pscleanair.org
Puget Sound Clean Air Agency

1904 Third Avenue, Suite 105
Seattle, Washington 98101
www.pscleanair.org

2011

Air Quality Data Summary

NOVEMBER 2012

Working Together for Clean Air

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The 2011 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.

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Executive Summary

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 quality monitoring results for six criteria air pollutants and air toxics. The U.S. Environmental Protection Agency (EPA) sets national ambient air quality standards (NAAQS) for the criteria pollutants. The criteria pollutants are:

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

The Air Quality Index (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 2011. However, air quality degraded into "moderate" 12% of the time and to "unhealthy for sensitive groups" for brief periods.

Air toxics are 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).

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 pollutants at 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 pscleanair.org/default.aspx. Wind roses, air quality graphing tools and historical data summaries are available at pscleanair.org/airq/reports.aspx. To receive the Agency's most updated news and stay current on air quality issues in King, Kitsap, Pierce and Snohomish Counties, visit pscleanair.org/news/agencynews.aspx and select your favorite news feed method. Friends and subscribers receive the latest on air quality news and updates on projects in the Puget Sound region. You can also find us on Facebook and Twitter.

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.

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

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

The Agency and Ecology continued to monitor the region's air quality in 2011. 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. The EPA continues to strengthen NAAQS by following scientific analysis and health information to continue improving public health.

Elevated fine particle levels pose the greatest air quality challenge in our jurisdiction. Of the six criteria air pollutants monitored in the Puget Sound area, $PM_{2.5}$ is associated with the most serious health effects. Achieving significant reductions in particulate matter is a top priority of the Agency. Exposure to $PM_{2.5}$ is linked with respiratory disease, decreased lung function, asthma attacks, heart attacks and premature death. Children, older adults and people with respiratory illnesses are especially at risk. Further, some types of particulate matter are air toxics. For example, exposure to particulate matter from diesel exhaust is associated with increased risk of cancer. Fine particles are also responsible for reducing visibility in the beautiful Puget Sound region.

In 2009, EPA designated much of Tacoma and surrounding Pierce County areas as nonattainment for fine particles. The measured 3-year average 98th Percentile Design Value for fine particles at the Tacoma South L Street monitor was 35 micrograms per cubic meter at the end of 2011, the same as the level of the standard. Further, fine particle concentrations at monitoring sites in Snohomish County were close to EPA's daily $PM_{2.5}$ standard. Data from 2011 indicated that Snohomish county areas are in attainment, but pollution levels remain close to the standard. 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 remain 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 2011 ozone levels shown in this report are in attainment of the standard, but pollution levels are still close to the standard. The Enumclaw Mud Mountain monitor typically has the highest regional ozone concentrations during high-ozone episodes.

Air toxics were present in our air at levels that posed adverse health effects. These health effects include, but are not limited to, increased cancer risk and respiratory effects.

The Agency's jurisdiction is currently in attainment for carbon monoxide, ozone and PM_{10}, and has maintenance plans in place for these pollutants. EPA has announced the development and release of a more stringent nitrogen dioxide federal standard as well as the monitoring rules associated with these standards. EPA has recently promulgated standards for lead and sulfur dioxide. Monitoring is ongoing to investigate compliance with the new standards for lead and sulfur dioxide. Three years of data will be required for final EPA determination.

The Agency issues burn 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. 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 three burn bans in 2011. The dates were Jan 1-4, Nov 30-Dec 7, and Dec 11-14.

Many of the same emission sources that produce criteria and toxic air pollutants also generate greenhouse gases. The Agency works with public and private partners to reduce greenhouse gases[3]. For more information, see pscleanair.org/programs/climate/default.aspx.

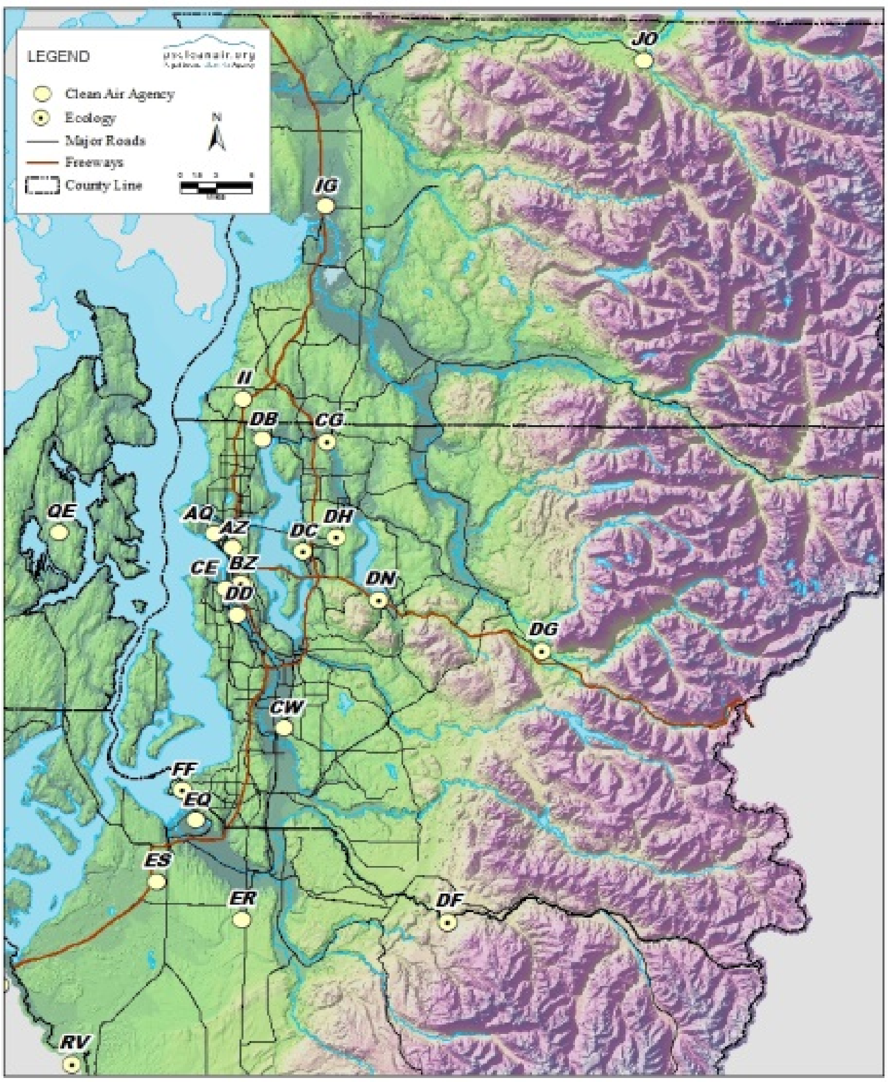
[3] Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound; pscleanair.org/programs/climate/rptfin.pdf.

Monitoring Network

The Agency and Ecology operated the Puget Sound region's monitoring network in 2011. The network is comprised of meteorological, pollutant-specific equipment and equipment for special studies. Data from the network are normally collected automatically via the Ecology data network, or in some cases, collected manually by field staff. Monitoring stations are located in a variety of geographic locations in the Puget Sound region. Monitors are sited according to EPA criteria to ensure a consistent and representative picture of air quality.

King, Pierce, Snohomish and Kitsap County monitoring sites used in 2011 are shown in Map 1 and Table 1, Monitoring Network for 2011. A more interactive map is available at pscleanair.org/airq/network/default.aspx.

Map 1: Active Air Quality Monitoring Station Locations 2011



AQ	Seattle Queen Anne
AZ	Seattle Olive & Boren
BZ	Seattle Beacon Hill
CE	Seattle Duwamish
CG	Woodinville
CW	Kent
DB	Lake Forest Park
DC	Bellevue
DD	Seattle South Park
DF	Enumclaw Mud Mt Dam
DG	North Bend
DH	Bellevue 148th Street
DN	Lake Sammamish State Park
EQ	Tacoma Alexander
ER	Puyallup South Hill
ES	Tacoma South L Street
FG	Mount Rainier
FF	Tacoma Indian Hill
FH	La Grande Pack Forest
II	Lynnwood
IG	Marysville
JO	Darrington

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

Table 1: Air Quality Monitoring Network Parameters 2011

Station ID	Location	$PM_{2.5}$ ref	$PM_{2.5}$ Spec	$PM_{2.5}$ FEM	$PM_{2.5}$ lc	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
AQ	Queen Anne Hill, 400 W Garfield St, Seattle (photo/visibility included)				●						●	●	●		●	a, d, f
AZ	Olive Way & Boren Ave, 1624 Boren Ave, Seattle				●						●	●	●		●	a, d
BW ⦿	Beacon Hill, 4103 Beacon Ave S, Seattle	●	●	●			●	●	●	●		●	●	●	●	b, d, f
CE	Duwamish, 4401 E Marginal Way S, Seattle		●	●	●	●					●	●	●		●	a, e
CW	James St & Central Ave, Kent			●	●	●					●	●	●		●	b, d
DB	17171 Bothell Way NE, Lake Forest Park				●						●	●	●		●	b, d, f
DC ⦿	305 Bellevue Way NE, Bellevue				●						●				●	a, d
DD	South Park, 8201 10th Ave S, Seattle				●						●				●	b, e, f
DF ⦿	30525 SE Mud Mountain Road, Enumclaw						●					●	●			c
DG ⦿	42404 SE North Bend Way, North Bend				●		●				●	●	●		●	c, d, f
DN ⦿	20050 SE 56th, Lake Sammamish State Park, Issaquah						●									b, d
EQ	Tacoma Tideflats, 2301 Alexander Ave, Tacoma		●		●	●					●	●	●		●	a, e
ER	South Hill, 9616 128th St E, Puyallup				●	●					●	●	●		●	b, f
ES	7802 South L St, Tacoma	●	●	●	●	●					●	●	●		●	b, f
FF ⦿	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma											●	●			b, f
FG ⦿	Mt Rainier National Park, Jackson Visitor Center						●									c
IG	Marysville JHS, 1605 7th St, Marysville	●	●	●	●	●					●	●	●		●	b, d
II	6120 212th St SW, Lynnwood			●	●						●	●	●		●	b, d
JO	Darrington High School, Darrington 1085 Fir St	●		●	●	●					●	●	●		●	d, f
QE	Meadowdale, 7252 Blackbird Dr NE, Bremerton			●	●						●	●	●		●	b, f

⦿	Station operated by Ecology	SO_2	Sulfur Dioxide
⬣	Indicates parameter currently monitored	NO_y	Nitrogen Oxides
$PM_{2.5}$ ref	Particulate matter <2.5 micrometers (reference)	CO	Carbon Monoxide
$PM_{2.5}$ Spec	Speciation	b_{sp}	Light scattering by atmospheric particles (nephelometer)
$PM_{2.5}$ FEM	Particulate matter <2.5 micrometers (teom-fdms continuous)	Wind	Wind direction and speed
$PM_{2.5}$ ls	Particulate matter <2.5 micrometers (light scattering nephelometer continuous)	Temp	Air temperature (relative humidity also measured at BW)
$PM_{2.5}$ bc	Particulate matter <2.5 micrometers black carbon (light absorption aethalometer)	AT	Air Toxics
O_3	Ozone (May through September except Beacon Hill)	VSBY	Visual range (light scattering by atmospheric particles)
Location		PHOTO	Visibility (camera)
a	Urban Center		
b	Suburban		
c	Rural		
d	Commercial		
e	Industrial		
f	Residential		

The Agency conducted monitoring as early as 1965. Table 1 above shows which parameters were measured in 2011 and where those parameters were measured.

A summary of the monitoring stations and parameters used over the history of the program is found on page A-6 of the Appendix. The network changes periodically because the Agency and Ecology regularly re-evaluate monitoring objectives, resources and logistics.

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 epa.gov/ttn/amtic/. Information on air toxics monitoring methods is available at epa.gov/ttn/amtic/airtox.html.

Air Quality Index

EPA established the air quality index (AQI) as an index for reporting daily air quality. It tells you how clean or polluted your air is and what associated health effects might be a concern for you. The AQI focuses on health effects that you may experience within a few hours or days after breathing polluted air. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide and nitrogen dioxide.

Think of the AQI as a yardstick that runs from 0 to 500. As the AQI increases, the level of air pollution and the health concern increases. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered unhealthy first for certain sensitive groups of people, then for everyone as AQI values get higher.

The purpose of the AQI is to help people understand what local air quality means to health. To make it easier to understand, the AQI is divided into six categories:

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is:	*…air quality condition is:*	*…look for this color:*
0 – 50	**Good**	**Green**
51 – 100	**Moderate**	**Yellow**
101 – 150	**Unhealthy for Sensitive Groups**	**Orange**
151 – 200	**Unhealthy**	**Red**
201 – 300	**Very Unhealthy**	**Purple**
301 - 500	**Hazardous**	**Maroon**

GOOD AQI is 0 – 50: Air pollution poses little or no risk.

MODERATE AQI is 51 – 100: Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.

UNHEALTHY FOR SENSITIVE GROUPS AQI is 101 – 150: Although the general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air. .

UNHEALTHY AQI is 151 – 200: Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.

VERY UNHEALTHY AQI is 201 – 300: This would trigger a health alert signifying that everyone may experience more serious health effects.

HAZARDOUS is AQI greater than 300: This would trigger a health warning of emergency conditions. The entire population is more likely to be affected.

Table 2 shows the AQI breakdown by percentage in each category for 2011. Pierce County registered the highest daily AQI value of 152 on January 1, which was $PM_{2.5}$. $PM_{2.5}$ normally determines the AQI in the Puget Sound area on days considered unhealthy for sensitive groups.

Table 2: AQI Ratings for 2011

County	**AQI Rating (% of year)**				**Highest AQI**
	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	
Snohomish	83%	15%	2%	0%	147
King	87%	13%	0%	0%	98
Pierce	84%	13%	3%	0%	152
Kitsap	94%	6%	0%	0%	111

The Agency participates in a forecasting and a real time AQI reporting website. National information can be found at the Air Now page here: airnow.gov/index.cfm?action=airnow.main. Local information can be found at the Current Air Quality link at our home page here: pscleanair.org/airq/aqi.aspx.

Further, we have tracked how many days each year our data indicated in each AQI category, as summarized by the following charts by county. Most days in the Puget Sound region are in the “Good” category, but the local meteorological conditions, along with polluting sources cause levels to rise into “Moderate” or above.

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

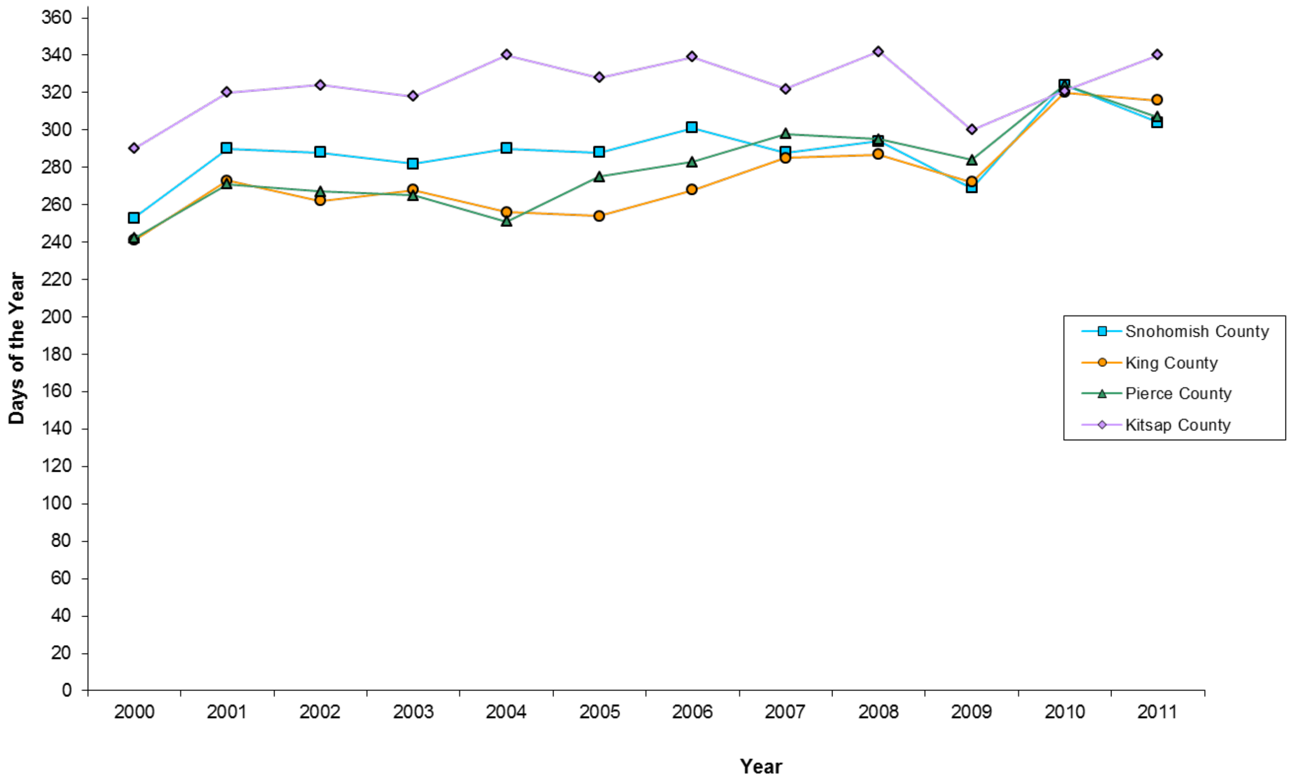


Figure 1 (above) shows the number of days that the AQI fell into the Good category for each of the four counties of our jurisdiction.

Figures 2 through 5 present number of AQI days that were not "good" 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 2011.

