	0	0	0	0	0	0	96	Dec 19	PM
2009	269	84	12	0	0	365	0	0	0	12	0	0	117	Jul 5	PM
2010	<u>324</u>	<u>41</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>365</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	98	Nov 24	PM
Totals	8681	2527	53	21	0	6545	4468	236	33	55	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 (PM₁₀).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle (PM_{2.5}) and 8-hour ozone (O₃) standards. The O₃ standard was again revised in March 2008.

Monitoring Methods Used from 1999 to 2010 in the Puget Sound Air shed

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
SO ₂	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 – 2010

1988	Dec 4 (1500) - Dec 7 (1800)
Jan 25(0830) - Jan 28 (0830)	
Feb 5 (1630) - Feb 6 (0930)	1998 None
Dec 1 (1430) - Dec 2 (0800)	
Dec 4 (1430) - Dec 5 (1400)	1999
Dec 16 (1430) - Dec 18 (1430)	Jan 5 (1400) - Jan 6 (1000)
	Dec 29 (1400) - Dec 31 (0600)
1989	
Jan 19 (1430) - Jan 20 (1430)	
Jan 24 (1430) - Jan 26 (0930)	2000
Feb 6 (1430) - Feb 8 (0930)	Feb 18 (1400) - Feb 20 (1000)
Feb 10 (1430) - Feb 16 (0930)	Nov 15 (1700) - Nov 23 (0600)
Nov 29 (1430) - Dec 2 (0930)	
Dec 22 (1430) - Dec 23 (1430)	2001
	Nov 8 (1400) - Nov 12 (1800)
1990	
Jan 19 (1430) - Jan 21 (1430)	2002
Dec 7 (1430) - Dec 8 (0930)	Nov 1 (1500) - Nov 6 (0900)
Dec 25 (1430) - Dec 27 (0815)*	Nov 27 (1000) - Dec 4 (1000)
*(Dec 26 1430 - Dec 27 0815) 2 nd Stage	
	2003
1991	Jan 7 (1500) - Jan 9 (1300)
Jan 5 (1430) - Jan 6 (0930)	
Jan 21 (1430) - Jan 24 (1500)*	2004 None
*(Jan 22 0930 - Jan 24 1500) 2 nd Stage	
Jan 29 (1430) - Jan 31 (0830)	2005
Dec 15 (1430) - Dec 17 (1430)*	Feb 21 (1600) - Feb 28 (0800)
*(Dec 16 1430 - Dec 17 0930) 2 nd Stage	Dec 9 (1700) - Dec 18 (1200)
1992	2006 None
Jan 8 (1430) - Jan 9 (0930)	
Jan 19 (1430) - Jan 20 (1430)	2007
Feb 5 (1000) - Feb 6 (1430)	Jan 13 (1400) - Jan 16 (1500)
Nov 25 (1430) - Nov 26 (1430)	Jan 28 (1400) - Jan 31 (1400)
	Dec 9 (1400) - Dec 11 (0930)
1993	
Jan 11 (1430) - Jan 13 (0830)	2008
Jan 15 (1430) - Jan 16 (0700)	Jan 23 (1400) - Jan 26 (1200)
Jan 17 (1430) - Jan 19 (0600)	
Jan 31 (1430) - Feb 3 (0830)	2009
Dec 20 (1430) - Dec 21 (1430)	Jan 16 (1200) - Jan 24 (1200)
Dec 26 (1430) - Dec 29 (0830)	Feb 3 (1400) - Feb 6 (0900)
	Dec 8 (1000) - Dec 13 (1000)
1994	Dec 23 (1600) - Dec 30 (1200)
None	
1995	
Jan 4 - Jan 7	2010
	Jan 28 (1200) - Jan 31 (1000)
1996	Dec 30 (1700) - 31 Dec (2400)*
Feb 14 (1430) - Feb 16 (1630)	*continued to Jan 4 (1700)
1997	
Nov 13 (1500) - Nov 15 (1500)	

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

Micrograms per Cubic Meter

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

2010

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	120	6.5	3.5	5.6	9.1	6.2	24.1	26.8
Marysville JHS, 1605 7th St, Marysville	361	8.5	4.8	6.7	8.3	7.1	22.1	27.4
7802 South L St, Tacoma	341	9.2	4.1	5.8	9.0	6.9	21.4	26.8

Notes:

(1) Sampling occurs for a 24 hour period from midnight to midnight.