Figure 2: Air Quality for King County

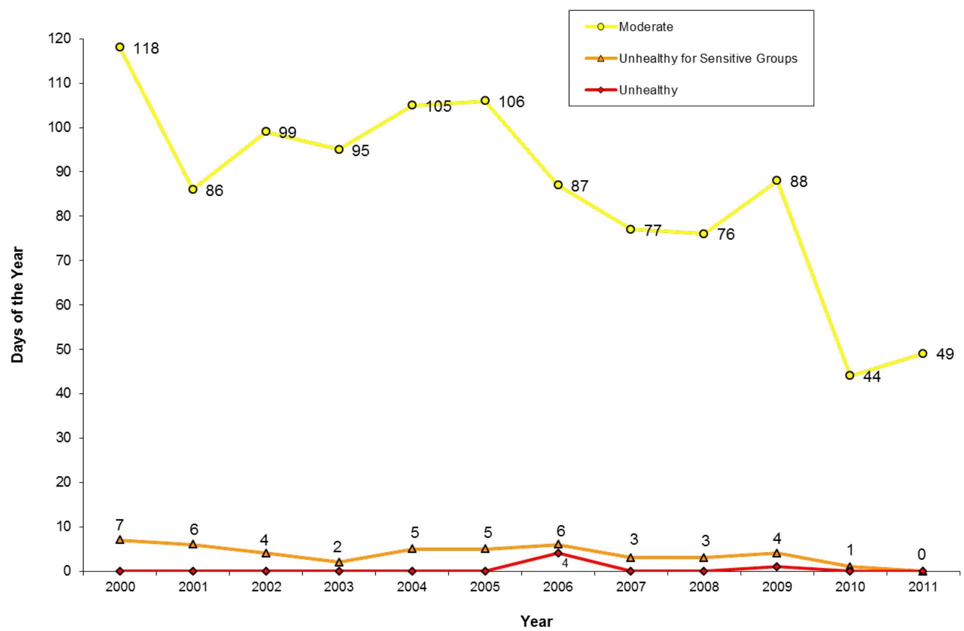


Figure 3: Air Quality for Kitsap County

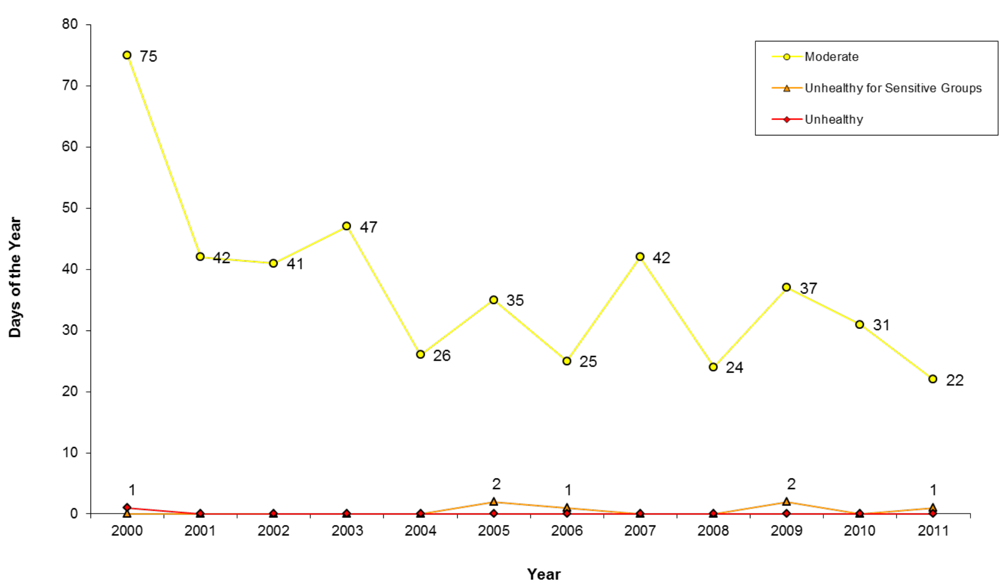


Figure 4: Air Quality for Pierce County

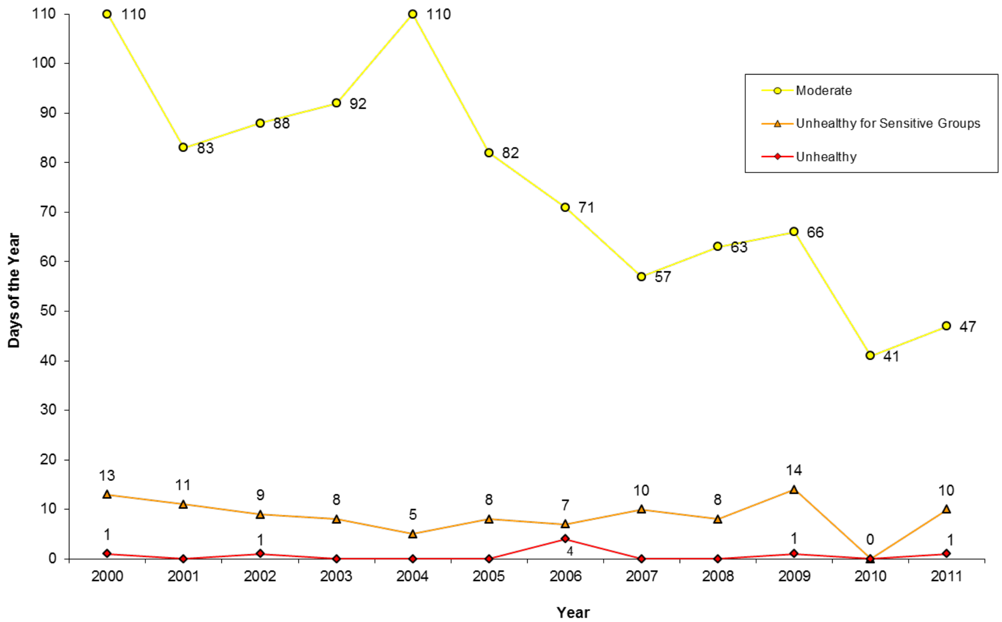
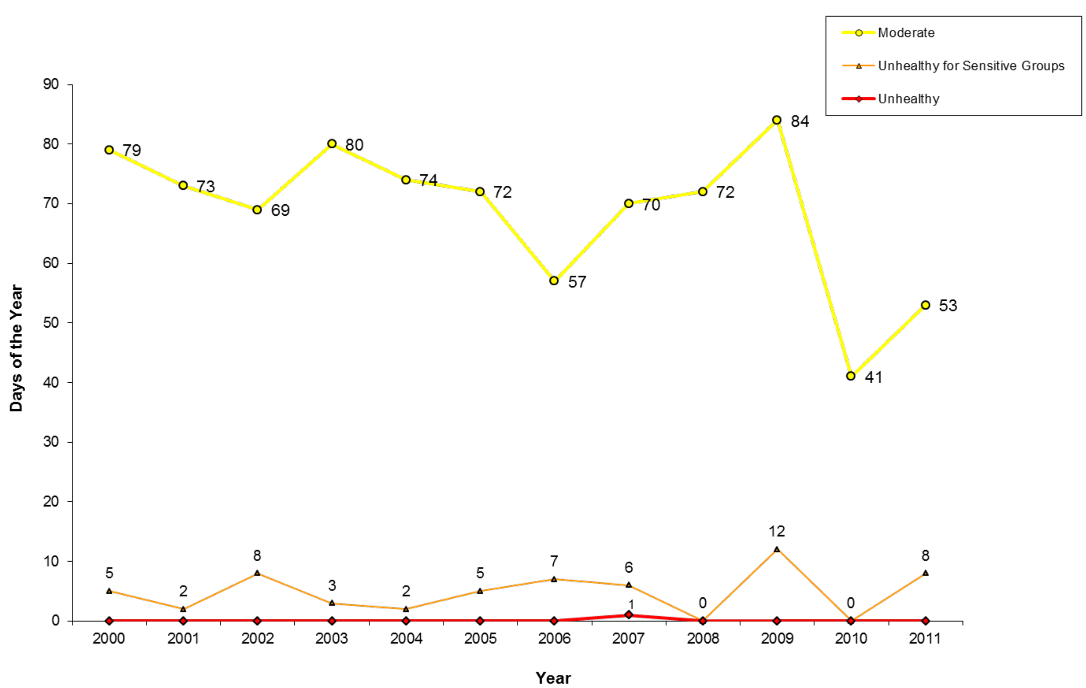


Figure 5: Air Quality for Snohomish County



Particulate Matter

"Particulate matter," also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution consists of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

EPA groups particle pollution into two categories. "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter. "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller.

PM_{10}

The Agency ceased all PM_{10} monitoring in 2006 and focused its efforts on $PM_{2.5}$ monitoring. For a historic look at Puget Sound area PM_{10} levels, please see pages 32-35 of the 2007 data summary at pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

$PM_{2.5}$ Health and Environmental Effects

An extensive body of scientific evidence shows that exposure to particle pollution and is linked to a variety of significant health problems, such as increased hospital admissions and emergency department visits for cardiovascular and respiratory problems, including non-fatal heart attacks and premature death. People most at risk from fine and coarse particle pollution exposure include people with heart or lung disease (including asthma), older adults and children. Research indicates that pregnant women, newborns and people with certain health conditions, such as obesity or diabetes, also may be more susceptible to PM-related effects. Particle pollution also contributes to haze in cities and some of our nation's most treasured national parks.

Fine particles are emitted directly from a variety of sources, including wood burning (both outside, and in wood stoves and fireplaces), vehicles and industry. They also form when gases from some of these same sources react in the atmosphere.

PM2.5– Federal Reference Method and Continuous Methods

Fine particulate matter ($PM_{2.5}$) is measured using a variety of methods to ensure the highest quality data. EPA has defined the federal reference method (FRM) to be the method used to determine $PM_{2.5}$ concentrations. The reference method is a filter-based method. EPA has further defined several federal equivalent methods (FEM), which are continuous instruments operated under specific standard operating procedures. The advantage of the continuous device is that it provides highly time resolved data (hourly averages).

The Agency uses the FRM, the FEM and a Nephelometer estimation method to provide 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 later be analyzed 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 in a photomultiplier tube, which is then compared to Reference and Equivalent method data to produce an estimate of $PM_{2.5}$. Light scattering has been proven to correlate well with $PM_{2.5.}$

The Agency and Ecology worked together to evaluate the TEOM-FDMS 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.

$PM_{2.5}$ Daily Federal Standard and Health Goal

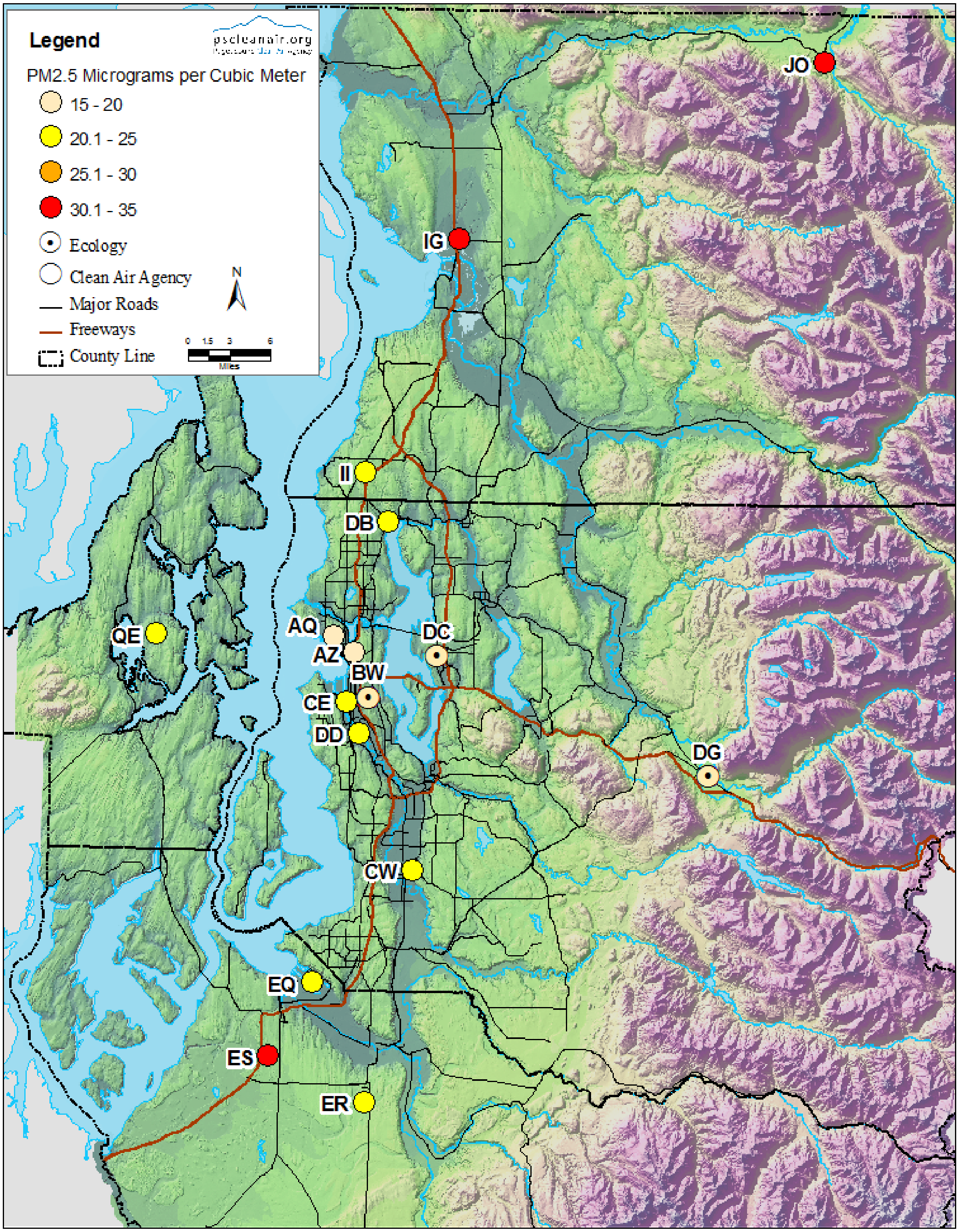
On September 21, 2006, EPA strengthened the PM2.5 daily standard.[4] EPA designated the Tacoma/Pierce County fine particle nonattainment area on December 14, 2009. We are working together with partners to reduce harmful emissions and bring the area into attainment using three main strategies: Enhanced enforcement of burn bans; required removal of older, more polluting uncertified wood stoves; and Implementation of strategies to reduce fine particle emissions from cars, trucks, ships, and industry.

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

Map 2 shows the 98th percentile of the 3-year average of daily $PM_{2.5}$ concentrations. The map includes only those monitoring sites with three years of complete data from 2009 to 2011.

[4] U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; epa.gov/particles/actions.html.

Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2011



Figures 6 through 9 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 2011 is the average of the 98th percentile daily concentration for 2009, 2010, and 2011. Concentrations for King, Pierce, and Snohomish Counties were measured using the FRM, except where noted.[5] Concentrations for Kitsap County were measured in 2011 using the Federal Equivalent Method (TEOM FEM).

Figure 7 does not include a three-year average for Kitsap County in 2008-2010 because the monitor did not meet data completeness criteria. Kitsap County data shows that PM2.5 levels are below the federal standard.

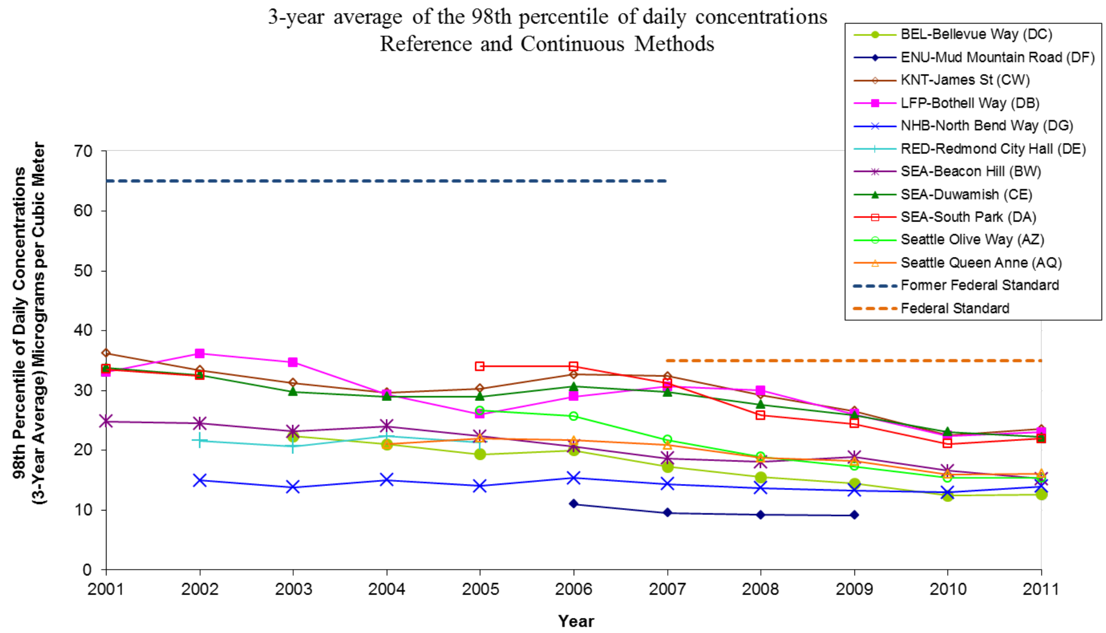
Figure 8 shows that the Tacoma South L Site, located in the Tacoma South End neighborhood, is at the federal standard of 35 $\mu g/m^3$.

Figure 9 shows concentrations at the Marysville and Darrington monitors in Snohomish County are the next highest range of concentrations at 30 and 32 $\mu g/m^3$, respectively.

Statistical summaries for 98th percentile daily concentrations for 2011 data are provided on page A-11 through A-13 of the Appendix.

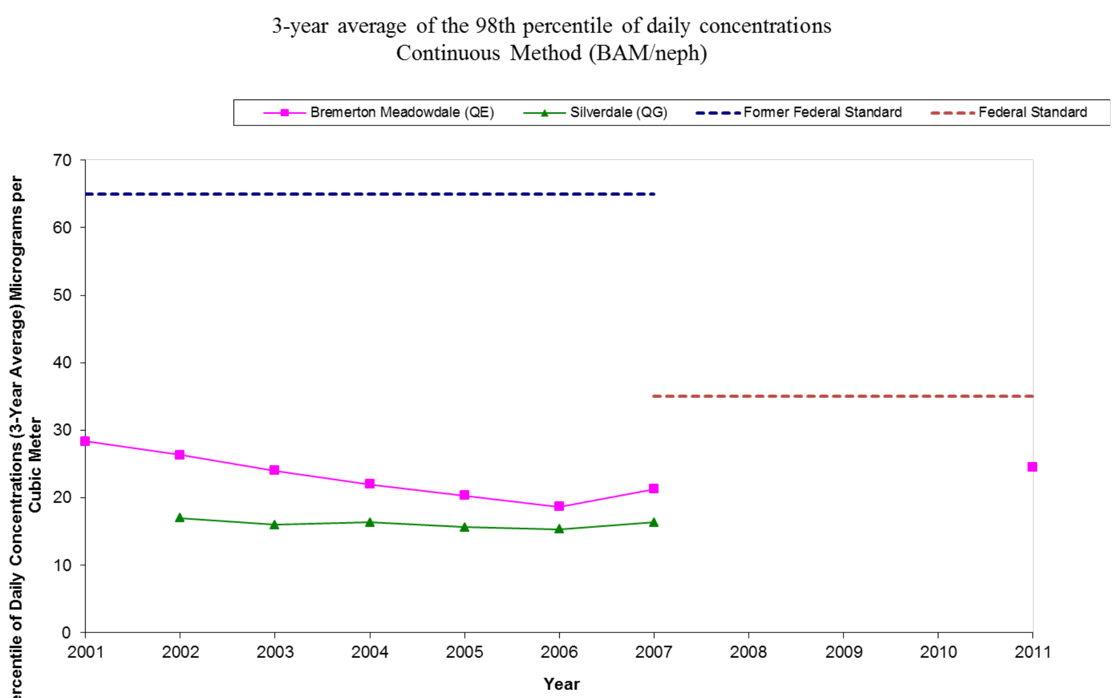
[5] Where possible, nephelometer method data are compared to the reference method values and calculations are made to estimate the PM 2.5. The estimate is used to make the data set “FRM-like”.

Figure 6: Daily $PM_{2.5}$ for King County



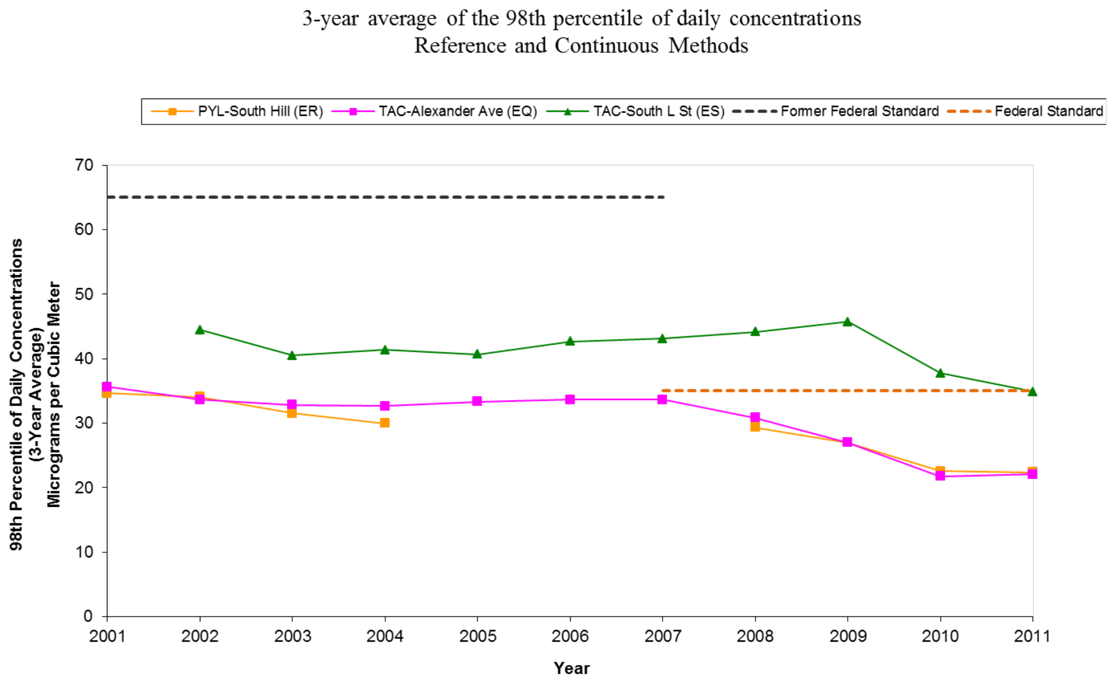
Note: Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011. Beacon Hill (BW) data are FRM from 1999-2011. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-11. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2011. Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-11. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2011. Olive Way (AZ) data are neph from 2003-2011. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2011. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010, TEOM-FEM 2011. Enumclaw (DF) data are from neph in 2000-2009.

Figure 7: Daily $PM_{2.5}$ for Kitsap County



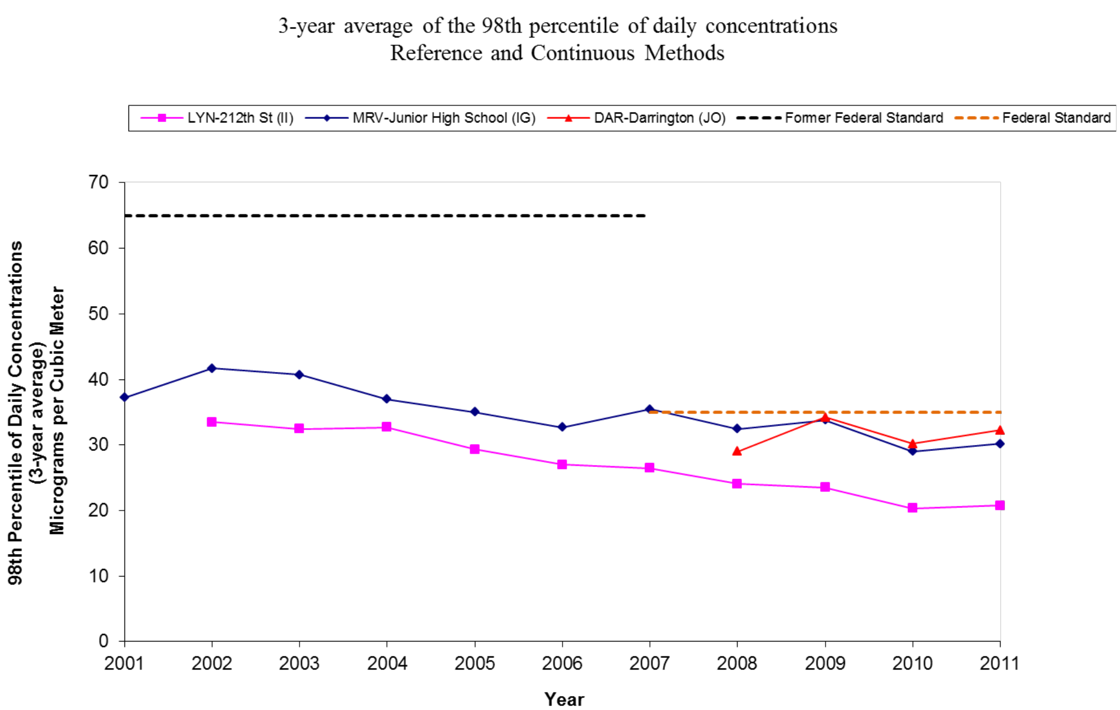
75% of data is required to calculate 98th percentile. Insufficient data available for 2008 so 3 year calculation not available for 2008-2010. 2011 data are TEOM-FEM.

Figure 8: Daily $PM_{2.5}$ for Pierce County



Note: All South L data are FRM from 2000- 2011. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2011. South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-2011; incomplete nephelometer data was collected from South Hill in 2005.

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



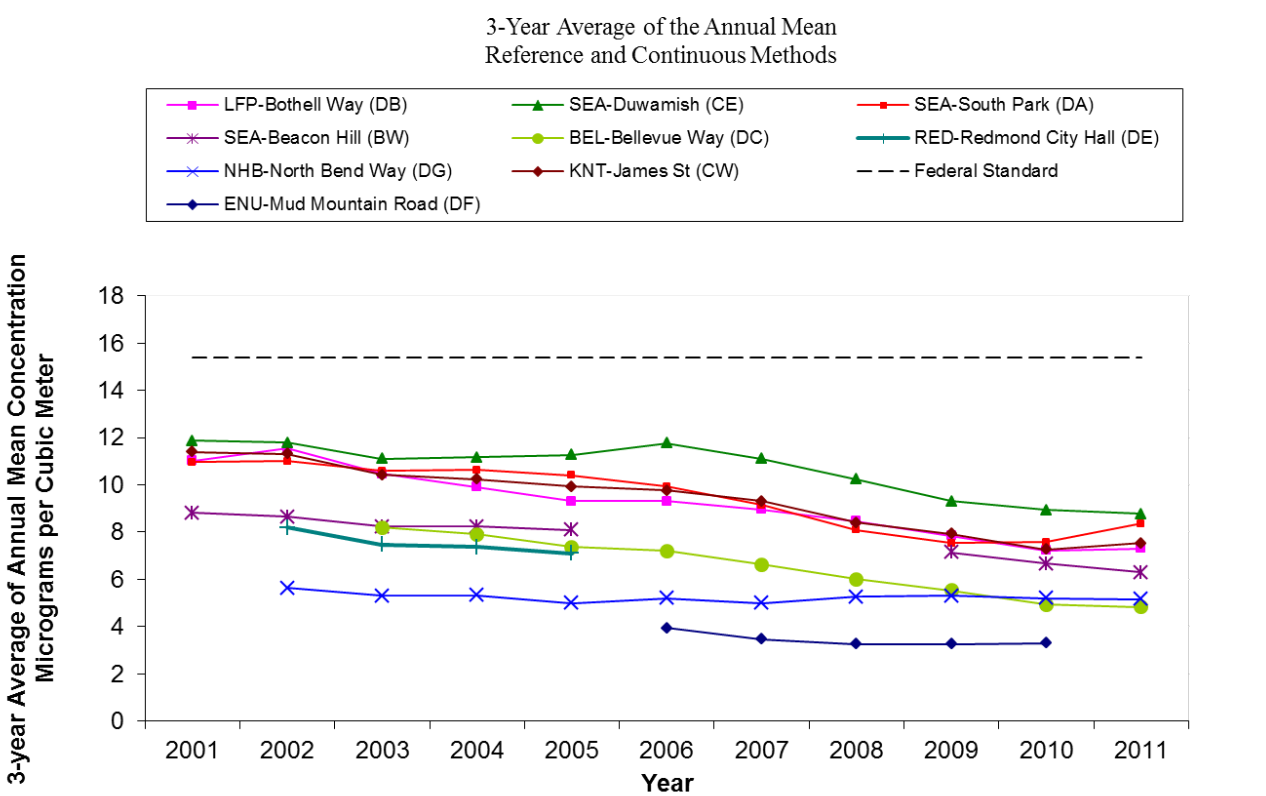
Note: Marysville data are FRM 999-2011. Lynnwood (II) data are FRM except 2004, 2007-2010 which were nephelometer, 2011 TEOM-FEM. Darrington (JO) data are neph in 2006, FRM in 2007-2011.

$PM_{2.5}$ Annual Federal Standard

Figures 10 through 13 show annual averages at each monitoring station for King, Kitsap, Pierce and Snohomish Counties. All counties have levels below the current annual standard of 15 micrograms per cubic meter and all counties are in attainment for the annual standard. Figure 11 does not show any 2008, 2009 or 2010 data for Kitsap County because the monitor did not achieve data completeness criteria.

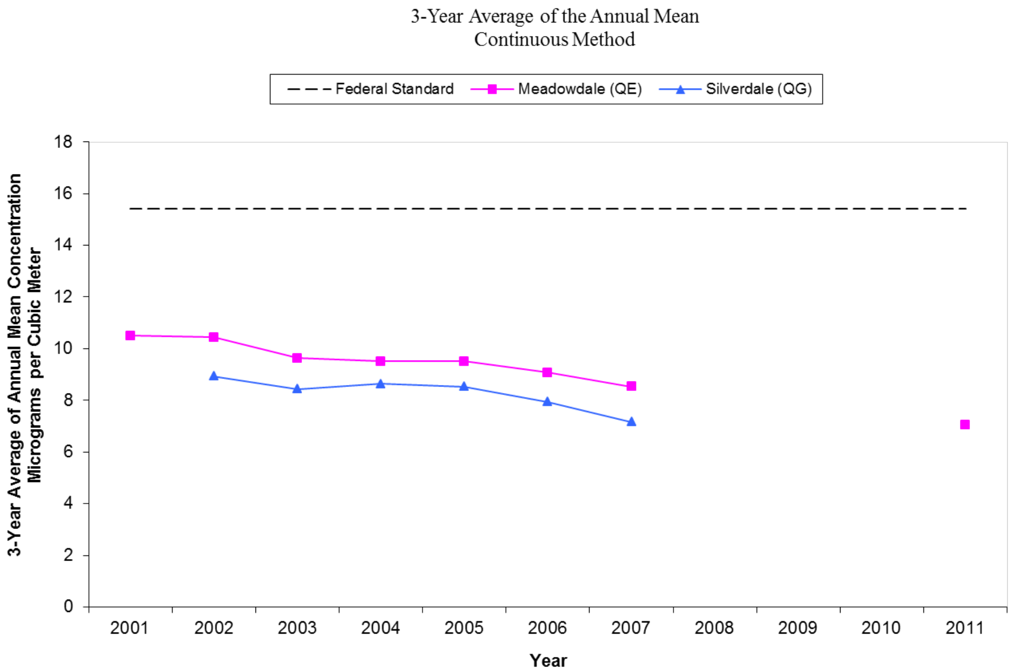
Figures 10 through 13 show data from the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, so each value on the graph is an average for three consecutive years. For example, the value shown for 2011 is the average of the annual averages for 2009, 2010 and 2011.

Figure 10: Annual $PM_{2.5}$ for King County



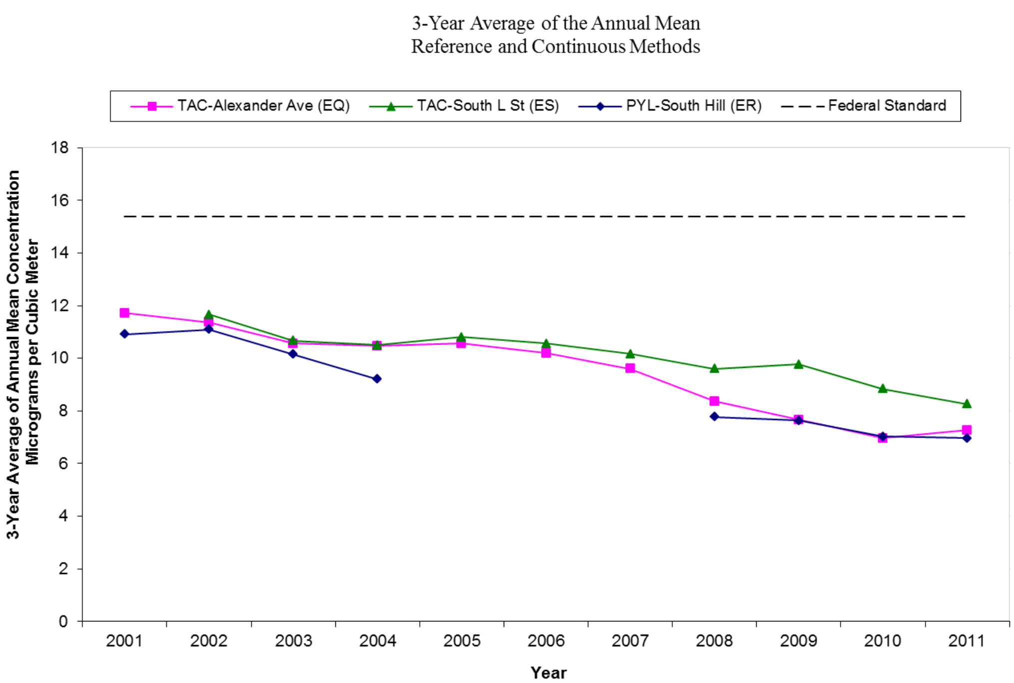
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2011. Beacon Hill (BW) data are FRM from 1999-2011. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2011. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2011. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2010,TEOM-FEM 2011. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2011.

Figure 11: Annual $PM_{2.5}$ for Kitsap County



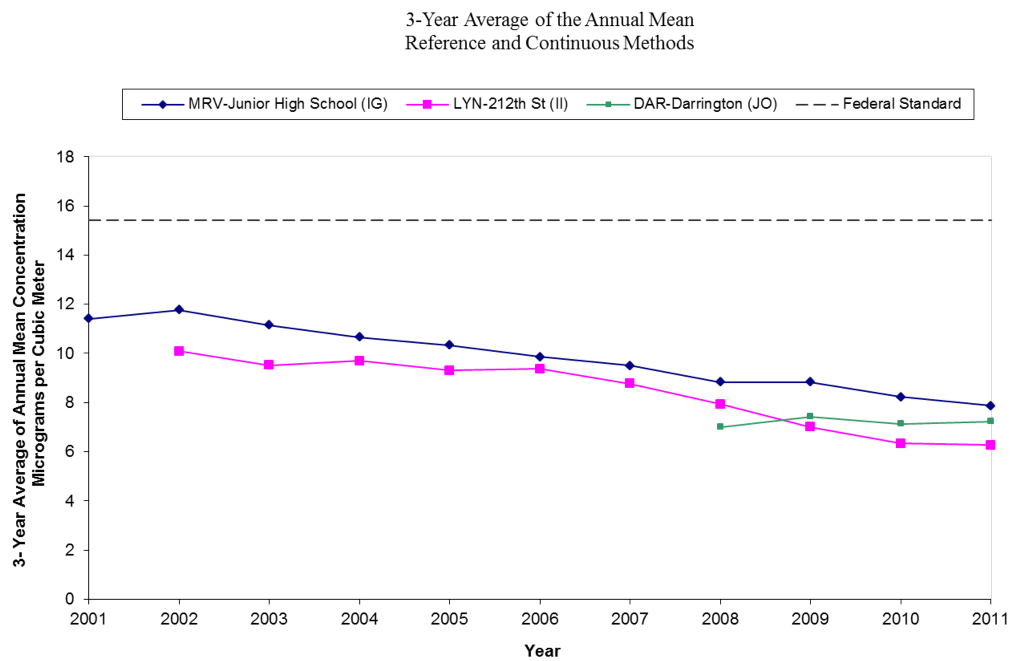
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010, TEOM-FEM 2011. Insufficient data in 2008 resulted in the inability to calculate a 3 year average for 2008, 2009, 2010.