Quarterly averages are shown only if 75% 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	Oct 17 Sun	Nov 24 Wed	Dec 31 Fri
Darrington HS, 1085 Fir St, Darrington	--	--	27
Marysville JHS, 1605 7th St Marysville			27
7802 South L St, Tacoma			27

-- Indicates no sample on specified day

Air Quality Index Summary

Location	Unhealthy for Sensitive Groups			
	Good	Moderate		Unhealthy
Darrington HS, 1085 Fir St, Darrington	113	7	0	0
Marysville JHS, 1605 7 th St, Marysville	333	28	0	0
7802 South L St, Tacoma	313	28	0	0

PARTICULATE MATTER (PM2.5) – Continuous -TEOM

Micrograms per Cubic Meter

Equivalent Sampling Methods: Mass Transducer R&P TEOM 1400ab-8500 FDMS Teflon-coated Glass Fiber

2010

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98 th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	321	6.4	3.0	3.8	9.3	5.6	22.0	34.7
Marysville JHS, 1605 7th St, Marysville	304		4.7	6.2	7.8	6.2	20.9	27.4
6120 212th St SW, Lynnwood	334	6.3	3.7	5.6	6.1	5.4	17.6	21.0
17171 Bothell Way NE, Lake Forest Park	34						22.0	22.0
Duwamish, 4752 E Marginal Way S, Seattle	344	10.6	9.2	11.4	10.3	10.4	21.0	28.2
James St & Central Ave, Kent	283		5.2	7.2			17.1	27.7
7802 South L St, Tacoma	317	10.0	4.5	6.1	9.3	7.5	20.5	26.4
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	298		4.4	5.5	7.9	5.9	17.4	26.0

Notes

- (1) Sampling occurs continuously for 24 hours each day.
Quarterly averages are shown only if 75% or more of the data is available.
- (2) Annual averages are shown only if there are at least three quarterly averages.
- (3) Lake Forest Park site was sampled using Mass Transducer R&P TEOM 1400ab only.

Summary of Maximum Observed Concentrations

Location	Jan 27 Wed	Aug 16 Mon	Oct 18 Mon	Nov 23 Tue	Nov 24 Wed	Nov 25 Thu	Dec 4 Sat
Darrington HS, 1085 Fir St, Darrington		--			35		
Marysville JHS, 1605 7th St, Marysville							27
6120 212th St SW, Lynnwood				21			
17171 Bothell Way NE, Lake Forest Park	22						
Duwamish, 4401 E Marginal Way S, Seattle		28					
James St & Central Ave, Kent						28	
7802 South L St, Tacoma			26				
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co				26			

-- Indicates no sample on specified day

PARTICULATE MATTER (PM2.5) – Continuous - Nephelometer

Micrograms per Cubic Meter

Sampling Method: Equivalent - Radiance Research M903 Nephelometer

2010

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98 th Percentile	Daily Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	346	7.4	3.3	5.4	7.6	5.8	20.6	22.9
Marysville JHS, 1605 7th St, Marysville	363	8.0	4.7	7.1	7.9	6.9	20.6	27.2
6120 212th St SW, Lynnwood	312	5.9		6.6	7.3	6.1	19.7	26.9
17171 Bothell Way NE, Lake Forest Park	356	6.9	4.4	7.3	8.1	6.6	19.2	30.6
Queen Anne Hill, 400 W Garfield St, Seattle	320	6.0	5.3		6.3	6.3	14.9	21.4
Olive & Boren, Seattle	349	5.2	4.8	7.3	6.7	5.9	15.5	20.4
15 th S & Charlestown, Beacon Hill, Seattle	112	4.9					10.4	13.1
Duwamish, 4752 E Marginal Way S, Seattle	351	9.0	6.9	9.5	8.7	8.5	18.0	26.1
South Park, 8025 10 th Ave S, Seattle	358	8.7	6.8	9.2	9.4	8.5	18.5	23.5
305 Bellevue Way NE, Bellevue	365	4.1	3.2	4.9	4.4	4.2	9.9	16.9
42404 SE North Bend Way, North Bend	355	3.2	3.9	7.2	4.8	4.8	13.1	27.9
James St & Central Ave, Kent	363	5.6	5.3	8.3	8.3	6.9	18.9	27.6
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	335	7.5	5.1	7.3	8.5	7.0	18.3	25.5
7802 South L St, Tacoma	344	8.2	4.1	6.4	8.8	6.8	20.6	27.4
South Hill, 9616 128 th St E, Puyallup	363	8.2	3.8	6.3	7.7	6.5	18.7	28.6
30525 SE Mud Mountain Road, Enumclaw	285	1.7	2.6	4.9		3.1	9.6	18.2
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	352	11.6	3.2	4.9	7.3	6.5	24.8	30.4