Figure 12: 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, 2008-2011 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 13: Annual $PM_{2.5}$ for Snohomish County



Note: Marysville (IG) data are FRM from 1999-2011. Lynnwood (II) data are FRM except 2004, 2007-2011. The 2004, 2007-2011 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2011.

$PM_{2.5}$ 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 airgraphing.pscleanair.org/ to plot the sites and timeframes of interest.

Particulate Matter – $PM_{2.5}$ Speciation and Aethalometers

The methods described above measure the total amount of fine particulate matter, but do not give us more specific information. 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.[6,7,8]

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. 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 2011:

- 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. For a list of PM2.5 analytes measured at these sites, please see Appendix A-14.

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[6] Puget Sound Air Toxics Evaluation, October 2003; pscleanair.org/airq/basics/psate_final.pdf.

[7] Tacoma and Seattle Air Toxics Evaluation, October 2010: epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf.

[8] Ogulei, 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.

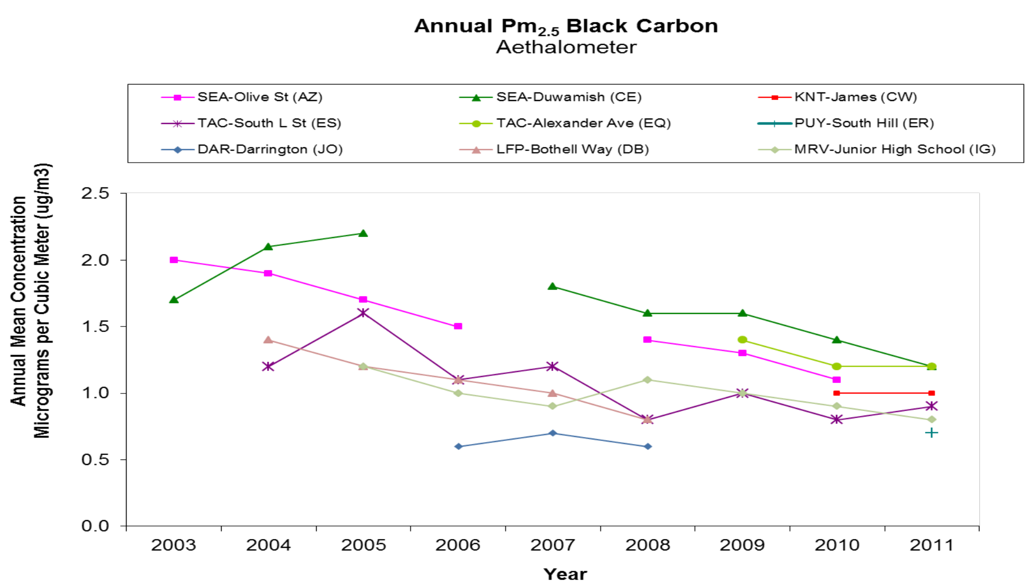
Aethalometer Data

Aethalometers provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption to estimate carbon concentrations using two channels, black carbon (BC) and ultraviolet (UV). 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.[9] Unfortunately, neither is 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 pscleanair.org/airq/Aeth-Final.pdf.

Figure 14 shows annual average trending of black carbon concentrations. Since 2003, the general trend shows reducing BC levels. A statistical summary of aethalometer black carbon data is presented on page A-15 of the Appendix.

Figure 14: Annual $PM_{2.5}$ Black Carbon



[9]Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area; 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.[10] Ozone has also been linked to immune system impairment.[11] 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.[12]

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 are transported downwind from their source by the time the highest ozone concentrations have formed in the afternoon and early evening. As shown on Map 3, the highest ozone concentrations occur at a monitor southeast of the urban area at the Enumclaw site.

[10] EPA, Air Quality Index: A Guide to Air Quality and Your Health; epa.gov/airnow/aqi_brochure_08-09.pdf.
[11] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ttn/oarpg/naaqsfin/o3health.html.
[12] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ttn/oarpg/naaqsfin/o3health.html.

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2011

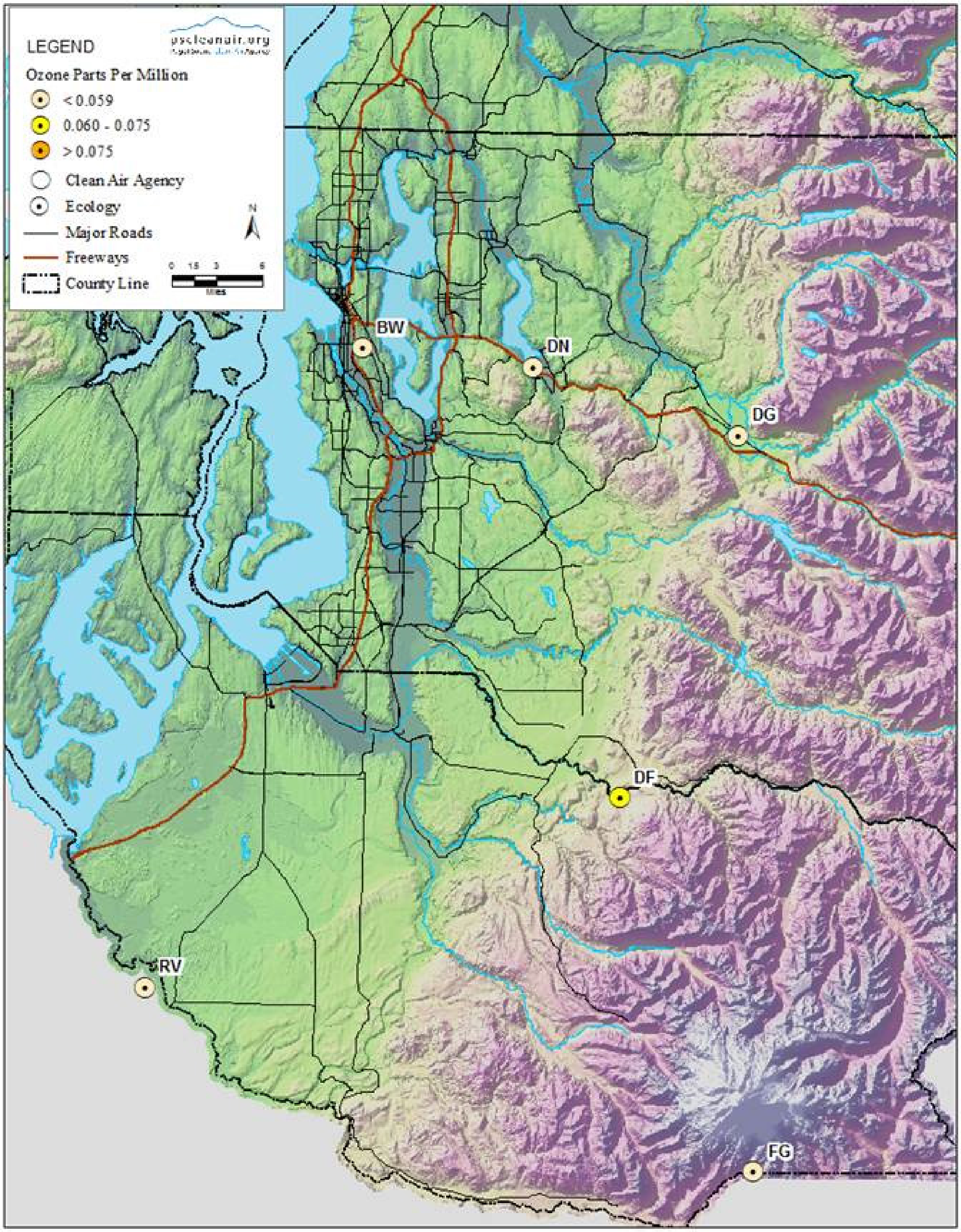


Figure 15 presents data for each monitoring station and the 8-hour federal standard. EPA revised its 8-hour standard from 0.08 parts per million (ppm) to 0.075 ppm in March 2008. The federal standard is based on the 3-year average of the 4th highest 8-hour concentration, called the "design value". The 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 2011 design value is 0.067 ppm, which does not violate the 2008 standard. The highest 2011 8-hour ozone concentration of 0.069 ppm was recorded at the Enumclaw Mud Mountain monitor.

For 2011, the Puget Sound area is in attainment with the 2008 0.075 ppm standard.

Figure 16 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-16 of the Appendix.

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

Figure 15: Ozone for Puget Sound Region

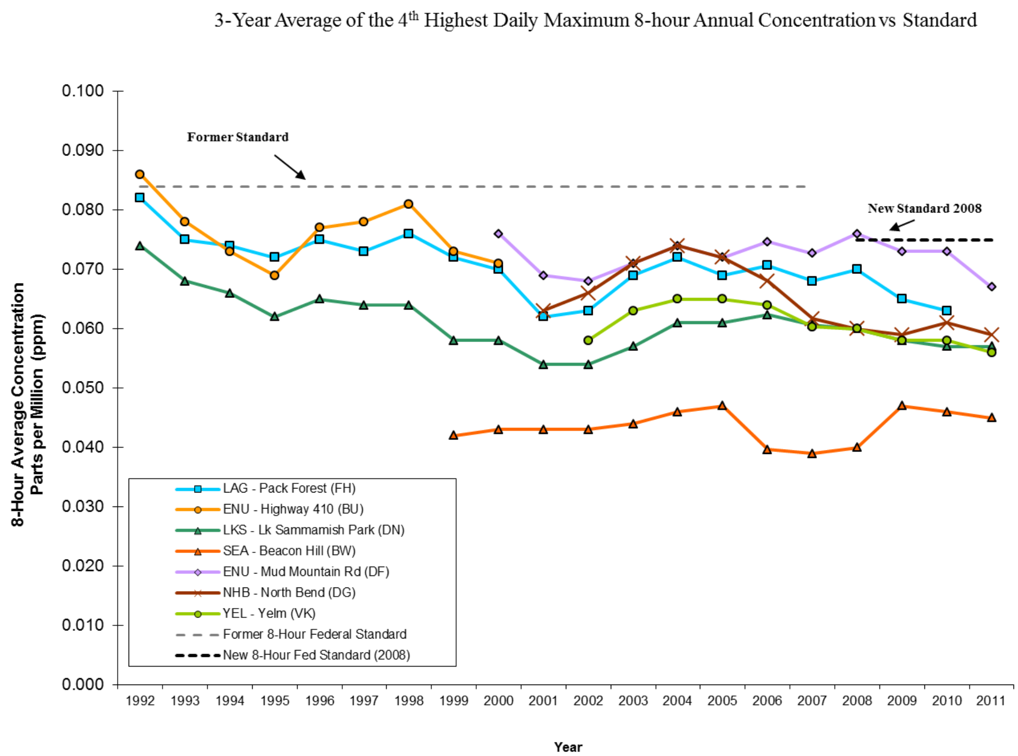
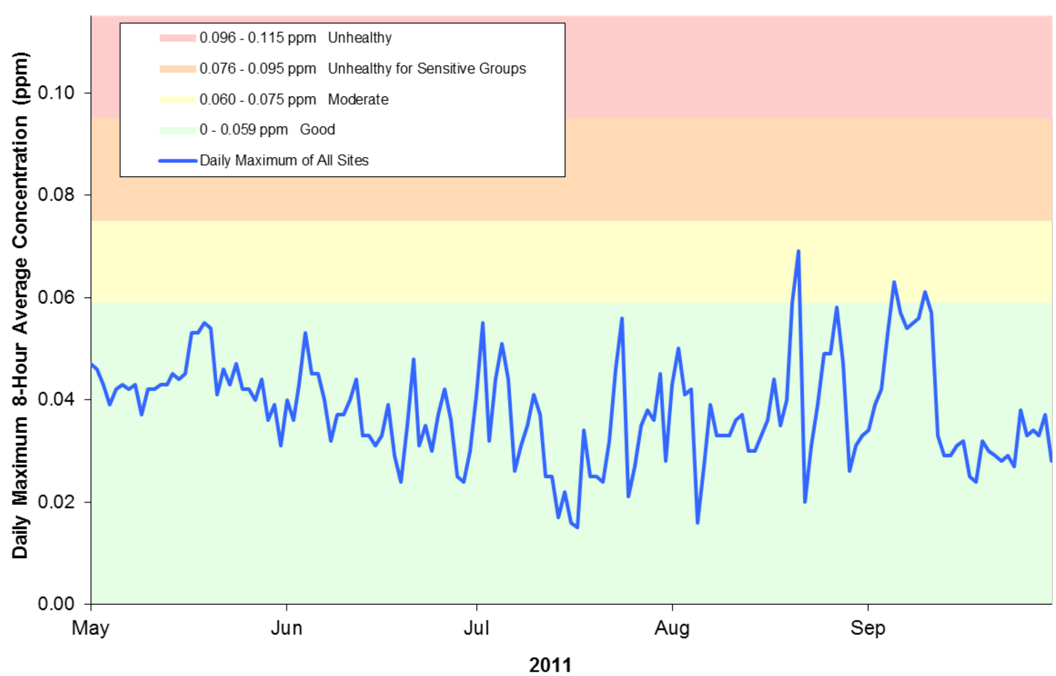


Figure 16: Ozone (O_3) for Puget Sound Region May-September 2011



Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and hydroperoxy (HO_2) and alkylperoxy (RO_2) free radicals in the atmosphere. NO_2 can cause coughing, wheezing and shortness of breath in people with respiratory diseases such as asthma.[13] Long-term exposure can lead to respiratory infections.

The term NO_x is defined as NO + NO_2. 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.

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 (HNO_3) and peroxyacetyl nitrate (PAN) can be important contributors to the formation of ozone and fine particulate matter. The additional nitroxyl compounds are generally present in much lower concentrations than NO_2 (or NO_x).

Figure 17 shows NO_2 concentrations through 2005. In 2006, no data were recorded due to the relocation of the Beacon Hill monitor to a different location on the same property. From 2007 onward, the concentration of NO_2 is represented as NO_y – NO, since NO_2 is no longer directly recorded, and NO_y = NO + NO_2 + other nitroxyl compounds. The annual average for each year has consistently been less than half of the federal standard, as shown in Figure 17 and in the statistical summary on page A-17 of the Appendix.

The maximum 1-hour average of NO_y – NO, measured in 2011, was 0.054 ppm on April 23. Visit epa.gov/air/nitrogenoxides/ for additional information on NO_2.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010.[14] 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 18 with historical data since 1998. The years prior to 2010 have been included on the graphs for historical comparison; the new air quality standard applies to 2010 and 2011.

[13] EPA, Airnow, NO_X Chief Causes for Concern; epa.gov/air/nitrogenoxides/
[14] EPA. New 1-hour National Ambient Air Quality Standards for Nitrogen Dioxide; epa.gov/air/nitrogenoxides/actions.html#jan10, accessed September, 2010.