Notes

- (1) Sampling occurs continuously for 24 hours each day.
Quarterly averages are shown only if 75% or more of the data is available.
- (2) All data values are correlated using site-specific relationships with Federal Reference Method samplers.

Summary of Maximum Observed Concentrations

Location	Jan 23 Sat	Jan 27 Wed	Aug 5 Thu	Aug 16 Mon	Aug 17 Tue	Oct 18 Mon	Nov 23 Tue	Dec 4 Sat	Dec 5 Sun	Dec 6 Mon	Dec 31 Fri
Darrington HS, 1085 Fir St, Darrington	23						--				
Marysville JHS, 1605 7th St, Marysville								27			
6120 212th St SW, Lynnwood							27				
17171 Bothell Way NE, Lake Forest Park							31	--	--	--	
Queen Anne Hill, 400 W Garfield St, Seattle				21							
Olive & Boren, Seattle				20							
15 th S & Charlestown, Beacon Hill, Seattle		13	--	--	--	--	--	--	--	--	--
Duwamish, 4752 E Marginal Way S, Seattle				26		--					
South Park, 8025 10 th Ave S, Seattle					24						
305 Bellevue Way NE, Bellevue				17							
42404 SE North Bend Way, North Bend				28							
James St & Central Ave, Kent					28						
Tacoma Tideflats, 2301 Alexander Ave, Tacoma							--			26	
7802 South L St, Tacoma						27					
South Hill, 9616 128 th St E, Puyallup									29	--	
30525 SE Mud Mountain Road, Enumclaw				18		--	--	--	--	--	--
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co											30

-- Indicates no sample on specified day

PM_{2.5} Speciation Analytes Monitored in 2010
Average Annual Concentrations in Micrograms per Cubic Meter

Parameter	Beacon Hill	Duwamish	Marysville	South L St	Tideflats
Acceptable Pm2.5 Aqi & Speciation Mass	6.1	8.0	8.4	8.3	7.9
Aluminum Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Ammonium Ion Pm2.5 Lc	0.250	0.254	0.219	0.206	0.230
Antimony Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Arsenic Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Barium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Bromine Pm2.5 Lc	0.002	0.002	0.002	N/A	0.002
Cadmium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Calcium Pm2.5 Lc	0.021	0.085	0.015	0.020	0.043
Cerium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Cesium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Chlorine Pm2.5 Lc	0.050	0.096	0.062	0.081	0.064
Chromium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Cobalt Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Copper Pm2.5 Lc	0.010	0.003	N/A	N/A	0.005
Indium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Iron Pm2.5 Lc	0.052	0.108	0.049	0.046	0.135
Lead Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Magnesium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Manganese Pm2.5 Lc	N/A	0.006	N/A	N/A	0.005
Nickel Pm2.5 Lc	N/A	0.002	N/A	N/A	0.003
Phosphorus Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Potassium Ion Pm2.5 Lc	N/A	N/A	0.058	0.056	N/A
Potassium Pm2.5 Lc	0.039	0.040	0.065	0.060	0.055
Rubidium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Selenium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Silicon Pm2.5 Lc	0.047	0.068	0.040	0.042	0.071
Silver Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Sodium Ion Pm2.5 Lc	0.148	0.192	0.154	0.166	0.147
Sodium Pm2.5 Lc	0.112	0.171	0.111	0.126	0.113
Strontium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Sulfate Pm2.5 Lc	0.822	0.943	0.745	0.747	0.859
Sulfur Pm2.5 Lc	0.281	0.316	0.256	0.262	0.306
Tin Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Titanium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Total Nitrate Pm2.5 Lc	0.609	0.544	0.556	0.561	0.504
Vanadium Pm2.5 Lc	N/A	N/A	N/A	N/A	0.006
Zinc Pm2.5 Lc	0.006	0.021	0.007	0.008	0.012
Zirconium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Elemental Carbon TOR	0.563	1.22	0.725	0.729	1.26
Organic Carbon TOR	1.73	2.45	2.50	2.46	2.57
Total Carbonaceous Mass	2.98	4.65	4.23	4.17	4.86
Soil	0.333	0.619	0.288	0.313	0.634
Reconstructed Fine Mass - Urban PM2.5	5.26	7.27	6.29	6.28	7.41