Figure 17: Annual Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-2011)

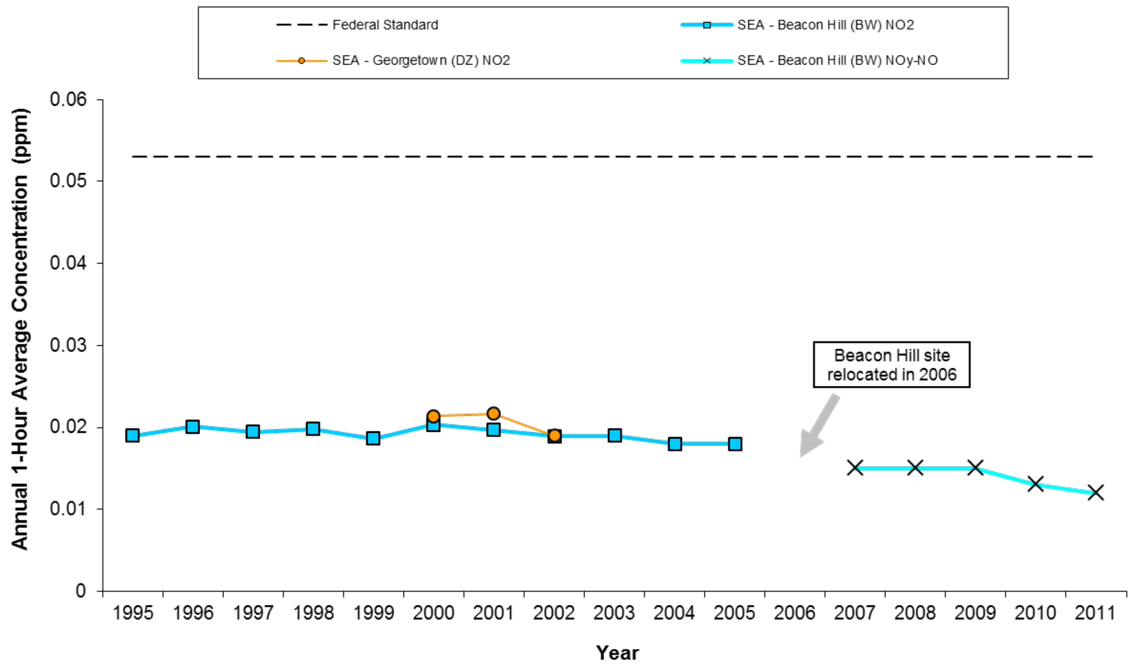
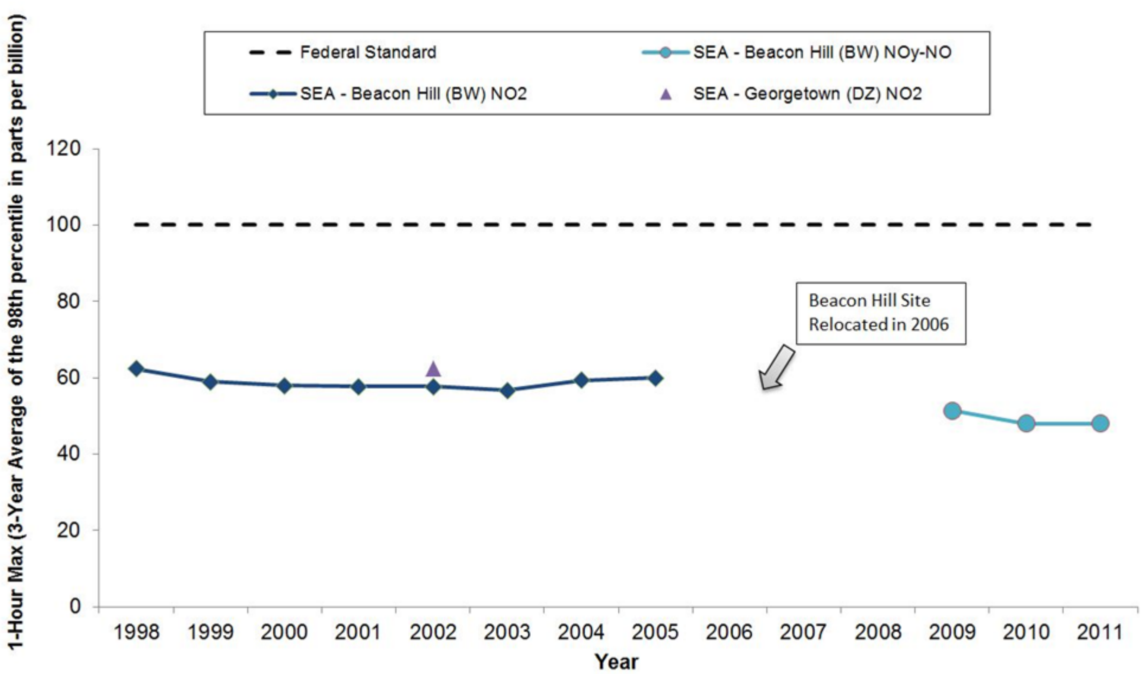


Figure 18: 2010 1-Hour Maximum Standard for Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-2011)



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 CO monitoring in the region. Historically, CO monitoring stations were 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 Beacon Hill site operated during 2011.

The CO national ambient air quality standard is based on the 2^{nd} highest 8-hour average. Figure 19 shows the 2^{nd} 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.

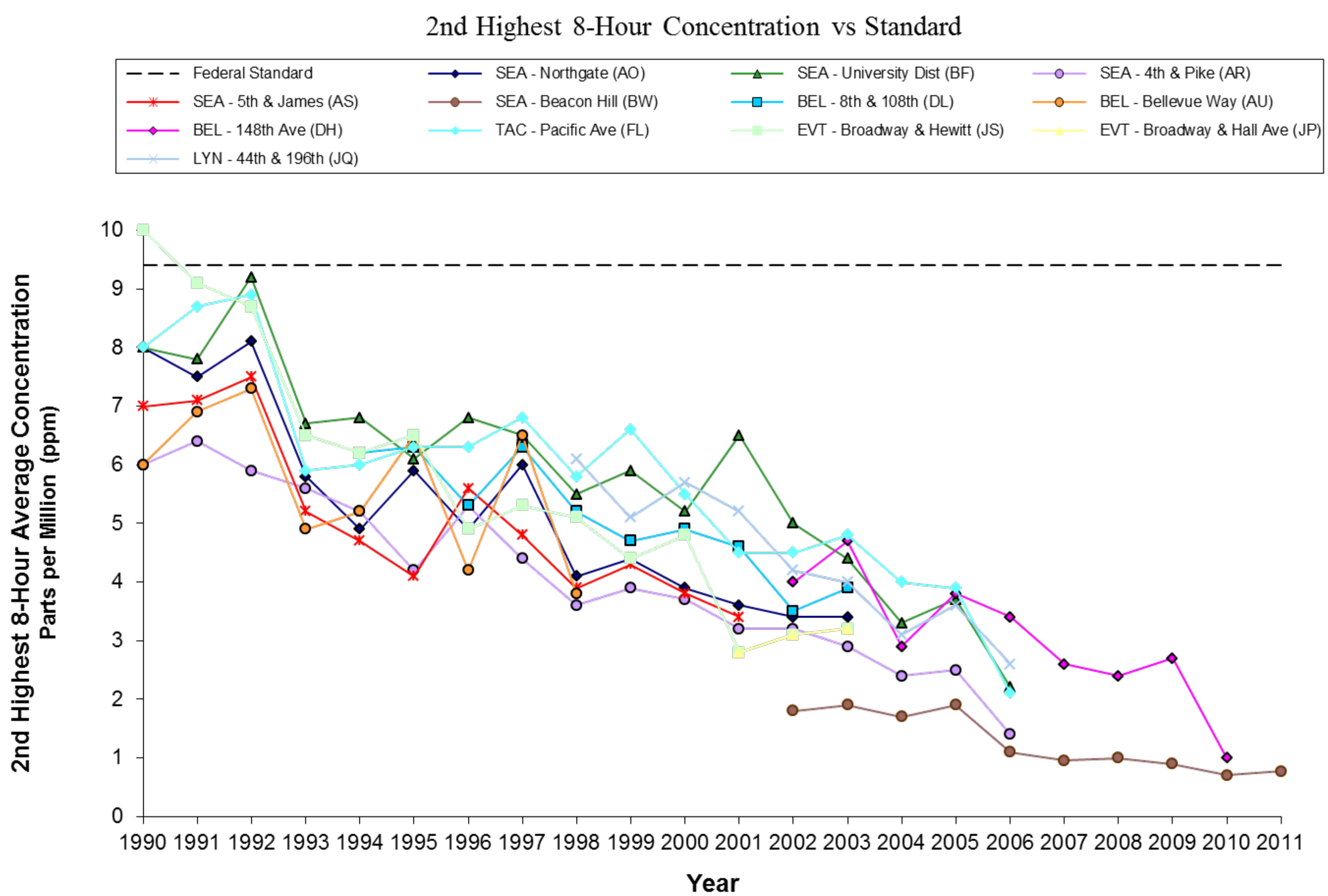
The maximum 8-hour concentration for CO in 2011 was 0.9 parts per million (ppm) and occurred on January 27 at the Bellevue site.

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.

In 2011, EPA completed an ambient standard review for carbon monoxide, and left the level of the health-based standards unchanged.

Statistical summaries for 8-hour average CO data are provided on page A-18 of the Appendix. For additional information on CO, visit epa.gov/air/urbanair/co/index.html.

Figure 19: Carbon Monoxide (CO): 2nd Highest Annual 8-hour Value for Puget Sound Region



Sulfur Dioxide

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

SO_2 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 SO_2 levels are high. SO_2 can also form sulfates in the atmosphere, a component of fine particulate matter.

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

EPA changed the SO_2 standard in June of 2010 to a more short-term (1-hour) standard and revoked the annual and daily average standards. Historic comparisons to federal and Washington State standards can be seen in our 2009 data summary at pscleanair.org/news/library/reports/2009_AQDS_Report.pdf.

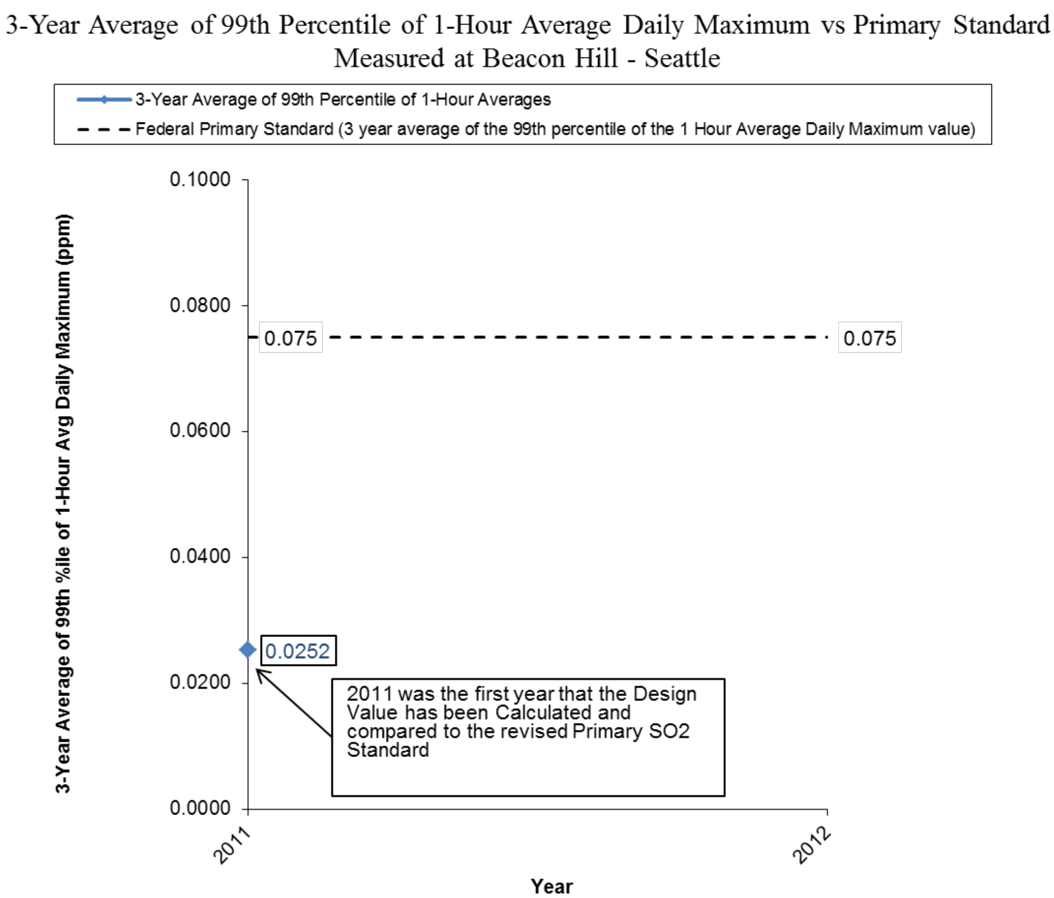
The new standard is a 3-year average of the 99th percentile of the daily 1-hour maximum concentrations. Levels must be below 0.075 ppm. Demonstration of attainment is determined from the 2008-2010 data. The Seattle Beacon Hill site is below the new standard based on 2009-2011 values.

Figure 20 shows the maximum 3-year average of the 99th percentile of 1-hour maximum concentrations at Beacon Hill. The maximum measured SO_2 concentrations in 2011 were below standards.

Statistical summaries for SO_2 data from the Beacon Hill site are available on page A-19 of the Appendix.

Additional information on SO_2 is available at epa.gov/air/sulfurdioxide/.

Figure 20: Sulfur Dioxide (SO_2) 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 epa.gov/ttnatw01/hlthef/lead.html for ways to limit your exposure to these lead sources.

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 pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

In October 2008, EPA strengthened the lead standard from 1.5 µg/m^3 to 0.15 µg/m^3 (rolling three-month average).[15] 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 epa.gov/air/lead.

[15]US EPA, National Ambient Air Quality Standard for Lead, Final Rule. Federal Register, November 12, 2008; epa.gov/fedrgstr/EPA-AIR/2008/November/Day-12/a25654.pdf.

Visibility

As of 2011, 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, 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 21 through 25 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-13 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 21-year period from December 1990 through December 2011, the 12-month moving average increased from 47 miles to 84 miles.