N/A = Over 50% Below the MDL

25-50% Below the MDL

PM_{2.5} BLACK CARBON
micrograms per cubic meter

Sampling Method: Light Absorption by Aethalometer

2010

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1 st	2 nd	3 rd	4 th		
Marysville JHS, 1605 7th St, Marysville	299		0.6	0.8	1.3	0.9	3.7
Olive & Boren, Seattle	353	1.5	0.8	0.9	1.3	1.1	3.4
Duwamish, 4401 E Marginal Way S, Seattle	354	2.2	0.8	0.9	1.8	1.4	7.1
James St & Central Ave, Kent	344	1.4	0.6	0.8	1.3	1.1	3.5
7802 South L St, Tacoma	358	1.1	0.4	0.5	1.1	0.8	3.1
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	345	1.7	0.7	0.8	1.7	1.2	7.2

Notes

- (1) Sampling occurs continuously for 24 hours each day.
 Quarterly averages are shown only if 75% 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 28 Thu	Jan 29 Fri	Nov 3 Wed	Dec 6 Mon
Marysville JHS, 1605 7th St, Marysville	--		3.7	
Olive & Boren, Seattle	3.4			
Duwamish, 4752 E Marginal Way S, Seattle				7.1
James St & Central Ave, Kent		3.5		
7802 South L St, Tacoma			--	3.1
Tacoma Tideflats, 2301 Alexander Ave, Tacoma			--	7.2

-- Indicates no sample on specified day

OZONE
(parts per million)
2010

Location / Continuous Sampling Period(s)	2010 Six Highest Daily 8-Hour Concentrations		4 th Highest Daily 8-Hour Concentration			3-Year Average of 4 th Highest 8-Hour Concentration
	Value	Date	2008	2009	2010	2008 - 2010
Beacon Hill, 15th S & Charlestown Seattle, Wa 1 Jan-31 Dec	.044 .043 .043 .043 .042 .041	4 Apr 29 Mar 9 May 15 Aug 13 Aug 8 Jul	.047	.049	.043	.046
20050 SE 56 th Lake Sammamish State Park, Wa 1 May-30 Sep	.058 .058 .056 .053 .051 .049	8 Jul 16 Aug 9 Jul 17 Aug 25 Aug 5 Aug	.054	.064	.053	.057
42404 SE North Bend Way, North Bend, Wa 1 May-30 Sep	.068 .067 .064 .063 .059 .054	17 Aug 9 Jul 25 Aug 16 Aug 5 Aug 26 Jul	.058	.063	.063	.061
30525 SE Mud Mountain Road, Enumclaw, Wa 1 May-30 Sep	.077 .075 .073 .068 .067 .061	17 Aug 8 Jul 16 Aug 25 Aug 9 Jul 7 Jul	.075	.076	.068	.073
Charles L Pack Forest La Grande, Wa 17 May-30 Sep	.068 .062 .062 .058 .056 .054	25 Aug 8 Jul 17 Aug 9 Jul 16 Aug 5 Aug	.068	.064	.058	.063
931 Northern Pacific Rd SE, Yelm, Wa 1 May-30 Sep	.060 .058 .058 .054 .054 .051	8 Jul 9 Jul 17 Aug 14 Aug 25 Aug 5 Aug	.060	.060	.054	.058