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

Figure 21: Puget Sound Visibility

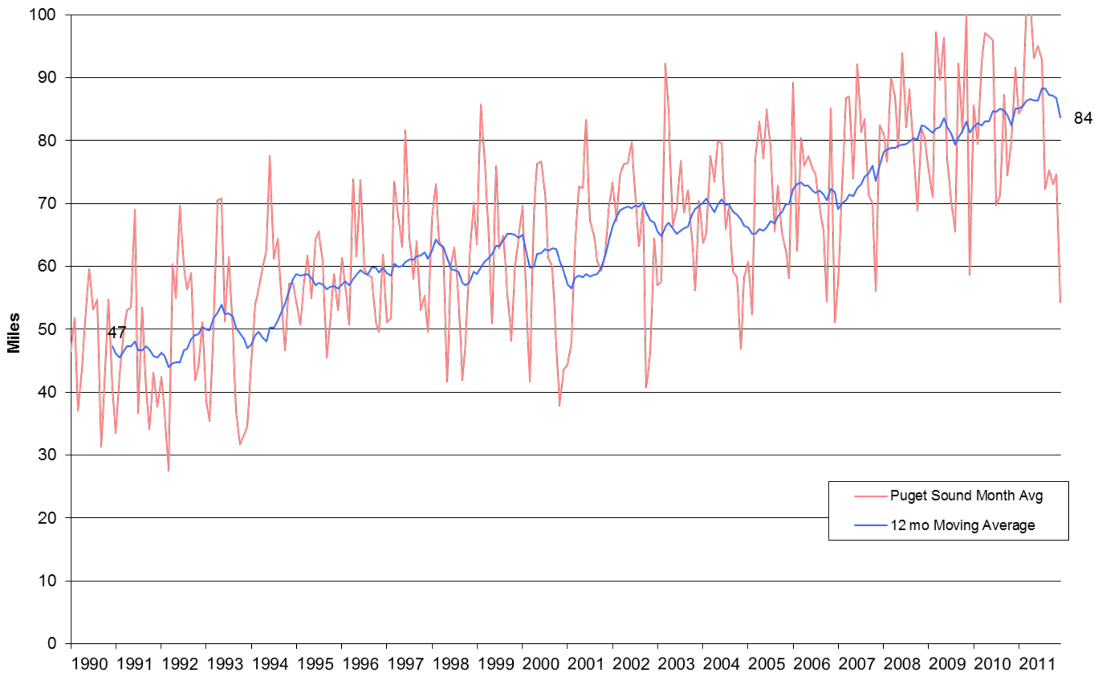


Figure 22: King County Visibility

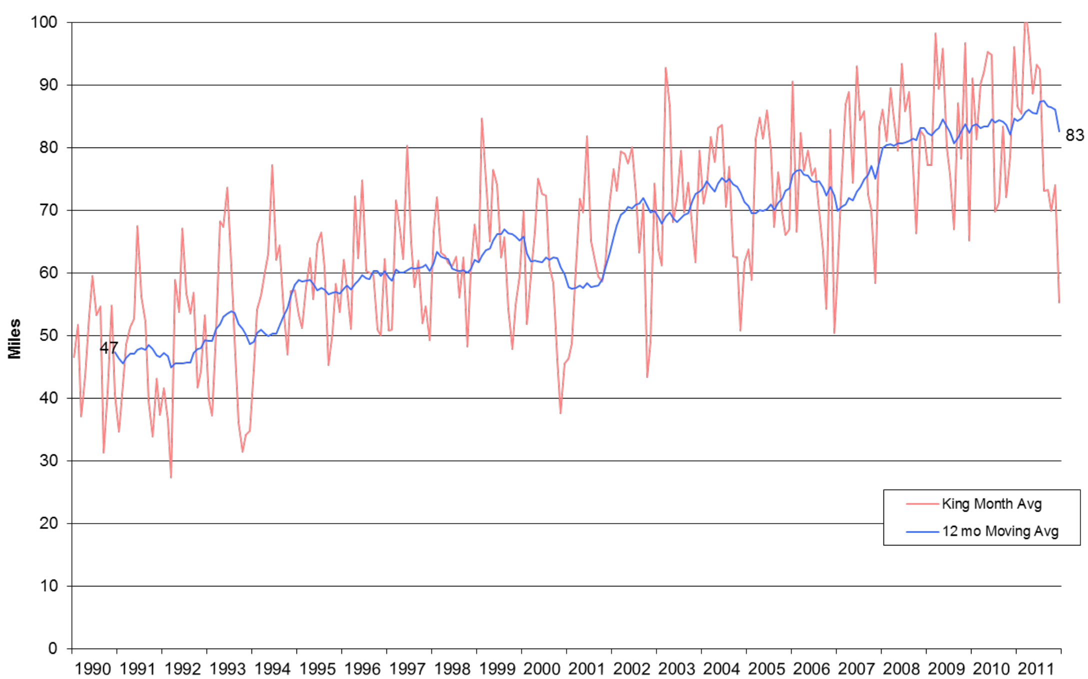


Figure 23: Kitsap County Visibility

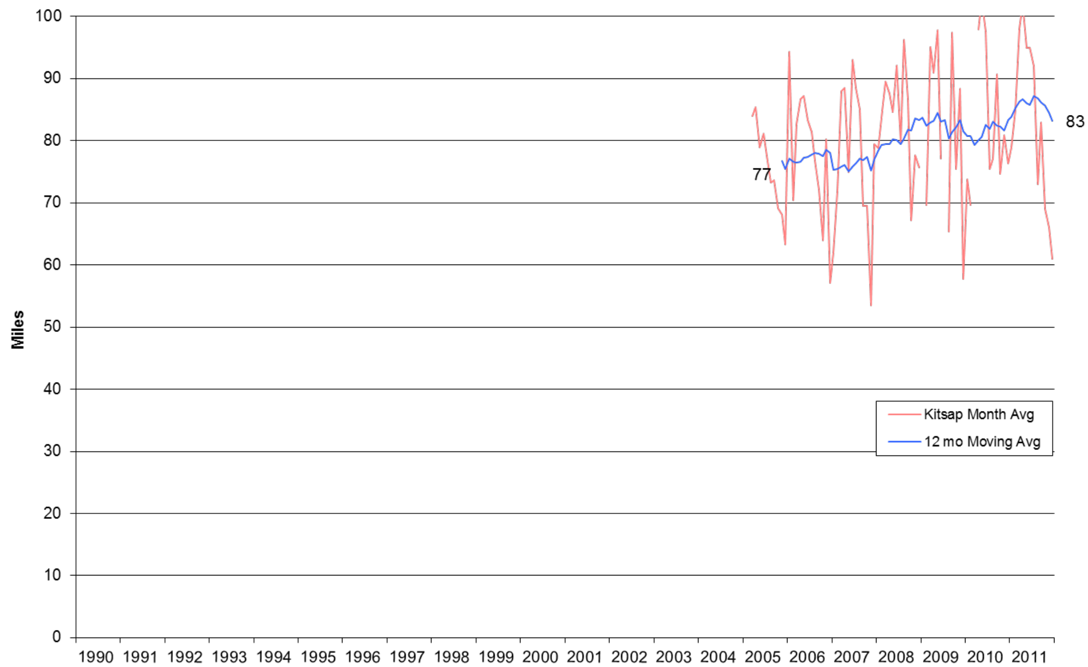


Figure 24: Pierce County Visibility

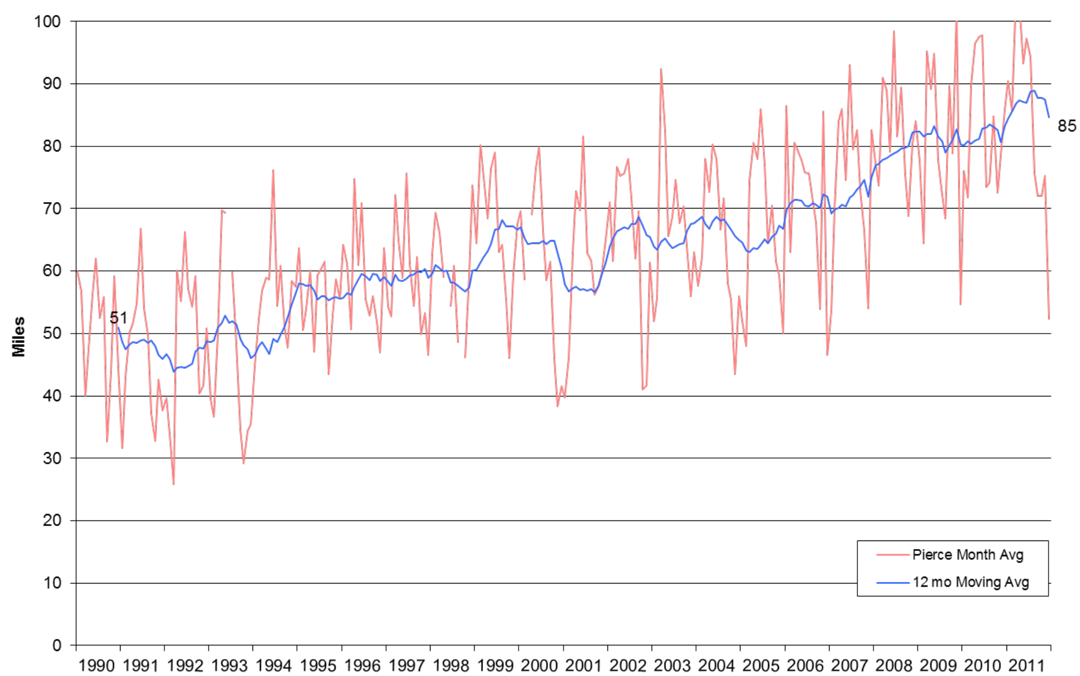
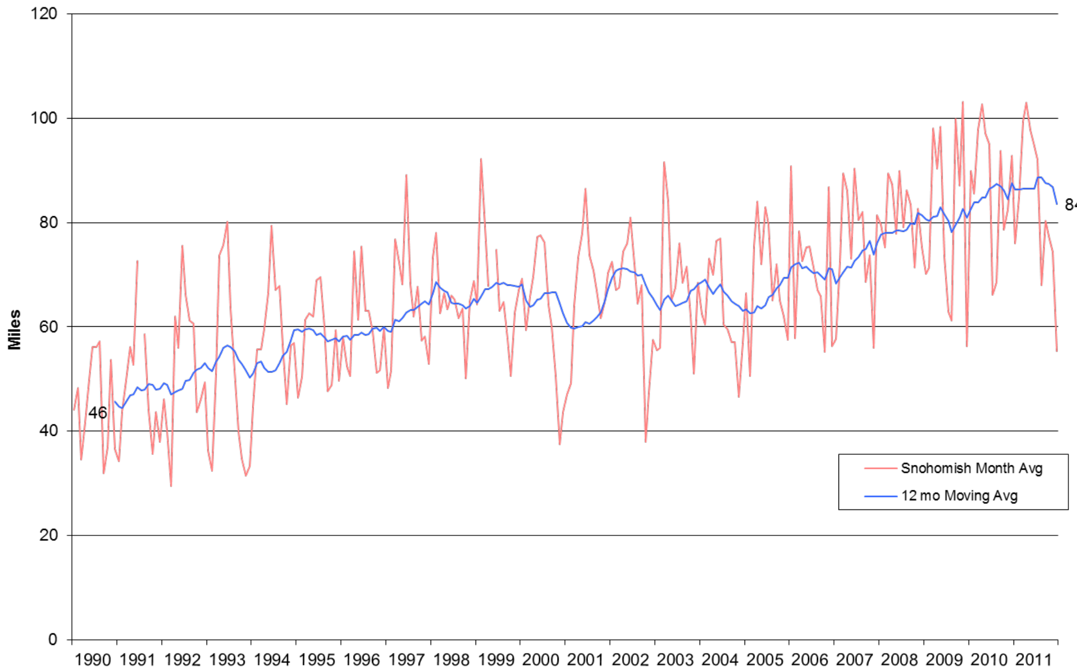


Figure 25: Snohomish County Visibility



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 2011 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 that year. 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 pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf.

For general information on air toxics, see pscleanair.org/airq/basics/airtoxics.aspx. Air toxics statistical summaries are provided on page A-20 of the Appendix.

Relative Ranking Based on Cancer Risk & Unit Risk Factors

Table 3 ranks 2011 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.[16]

For details on how air toxics were ranked, please see pages A-21 and A-22 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 3) are presented on page A-22 of the Appendix. Page A-22 also lists the frequency (percentage) of samples that were over the cancer screening level of one-in-a-million risk.

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

Table 3: 2011 Beacon Hill Air Toxics Ranking
(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk*
Carbon Tetrachloride	1	27
Benzene	2	21
1,3-Butadiene	3	15
Formaldehyde	5	5
Chromium VI (TSP) M	6	5
Dichloromethane	7	3
Chloroform	8	3
Acetaldehyde	9	3
Naphthalene	10	2
Arsenic (PM_{10}) M	11	2
Nickel (PM_{10}) M	12	1
Ethylbenzene	13	1
Tetrachloroethylene	15	1
Cadmium (PM_{10}) M	16	< 1
Manganese (PM_{10}) M	17	< 1

*Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level (WAC 173-460-150)[17]

M = metal

PM_{10} = 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.

[17] Washington State Administrative Code WAC 173-460-150, 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, we compared each air toxic 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.[18] 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-23 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.

We did not explore acute non-cancer health effects, 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 2011 at Beacon Hill. 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 2011. We do not present graphs for air toxics metals because few exceed potential cancer risk screening levels. EPA has not set ambient air standards for air toxics, so graphs do not include reference lines for federal standards.

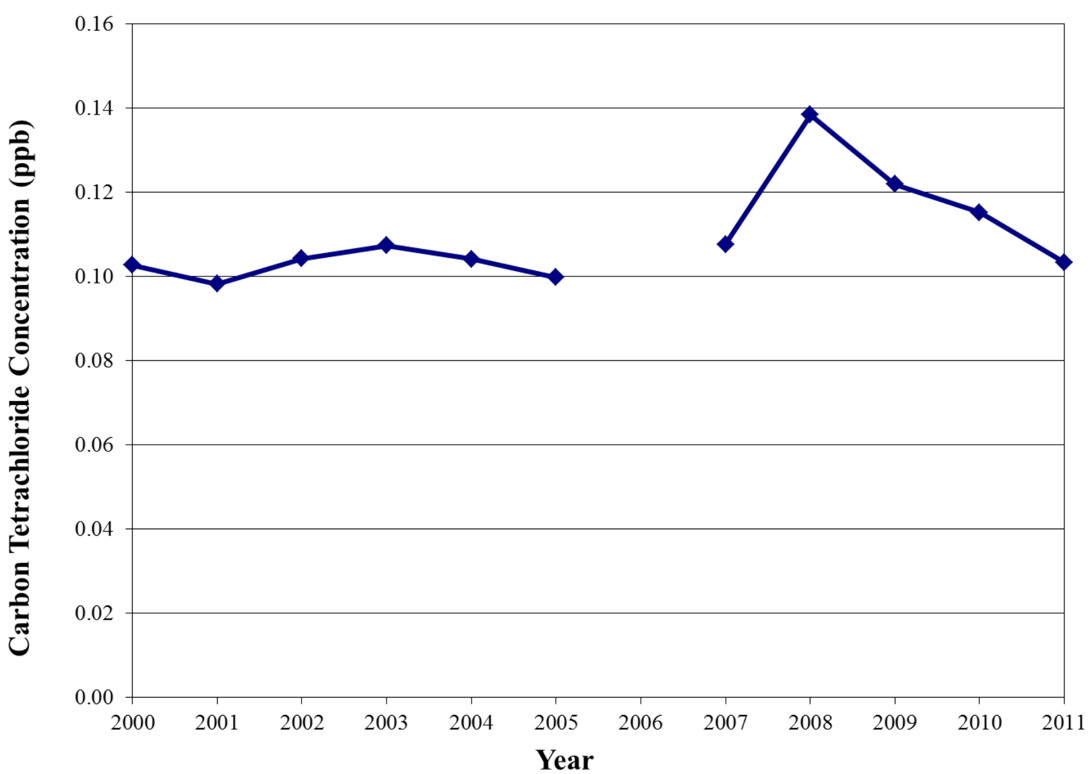
[18]EPA, Acrolein Hazard Summary; epa.gov/ttn/atw/hlthef/acrolein.html.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[19] 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 2011 average potential cancer risk range estimate at Beacon Hill was 27 in a million.

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

Figure 26: Carbon Tetrachloride Annual Average Concentrations at Beacon Hill, 2000-2011



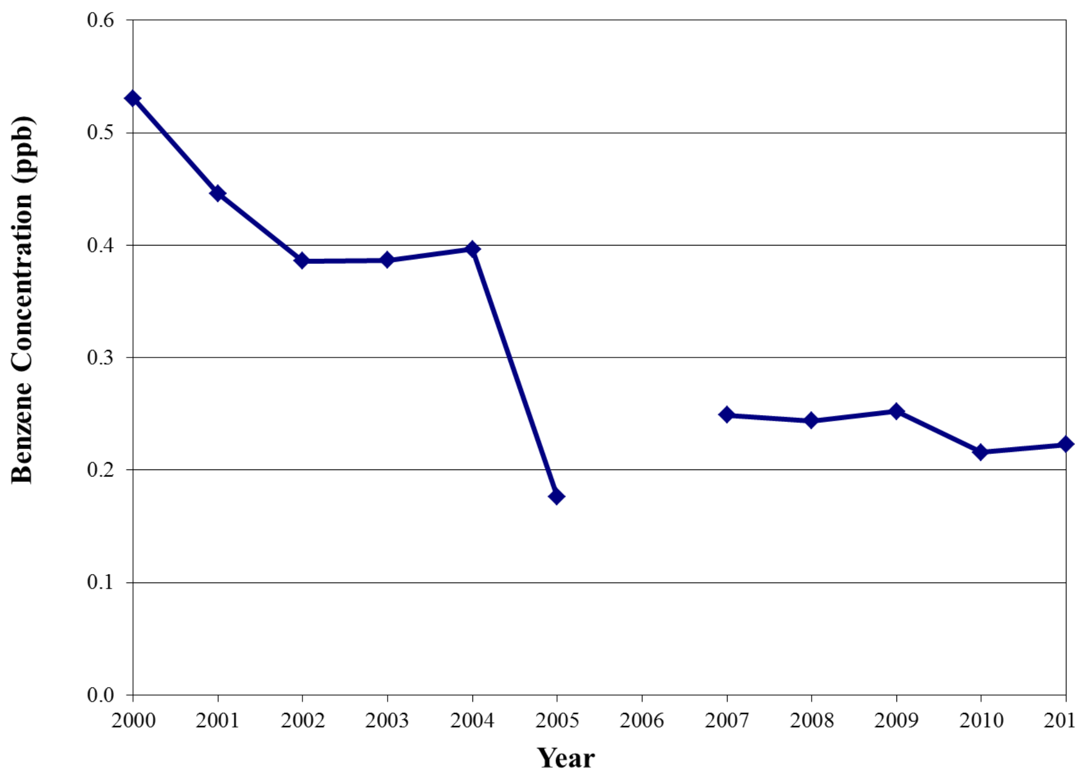
[19]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/carbonte.html.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune and nervous system disorders.[20] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvent and other combustion. Benzene's 2011 average potential cancer risk range estimate at Beacon Hill was 21 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 27: Benzene Annual Average Concentrations at Beacon Hill, 2000-2011



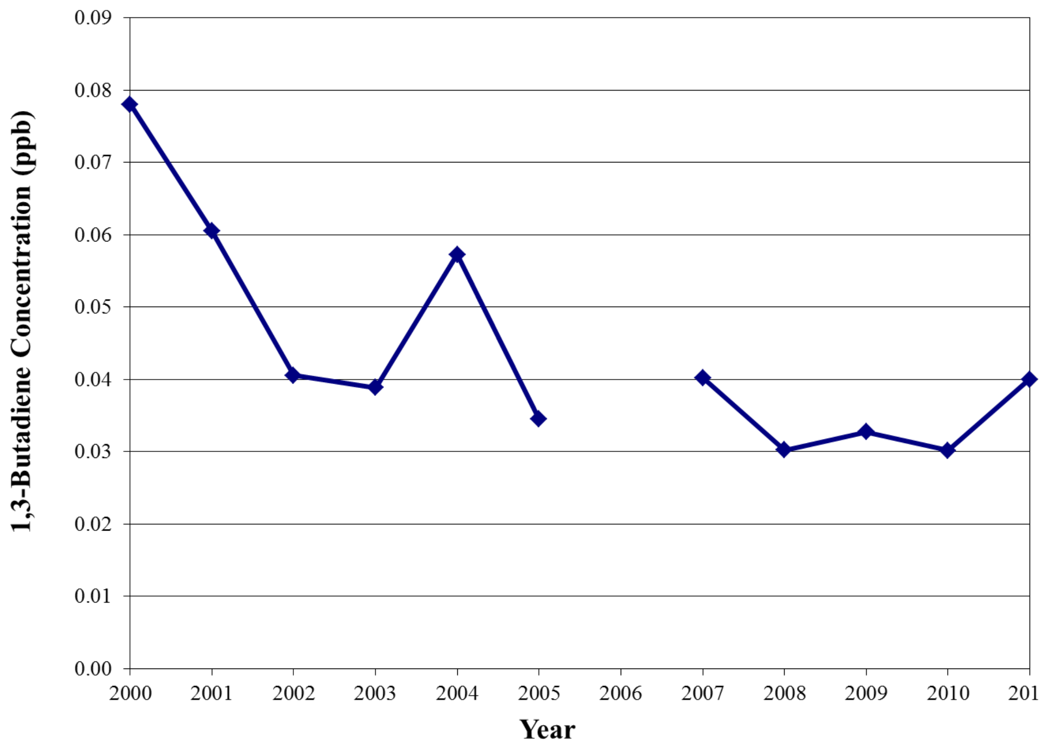
[20] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/benzene.html.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.[21] Primary sources of 1,3-butadiene include cars, trucks, buses and wood burning. 1,3-butadiene's 2011 average potential cancer risk estimate at Beacon Hill was 15 in a million.

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

Figure 28: 1,3-Butadiene Annual Average Concentrations at Beacon Hill, 2000-2011



[21]EPA Hazard Summary; epa.gov/ttnatw01/hlthef/butadien.html.