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)
2010

Monthly and Annual Arithmetic Averages

Location	Monthly Arithmetic Averages												No of 1-Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Beacon Hill, 15th S & Charlestown, Seattle	.015	.018	.014	.012	.010	.007	.010	.012		.014	.014	.014	8217	.013

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	.052	9 Jul	0900
	.052	16 Aug	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)
2010

Location / Continuous Sampling Period(s)	Six Highest Concentrations					Number of 8- Hour Averages Exceedin g 9 ppm	Number of Days 8-Hour Averages Exceeded 9 ppm
	1 Hour Average			8 Hour Average			
	Value	Date	End Time	Value	Date		
2421 148th Ave NE Bellevue 1 Jan-20 Jan	1.4	4 Jan	1700	1.1	4 Jan	0	0
	1.3	7 Jan	1600	1.0	7 Jan		
	1.3	11 Jan	2100	1.0	11 Jan		
	1.3	12 Jan	2000	1.0	12 Jan		
	1.3	18 Jan	1700	0.9	5 Jan		
	1.2	7 Jan	0900	0.9	8 Jan		
Beacon Hill, 15th S and Charlestown Seattle 1 Jan-31 Dec	1.2	1 Mar	0900	0.8	6 Dec	0	0
	1.1	1 Mar	0800	0.7	1 Mar		
	1.0	6 Dec	1700	0.7	16 Jan		
	1.0	2 Mar	0700	0.7	26 Jan		
	0.9	26 Jan	2200	0.7	28 Jan		
	0.9	15 Sep	0600	0.7	27 Jan		

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.

SULFUR DIOXIDE
(parts per million)
2010

Monthly and Annual Arithmetic Averages

Location	Monthly Arithmetic Averages												No of 1-Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Beacon Hill, 15th S & Charlestown, Seattle	.001	.001	.001	.001	.001	.001	.002	.002	.001	.001	.001	.001	8313	.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	.030	20 Mar	0800	.009	16 Aug
	.029	5 Jan	0300	.008	26 Jul

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.

2010 Beacon Hill Air Toxics Statistical Summary for Air Toxic Gases (units in parts per billion)

	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Carbon Tet	Chloroform	Dichloromethane	Formaldehyde	Tetrachloroethylene
2010 Count	59	59	57	59	59	59	59	59	59
NDs (reported as 0)	6	0	0	0	0	0	0	0	7
Median (ppb)	0.028	0.421	0.224	0.220	0.112	0.028	0.316	0.464	0.017
Mean (ppb)	0.030	0.446	0.480	0.216	0.115	0.029	0.721	0.515	0.018
95%tile (ppb)	0.064	0.847	0.611	0.360	0.144	0.045	2.413	1.08	0.039
Max (ppb)	0.090	1.02	8.41	0.430	0.193	0.075	6.640	1.22	0.048
MDL (ppb)	0.010	0.007	0.037	0.019	0.024	0.017	0.023	0.005	0.011
# Below MDL	6	0	2	0	0	0	0	0	16
% Below MDL	10%	0%	4%	0%	0%	0%	0%	0%	27%

ND's were replaced with 1/2 the method detection limit.

2010 Beacon Hill Air Toxics Statistical Summary for PM₁₀ Metals (units in nanograms per cubic meter)

	Arsenic	Cadmium	Chromium	Cr+6 TSP	Lead	Manganese	Nickel	Beryllium	Naphthalene
2010 Count	58	58	58	59	58	58	58	58	58
NDs (reported as 0)	0	1	0	9	0	0	0	17	0
Median (ng/m3)	0.565	0.040	3.35	0.026	2.44	3.78	0.860	0.001	53.4
Mean (ng/m3)	0.584	0.083	3.27	0.028	2.63	5.75	1.94	0.002	61.1
95%tile (ng/m3)	1.20	0.221	4.07	0.063	5.56	15.2	5.17	0.005	113
Max (ng/m3)	2.11	0.436	4.80	0.078	6.23	44.0	10.6	0.014	222
MDL (ng/m3)	0.043	0.078	2.84	0.003	0.827	0.341	1.70	0.001	1.18
# Below MDL	0	33	5	9	0	0	34	34	1
% Below MDL	0%	57%	9%	15%	0%	0%	59%	59%	2%

Toxics in gray are over 50% below the method detection limit.