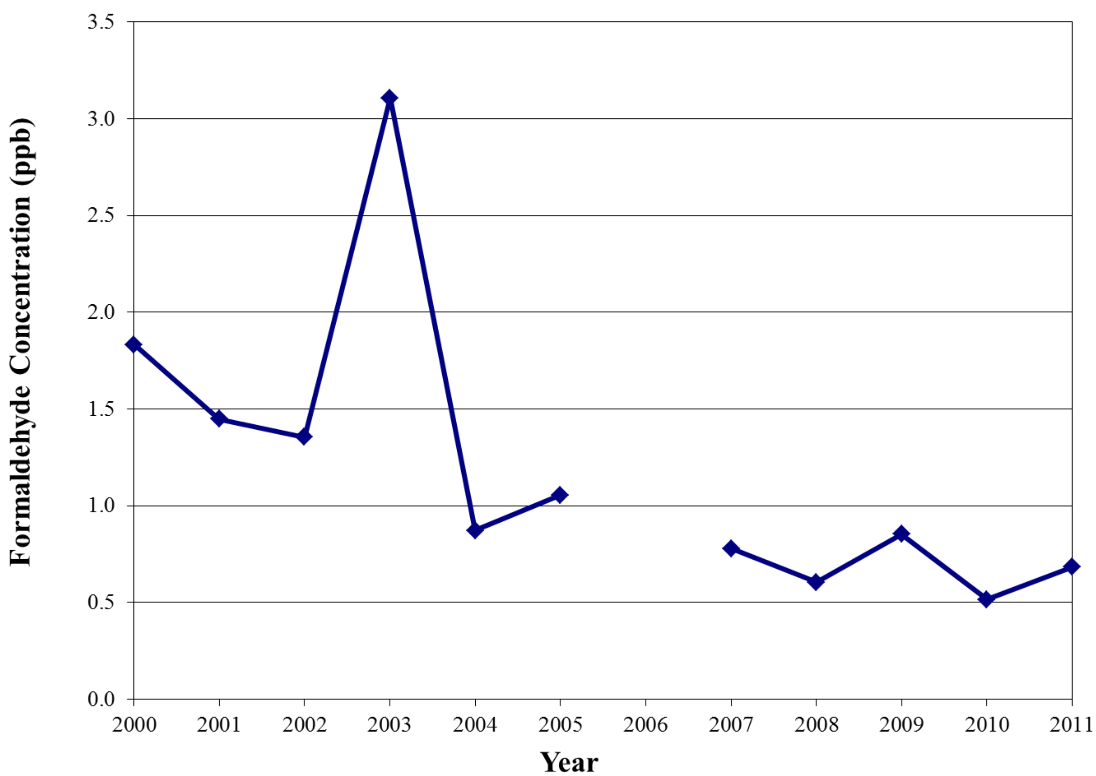
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat and lung irritation.[22] Sources of ambient formaldehyde include automobiles, trucks, wood burning and other combustion. Formaldehyde's 2011 average potential cancer risk range estimate at Beacon Hill was 5 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 29: Formaldehyde Annual Average Concentrations at Beacon Hill, 2000-2011



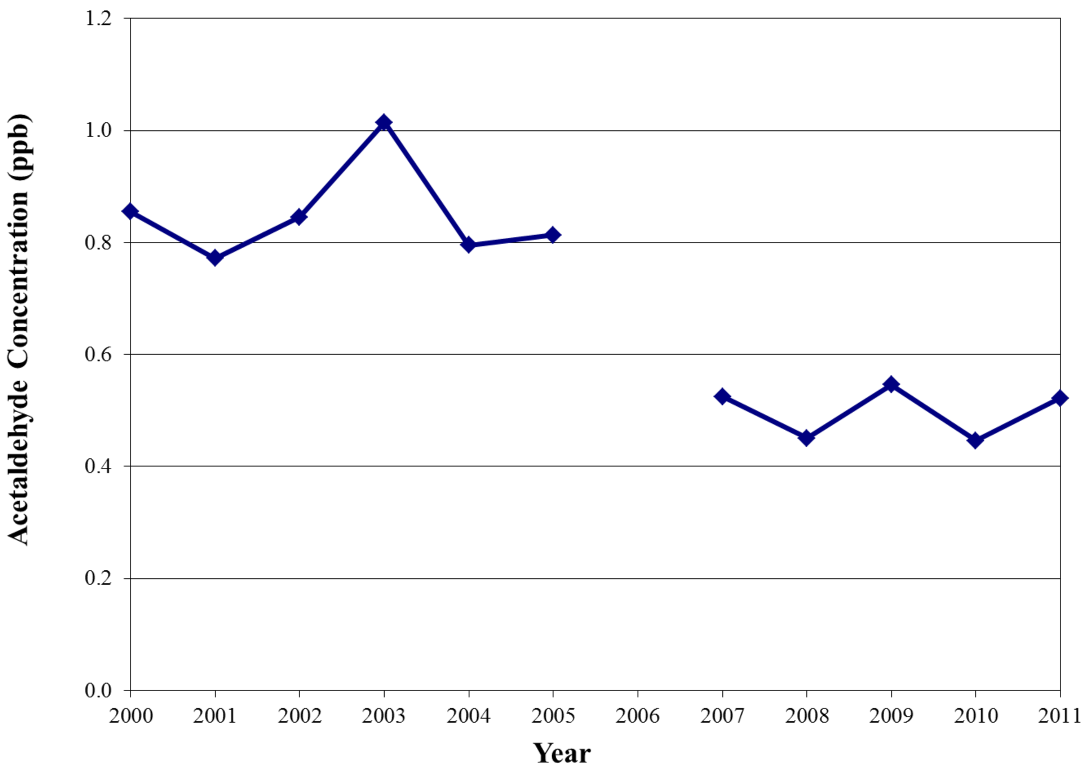
[22]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/formalde.html.

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.[23] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2011 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 30: Acetaldehyde Annual Average Concentrations at Beacon Hill, 2000-2011



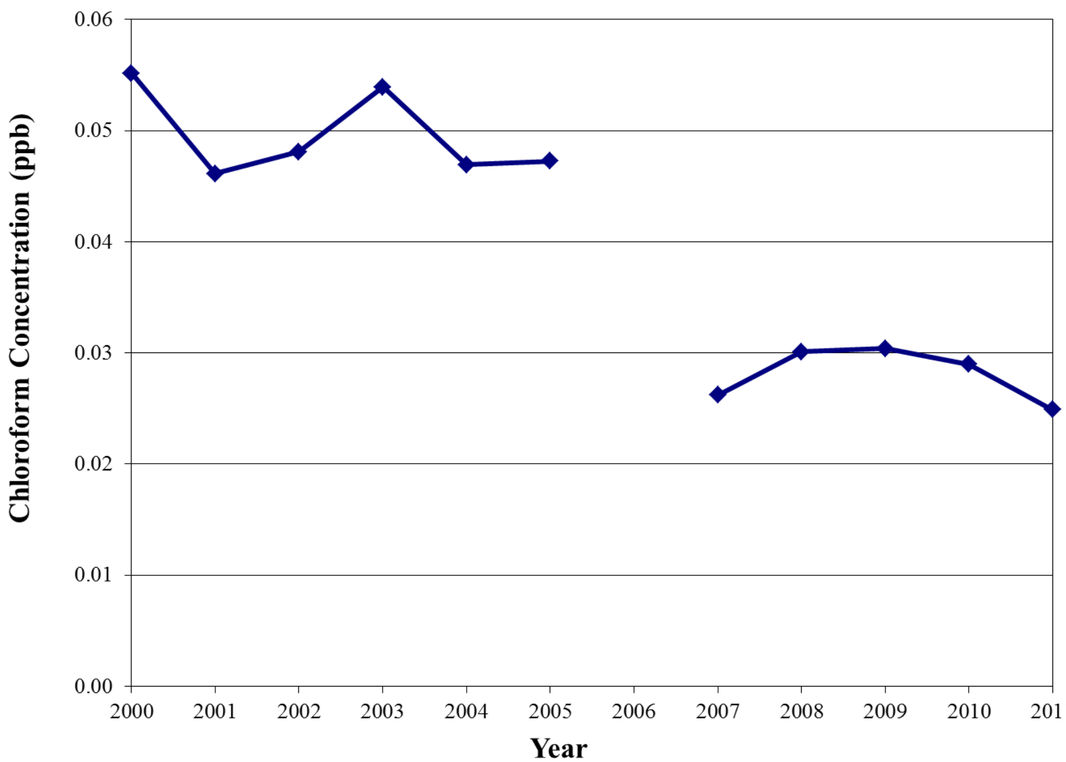
[23]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/acetalde.html.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.[24] 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 2011 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.[25]

Figure 31: Chloroform Annual Average Concentrations at Beacon Hill, 2000-2011

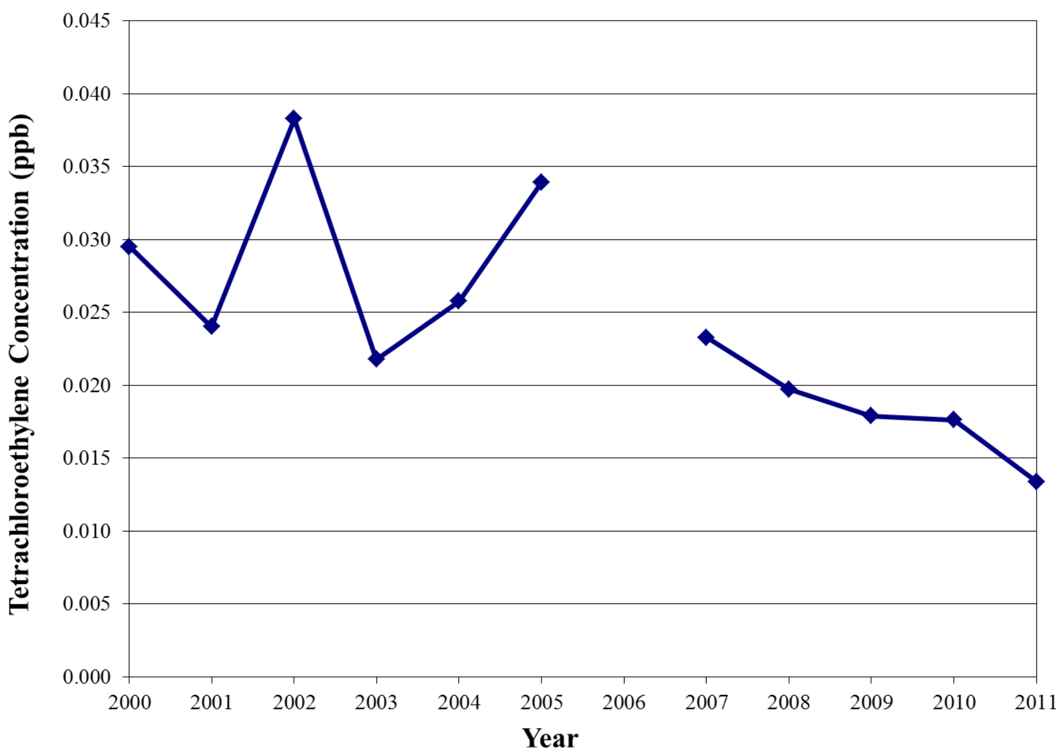


[24]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/chlorofo.html.
[25]Seattle Public Utilities. 2011Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/groups/public/@spu/@water/documents/webcontent/02_016357.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform.

Tetrachloroethylene

EPA lists tetrachloroethylene, also known as perchloroethylene or "perc", as a probable human carcinogen. Tetrachloroethylene inhalation is also associated with central nervous system effects, liver and kidney damage, and cardiac arrhythmia.[26] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2011 average potential cancer risk estimate at Beacon Hill was one-in-a-million.

Figure 32: Tetrachloroethylene Annual Average Concentrations at Beacon Hill, 2000-2011



[26] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/tet-ethy.html.

Ethylbenzene

EPA lists Ethylbenzene as a Group D pollutant, which is not classifiable as to human carcinogenicity due to limited information available.[27] Chronic exposure to Ethylbenzene may affect the blood, liver and kidneys. Local sources of Ethylbenzene are from fuels, asphalt and naphtha. It is also used in styrene production. Ethylbenzene's 2011 average potential cancer risk estimate at Beacon Hill was one-in-a-million. The Agency works with and regulates solvent-using businesses to reduce Ethylbenzene emissions.

Naphthalene

EPA lists naphthalene as a possible human carcinogen. Naphthalene is similarly associated with respiratory effects and retina damage.[28] Local sources of naphthalene include combustion of wood and heavy fuels. Naphthalene's 2011 average potential cancer risk estimate at Beacon Hill was 2 in a million. Since naphthalene is below one-in-a-million cancer risk most other years, no graph of estimated potential risk is presented.

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

Metals

Table 3 (2011 Beacon Hill Air Toxics Ranking), shown previously in this section, includes estimated potential cancer risks for several PM_{10} metals monitored at Beacon Hill, as well as total suspended particulate (TSP) hexavalent chromium. Hexavalent chromium and arsenic posed the greatest potential cancer risks. Other metals were below non-cancer screening levels (see Appendix page A-23).

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.[29] 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).

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[27] EPA Hazard Summary: epa.gov/ttn/atw/hlthef/ethylben.html.
[28] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/naphthal.html.
[29] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/chromium.html.

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 5 in a million.

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.[30] Arsenic is used to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2011 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.[31] Combustion of gasoline and diesel fuels (car, truck and bus exhaust) is a main source of nickel in the Puget Sound area. Nickel's 2011 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.[32] Combustion of distillate oil is a main source of cadmium in the Puget Sound area. Cadmium's 2011 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

Manganese

EPA lists manganese as "not classifiable" for cancer. Manganese exposures are primarily associated with central nervous system effects.[33] 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. 2011 manganese levels in the Puget Sound area are below levels indicating health risk, with a hazard index of less than one.

[30] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/arsenic.html.
[31] EPA Hazard Summary; epa.gov/iris/subst/0273.htm.
[32] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/cadmium.html.
[33] EPA National Air Toxics Assessment; epa.gov/ttnatw01/hlthef/manganes.html.

Definitions

General Definitions

Air Quality Index

Table 4: 2011 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	Very unhealthy
(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)]NO_2 has no short-term National Ambient Air Quality Standard (NAAQS) and can generate an AQI only above a value of 200.

[(c)]8-hour O_3 values do not define higher AQI values (above 300). AQI values above 300 are calculated with 1-hour O_3 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/m^3, instead of the current 40.4 µg/m^3). 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 SO_2 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 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 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 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.

pscleanair.org
Puget Sound Clean Air Agency

1904 Third Avenue, Suite 105
Seattle, Washington 98101
www.pscleanair.org

2011

Air Quality
Data Summary
Appendix

NOVEMBER 2012

Working Together for Clean Air

Air Quality Index
1980 – 2011

King County															
	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1980	73	275		18	0	95	270	1		1	17		194	Jan 23	PM
1981	69	267		28	1	109	254	2		5	24		213	Jan 15	CO
1982	86	268		10	1	96	264	5		1	10		214	Feb 6	PM
1983	98	258		9	0	101	261	3		0	9		183	Jan 28	CO
1984	146	218		2	0	111	242	13		2	0		103	Dec 6	PM
1985	150	202		10	3	156	206	3		6	7		204	Dec 12	PM
1986	130	226		8	1	113	246	6		1	8		206	Jan 7	PM
1987	120	238		7	0	119	246	0		3	4		184	Feb 6	PM
1988	215	146		5	0	67	298	1		2	3		150	Dec 3	CO
1989	231	134		0	0	129	233	3		0	0		100	Jan 19 #	CO
1990	216	145		4	0	139	201	6	19	0	0	4	131	Aug 11	O_3
1991	229	136		0	0	140	190	8	27	0	0	0	100	Dec 15 #	CO
1992	206	159		1	0	103	230	1	32	0	1	0	167	Feb 3	CO
1993	240	125		0	0	118	235	1	11	0	0	0	88	Jan 11	PM
1994	293	70		2	0	72	270	1	22	0	0	2	134	Jul 21	O_3
1995	299	66		0	0	95	249	5	16	0	0	0	89	Jan 3	CO
1996	297	69		0	0	85	252	2	27	0	0	0	100	Oct 9	CO
1997	302	63		0	0	117	230	0	18	0	0	0	94	Jan 16	PM
1998	317	46		2	0	111	228	0	26	0	0	2	114	Jul 27 #	O_3
1999	267	92	6	0	0	251	60	0	54	5	0	1	134	Jan 4	PM
2000	241	118	7	0	0	288	25	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	320	44	1	0	0	261	0	0	104	0	0	1	104	Aug 17	O_3
2011	316	49	0	0	0	192	0	0	173	0	0	0	98	Dec 10	PM
Totals	7286	4233	52	111	6	5581	4723	61	1323	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 (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Air Quality Index
1990 – 2011

Kitsap County															
	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1990															
1991															
1992	353	8		0	0	361				0			68	Nov 25	PM
1993	343	12		0	0	355				0			62	Jan 11	PM
1994	364	1		0	0	248	117			0	0		54	Dec 23	CO
1995	361	4		0	0	86	279			0	0		57	Jan 5	CO
1996	361	1		0	0	206	156			0	0		51	Mar 2	PM
1997	361	1		0	0	362				0			55	Jan 15	PM
1998	347	9		0	0	356				0			87	Nov 8	PM
1999	333	32	0	0	0	365				0			81	Jan 5 #	PM
2000	290	75	0	1	0	366				1			159	Jul 4	PM
2001	320	42	0	0	0	362				0			91	Dec 25	PM
2002	324	41	0	0	0	365				0			78	Nov 2	PM
2003	318	47	0	0	0	365				0			78	Nov 3	PM
2004	340	26	0	0	0	366				0			80	Jul 4	PM
2005	328	35	2	0	0	365				2			136	Jul 4	PM
2006	339	25	1	0	0	365				1			105	Dec 17	PM
2007	322	42	0	0	0	364				0			92	Nov 24	PM
2008	342	24	0	0	0	366				0			78	Dec 23	PM
2009	300	37	2	0	0	339				2			111	Dec 3	PM
2010	321	31	0	0	0	352				0			88	Dec 31	PM
2011	340	22	1	0	0	363				1			111	Jan 1	PM
Totals	6707	515	6	1	0	6677	552	0	0	7	0	0			

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

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

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Air Quality Index
1980 – 2011

Pierce County

Year	Days in Each Air Quality Category: Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	Pollutant Determining the AQI: All Days PM	All Days CO	All Days SO_2	All Days O_3	Unhealthy Days PM	Unhealthy Days CO	Unhealthy Days O_3	Highest Value: AQI	Date	Pollutant
1980	83	271		12	0	256	107	3		4	8		160	Apr 12	PM
1981	74	278		10	3	222	137	6		1	12		227	Jan 12	CO
1982	119	242		4	0	255	101	9		0	4		167	Dec 30	CO
1983	140	222		3	0	228	128	9		1	2		137	Dec 23	PM
1984	162	198		6	0	207	149	10		0	6		117	Jan 19 #	CO
1985	140	213		12	0	252	109	4		1	11		165	Dec 13	PM
1986	161	197		7	0	247	114	4		2	5		167	Oct 23	CO
1987	173	177		13	2	227	136	2		5	10		220	Feb 5	CO
1988	226	132		8	0	184	175	7		3	5		183	Jan 27	CO
1989	260	103		2	0	217	121	27		0	2		117	Nov 30 #	CO
1990	271	91		3	0	219	87	41	18	1	0	2	118	May 5	PM
1991	261	103		1	0	247	85	12	21	0	1	0	117	Jan 31	CO
1992	260	106		0	0	231	83	27	25	0	0	0	100	Feb 3 #	CO
1993	289	76		0	0	247	82	23	13	0	0	0	89	Feb 1	CO
1994	313	51		1	0	235	75	31	24	0	0	1	105	Jul 21	O_3
1995	307	58		0	0	239	97	13	16	0	0	0	83	Jan 3	PM
1996	322	44		0	0	206	119	23	18	0	0	0	78	Oct 9	CO
1997	316	49		0	0	262	75	16	12	0	0	0	84	Jan 16	PM
1998	338	25		2	0	213	112	25	15	0	0	2	120	Jul 27	O_3
1999	265	97	3	0	0	318	1	1	45	3	0	0	139	Jan 4	PM
2000	242	110	13	1	0	318	2	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	324	41	0	0	0	259	0	0	106	0	0	0	83	Dec 5	PM
2011	307	47	10	1	0	365	0	0	0	11	0	0	152	Jan 1	PM
Totals	7842	3643	106	92	5	8103	2101	293	1191	125	66	12			