Estimates of Air Toxics Risk 2010 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:

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

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. Cancer risk was estimated using unit risk factors from the Washington State Acceptable Source Impact Levels (ASIL).¹ The two sources for the ASIL include EPA's Integrated Risk Information System² (IRIS) as well as California EPA's Office of Environmental Health and Hazard Assessment³ (OEHHA).⁴ Both of these sources are based on peer-reviewed literature and extensive review. We present potential cancer risk estimates based on the Washington ASIL values (listed 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.⁵

2010 Air Toxics Unit Risk Factors

AIR TOXIC	WA ASIL 460 UNIT RISK FACTOR RISK/ $\mu\text{g}/\text{m}^3$	CANCER RATING ⁶
Formaldehyde	6.0E-06	B1
Benzene	2.9E-05	A
Carbon Tetrachloride	4.2E-05	B2
Chromium (Hexavalent) (M)	1.5E-01	A
Chloroform	2.3E-05	B2
Arsenic (M)	3.3E-03	A
1,3-Butadiene	1.7E-04	A
Acetaldehyde	2.7E-06	B2
Nickel (Subsulfide) (M)	2.4E-04	A
Tetrachloroethylene	7.4E-06	B2
Cadmium (M)	4.2E-03	B1
Lead (M)	1.2E-05	B2
Dichloromethane	1.0E-06	B2
Naphthalene	3.4E-05	C
Manganese (M)	2.5E-05	D

¹Washington State Administrative Code. <http://apps.leg.wa.gov/wac/default.aspx?cite=173-460-150>.

²Integrated Risk Information System, EPA; <http://www.epa.gov/iris/>.

³California EPA, Consolidated Table of OEHHA/ARB-Approved Risk Assessment Health Values, June 25, 2008; <http://www.arb.ca.gov/toxics/healthval/healthval.htm>.

⁴For details on the ASIL, see: http://www.ecy.wa.gov/laws-rules/wac173460_400/February/ASIL_20list_20pollutants2-8-08-5pm1.pdf.

⁵International Agency for Research on Cancer; <http://monographs.iarc.fr/>.

⁶Ratings per 1986 EPA guidelines.

2010 Beacon Hill Potential Cancer Risk Estimates per 1,000,000 – 95th Percentile percentage of samples greater than cancer screen value

Air Toxic	Rank	RISK based on 95 th Percentile Concentrations Washington ASIL	% of samples > ASIL screen
Carbon Tetrachloride	1	38	100%
Benzene	2	33	100%
1,3-Butadiene	3	24	88%
Chromium VI (TSP)	4	10	85%
Dichloromethane	5	8	19%
Formaldehyde	6	8	95%
Chloroform	7	5	7%
Acetaldehyde	8	4	61%
Arsenic (PM ₁₀)	9	4	79%
Naphthalene	10	4	84%
Nickel (PM ₁₀)	11	3	34%
Tetrachloroethylene	12	2	0%
Cadmium (PM ₁₀)	13	< 1	5%
Manganese (PM ₁₀)	14	< 1	2%
Lead (PM ₁₀)	15	< 1	0%

Shaded air toxics have >50% of samples with estimated concentrations (values below the reported laboratory detection limit). Screening value used is concentration equivalent to an estimated one-in-a-million potential cancer risk.

Non-cancer Reference Concentrations (RfC) and Hazard Indices >1

Air toxic	Non Cancer RfC (ug/m3)	Mean Hazard Index
Acrolein	0.35	3.1
Formaldehyde	9	0.070
Manganese (PM10)	0.09	0.064
Arsenic (PM10)	0.015	0.039
Nickel (PM10)	0.05	0.039
Carbon Tetrachloride	40	0.018
Benzene	60	0.011
Dichloromethane	400	0.006
Acetaldehyde	140	0.006
Cadmium (PM10)	0.02	0.004
Tetrachloroethylene	35	0.003
1,3-Butadiene	20	0.003
Chloroform	300	< 0.001
Beryllium (PM10)	0.007	< 0.001
Chromium VI (TSP)	0.2	< 0.001

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 the only air toxic that fails the screen with a hazard index greater than 1.