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

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

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Air Quality Index
1980 – 2011

Snohomish County

	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	SO_2	AQI	Date	Pollutant
1980	340	19		0	0	356		3		0		0	60	Jan 23	PM
1981	350	11		0	0	340		21		0		0	62	Jan 16	PM
1982	334	30		1	0	277	70	18		0	1	0	117	Dec 30	CO
1983	308	56		1	0	191	150	24		0	1	0	117	Nov 30	CO
1984	309	57		0	0	105	217	44		0	0	0	92	Sep 28	PM
1985	300	64		1	0	152	166	47		0	1	0	117	Dec 11	CO
1986	324	41		0	0	169	148	48		0	0	0	89	Jan 25	CO
1987	203	158		3	0	96	250	18		0	3	0	117	Jun 26 #	CO
1988	174	184		8	0	15	345	6		0	8	0	133	Sep 13 #	CO
1989	150	213		2	0	26	338	1		0	2	0	133	Feb 10	CO
1990	166	197		2	0	29	335	1		0	2	0	117	Mar 2 #	CO
1991	188	176		1	0	32	333	0		0	1	0	117	Dec 16	CO
1992	180	186		0	0	34	332	0		0	0	0	100	Feb 4 #	CO
1993	237	128		0	0	56	306	0	3	0	0	0	79	Jan 11	PM
1994	294	71		0	0	28	334	1	2	0	0	0	78	Dec 30	CO
1995	316	49		0	0	59	294	1	11	0	0	0	78	Jul 7	CO
1996	340	26		0	0	54	299	0	13	0	0	0	67	Jul 26	O_3
1997	348	17		0	0	210	151	0	4	0	0	0	67	Jan 14	PM
1998	353	11		1	0	143	219	3	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	324	41	0	0	0	365	0	0	0	0	0	0	98	Nov 24	PM
2011	304	53	8	0	0	365	0	0	0	8	0	0	147	Jan 1	PM
Totals	8985	2580	61	21	0	6910	4468	236	33	63	19	0			

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

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

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Monitoring Methods Used from 1999 to 2011 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

Historical 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 4th Ave, Seattle (ended Jun 30, 2006)												X						a, d
AS⦿	5th Ave & James St, Seattle (ended Feb 28, 2001)												X						a, d
AU⦿	622 Bellevue Way NE, Bellevue (ended Jul 30, 1999)												X						a, d
AZ	Olive Way & Boren Ave, 1624 Boren Ave, Seattle							●	X					●	●	●		●	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				●		●	X	X	●	●	●	●	X	●	●	●	●	b, d, f
CE	Duwamish, 4752 E Marginal Way S, Seattle SPECIATION SITE	X		X	X		●	●	●		X			X	●	●		●	a, e
CG⦿	Woodinville, 17401 133rd Av NE, Woodinville							●						●					b ,d ,f
CW	James St & Central Ave, Kent	X		X	X		●	●						●	●	●		●	b, d
CX	17711 Ballinger Way NE, Lake Forest Park (ended Jun 4, 1999)	X	X											X	X			X	b, d, f
CZ	Aquatic Center, 601 143rd Ave NE, Bellevue (ended May 31, 2006)						X	X						X				X	b, f
DA	South Park, 8025 10th Ave S, Seattle (ended Dec 31, 2002)	X			X			X						X	X			X	b, e, f

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		X		X	●	X					●	●	●		●	b, d, f
DC⦿	305 Bellevue Way NE, Bellevue				X			●						●				●	a, d
DD	South Park, 8201 10th Ave S, Seattle							●						●				●	b, e, f
DE⦿	City Hall, 15670 NE 85th St, Redmond (ended Dec 14, 2005)				X			X						X				X	a, d
DF⦿	30525 SE Mud Mountain Road, Enumclaw				X			X		●				X	●	●		X	c
DG⦿	42404 SE North Bend Way, North Bend				X		X	●		●				●	●	●		●	c, d, f
DH⦿	2421 148th Ave NE, Bellevue												●						b, d
DK⦿	43407 212th Ave SE, 2 mi west of Enumclaw (ended Sep 6, 2006)														X	X			c
DL⦿	NE 8th St & 108th Ave NE, Bellevue (ended March 4, 2003)												X						a, d
DN⦿	20050 SE 56th, Lake Sammamish State Park, Issaquah									●					X	X			b, d
DP⦿	504 Bellevue Way NE, Bellevue (ended Sep 30, 1999)	X			X														a, d
DZ⦿	Georgetown, 6431 Corson Ave S, Seattle (ended August 31, 2002)											X	X		X				a, d, e, f
EA	Fire Station #12, 2316 E 11th St, Tacoma (ended Dec 31, 2000)	X	X												X				a, e
EP	27th St NE & 54th Ave NE, Tacoma (ended Feb 29, 2000)	X									X				X				b, e, f
EQ	Tacoma Tideflats, 2301 Alexander Ave, Tacoma SPECIATION SITE	X	X	X	X		X	●	●		X			●	●	●		●	a, e
ER	South Hill, 9616 128th 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

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
FG⦿	Mt Rainier National Park, Jackson Visitor Center									●									c
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 7th St, Marysville SPECIATION SITE	X	X		●		●	●	●					●	●	●		●	b, d
IH	20935 59th Place West, Lynnwood (ended Jun 8, 1999)	X		X										X	X			X	a, d
II	6120 212th St SW, Lynnwood				X	X	●	●						●	●	●		●	b, d
JN⦿	5810 196th Street, Lynwood (ended Jun 30, 2006)												X						a,d
JO	Darrington High School, Darrington 1085 Fir St				●		●	●	●					●	●	●		●	d, f
JP⦿	2939 Broadway Ave, Everett (ended March 31, 2003)												X						a, d
JQ⦿	44th Ave W & 196th St SW, Lynnwood (ended May 3, 2004)												X						a, d
JS⦿	Broadway & Hewitt Ave, Everett (ended May 21, 2000)												X						a, d
QE	Meadowdale, 7252 Blackbird Dr NE, Bremerton	X				X	●	●						●	●	●		●	b, f
QF	Lions Park, 6th Ave NE & Fjord Dr, Poulsbo (ended Feb 29, 2000)														X				b, f
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	SO_2	Sulfur Dioxide
RV⦿	Shading indicates station functioning	NO_y	Nitrogen Oxides
●	Indicates parameter currently monitored	CO	Carbon Monoxide
X	Indicates parameter previously monitored	b_{sp}	Light scattering by atmospheric particles (nephelometer)
PM_{10} ref	Particulate matter <10 micrometers (reference)	Wind	Wind direction and speed
PM_{10} bam	Particulate matter <10 micrometers (beta attenuation continuous)	Temp	Air temperature (relative humidity also measured at BW)
PM_{10} 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 particles)
$PM_{2.5}$ bam	Particulate matter <2.5 micrometers (beta attenuation continuous)	PHOTO	Visibility (camera)
$PM_{2.5}$ teom	Particulate matter <2.5 micrometers (teom-fdms continuous)	O_3	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		

Burn Bans
1988 – 2011

Year	Start Date	Start Time	End Date	End Time
1988	Jan 25	0830	Jan 28	0830
	Feb 5	1630	Feb 6	0930
	Dec 1	1430	Dec 2	0800
	Dec 4	1430	Dec 5	1400
	Dec 16	1430	Dec 18	1430
1989	Jan 19	1430	Jan 20	1430
	Jan 24	1430	Jan 26	0930
	Feb 6	1430	Feb 8	0930
	Feb 10	1430	Feb 16	0930
	Nov 29	1430	Dec 2	0930
	Dec 22	1430	Dec 23	1430
1990	Jan 19	1430	Jan 21	1430
	Dec 7	1430	Dec 8	0930
	Dec 25	1430	Dec 26	1430
	Dec 26	1430	Dec 27	0815*
1991	Jan 5	1430	Jan 6	0930
	Jan 21	1430	Jan 22	0930
	Jan 22	0930	Jan 24	1500*
	Jan 29	1430	Jan 31	0830
	Dec 15	1430	Dec 16	1430
	Dec 16	1430	Dec 17	0930*
	Dec 17	0930	Dec 17	1430
1992	Jan 8	1430	Jan 9	0930
	Jan 19	1430	Jan 20	1430
	Feb 5	1000	Feb 6	1430
	Nov 25	1430	Nov 26	1430
1993	Jan 11	1430	Jan 13	0830
	Jan 15	1430	Jan 16	0700
	Jan 17	1430	Jan 19	0600
	Jan 31	1430	Feb 3	0830
	Dec 20	1430	Dec 21	1430
	Dec 26	1430	Dec 29	0830
1994	None			
1995	Jan 4		Jan 7	
1996	Feb 14	1430	Feb 16	1630

Year	Start Date	Start Time	End Date	End Time
1997	Nov 13	1500	Nov 15	1500
	Dec 4	1500	Dec 7	1800
1998	None			
1999	Jan 5	1400	Jan 6	1000
	Dec 29	1400	Dec 31	0600
2000	Feb 18	1400	Feb 20	1000
	Nov 15	1700	Nov 23	0600
2001	Nov 8	1400	Nov 12	1800
2002	Nov 1	1500	Nov 6	0900
	Nov 27	1000	Dec 4	1000
2003	Jan 7	1500	Jan 9	1300
2004	None			
2005	Feb 21	1600	Feb 28	0800
	Dec 9	1700	Dec 18	1200
2006	None			
2007	Jan 13	1400	Jan 16	1500
	Jan 28	1400	Jan 31	1400
	Dec 9	1400	Dec 11	0930
2008	Jan 23	1400	Jan 26	1200
2009	Jan 16	1200	Jan 24	1200
	Feb 3	1400	Feb 6	0900
	Dec 8	1000	Dec 13	1000
	Dec 23	1600	Dec 30	1200
2010	Jan 28	1200	Jan 31	1000
	Dec 30	1700	Jan 4	1700
2011	Jan 1	0000	Jan 4	1700
	Nov 30	1700	Dec 7	1300
	Dec 11	1700	Dec 14	1600

* Stage 2 Burn Ban

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

Micrograms per Cubic Meter

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

2011

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	117	10.5	3.4	5.1	10.8	7.5	31.1	37.7
Marysville JHS, 1605 7th St, Marysville	175	7.6	4.7	6.4	10.2	7.2	31.3	37.8
7802 South L St, Tacoma	354	8.8	4.2	5.9	13.3	8.1	35.7	55.9

Notes:
(1) Sampling occurs for a 24 hour period from midnight to midnight.
Quarterly averages are shown only if 75 percent or more of the data is available.
(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum Observed Concentrations

Location	Jan 1 Sat	Jan 3 Mon	Dec 5 Mon
Darrington HS, 1085 Fir St, Darrington		- -	37.7
Marysville JHS, 1605 7th St Marysville		37.8	
7802 South L St, Tacoma	55.9	- -	- -

- - Indicates no sample on specified day

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Darrington HS, 1085 Fir St, Darrington	106	9	2	0
Marysville JHS, 1605 7th St, Marysville	159	15	1	0
7802 South L St, Tacoma	310	36	7	1

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

2011

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	360	11.8	4.7	5.4	12.4	8.6	34.4	54.3
Marysville JHS, 1605 7th St, Marysville	330	6.1	5.0	6.3	10.6	7.0	20.9	34.0
6120 212th St SW, Lynnwood	340	5.2	4.1	5.5	9.7	6.1	21.1	25.9
Duwamish, 4752 E Marginal Way S, Seattle	350	9.5	6.4	6.7	11.3	8.5	21.3	28.8
James St & Central Ave, Kent	338	8.7	5.8	5.7	10.8	7.8	24.7	31.5
7802 South L St, Tacoma	351	9.5	4.5	5.5	11.7	7.8	28.0	57.5
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	347	6.7	4.0	4.6	9.7	6.3	19.6	38.7

Notes
(1) Sampling occurs continuously for 24 hours each day.
Quarterly averages are shown only if 75 percent or more of the data is available.
(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum Observed Concentrations

Location	Jan 1 Sat	Jan 3 Mon	Jan 4 Tue	Dec 6 Tue	Dec 10 Sat
Darrington HS, 1085 Fir St, Darrington	54.3				
Marysville JHS, 1605 7th St, Marysville	- -	- -	- -		34.0
6120 212th St SW, Lynnwood	- -	- -	- -	25.9	
Duwamish, 4401 E Marginal Way S, Seattle			28.8		
James St & Central Ave, Kent		31.5			
7802 South L St, Tacoma	57.5				
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	38.7				

- - Indicates no sample on specified day

PARTICULATE MATTER (PM2.5) – Continuous - Nephelometer

Micrograms per Cubic Meter

Sampling Method: Equivalent – Radiance Research M903 Nephelometer

2011

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	363	10.1	3.0	4.5	10.7	7.1	28.6	41.5
Marysville JHS, 1605 7th St, Marysville	363	7.6	5.0	6.7	11.3	7.7	22.4	35.9
6120 212th St SW, Lynnwood	300		4.2	5.4	10.9	6.8	23.3	29.4
17171 Bothell Way NE, Lake Forest Park	363	7.5	4.7	6.2	12.2	7.7	24.9	34.6
Queen Anne Hill, 400 W Garfield St, Seattle	363	5.2	5.2	6.4	8.4	6.3	15.1	21.6
Olive & Boren, Seattle	338	5.4	5.1	6.4	8.5	6.4	15.5	20.8
Duwamish, 4752 E Marginal Way S, Seattle	362	8.4	6.9	8.5	12.0	9.0	21.5	26.2
South Park, 8025 10th Ave S, Seattle	363	8.5	6.8	8.3	12.3	9.0	21.6	25.1
305 Bellevue Way NE, Bellevue	351	4.2	3.8	4.7	6.6	4.8	12.3	16.2
42404 SE North Bend Way, North Bend	349	4.1	4.3	6.7	6.1	5.3	15.1	18.9
James St & Central Ave, Kent	357	7.6	5.3	6.9	10.0	7.5	20.5	28.6
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	348	7.7	5.4	6.7	10.6	7.6	22.7	25.7
7802 South L St, Tacoma	359	8.7	4.4	6.6	14.3	8.5	35.8	50.7
South Hill, 9616 128th St E, Puyallup	352	6.0	3.6	6.2	10.3	6.5	21.4	51.6
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	361	6.8	3.7	5.0	10.2	6.4	20.0	39.4

Notes

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

(2) All data values are correlated using site-specific relationships with Federal Reference Method samplers.

Summary of Maximum Observed Concentrations

Location	Jan 1 Sat	Jan 3 Mon	Jan 4 Tue	Jul 5 Tue	Dec 6 Tue	Dec 7 Wed	Dec 10 Sat	Dec 11 Sun
Darrington HS, 1085 Fir St, Darrington	41.5							
Marysville JHS, 1605 7th St, Marysville		35.9						
6120 212th St SW, Lynnwood					29.4			
17171 Bothell Way NE, Lake Forest Park							34.6	
Queen Anne Hill, 400 W Garfield St, Seattle					21.6			
Olive & Boren, Seattle					20.8			
Duwamish, 4752 E Marginal Way S, Seattle			26.2		26.2			
South Park, 8025 10th Ave S, Seattle					25.1			
305 Bellevue Way NE, Bellevue						16.2		
42404 SE North Bend Way, North Bend								18.9
James St & Central Ave, Kent		28.6						
Tacoma Tideflats, 2301 Alexander Ave, Tacoma					25.7			
7802 South L St, Tacoma	50.7							
South Hill, 9616 128th St E, Puyallup	- -			51.6				
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	39.4							

- - Indicates no sample on specified day

$PM_{2.5}$ Speciation Analytes Monitored in 2011
Average Annual Concentrations in Micrograms per Cubic Meter

Parameter
Acceptable Pm2.5 Aqi & Speciation Mass
Aluminum Pm2.5 Lc
Ammonium Ion Pm2.5 Lc
Antimony Pm2.5 Lc
Arsenic Pm2.5 Lc
Barium Pm2.5 Lc
Bromine Pm2.5 Lc
Cadmium Pm2.5 Lc
Calcium Pm2.5 Lc
Cerium Pm2.5 Lc
Cesium Pm2.5 Lc
Chlorine Pm2.5 Lc
Chromium Pm2.5 Lc
Cobalt Pm2.5 Lc
Copper Pm2.5 Lc
Indium Pm2.5 Lc
Iron Pm2.5 Lc
Lead Pm2.5 Lc
Magnesium Pm2.5 Lc
Manganese Pm2.5 Lc
Nickel Pm2.5 Lc
Phosphorus Pm2.5 Lc
Potassium Ion Pm2.5 Lc
Potassium Pm2.5 Lc
Rubidium Pm2.5 Lc
Selenium Pm2.5 Lc
Silicon Pm2.5 Lc
Silver Pm2.5 Lc
Sodium Ion Pm2.5 Lc
Sodium Pm2.5 Lc
Strontium Pm2.5 Lc
Sulfate Pm2.5 Lc
Sulfur Pm2.5 Lc
Tin Pm2.5 Lc
Titanium Pm2.5 Lc
Total Nitrate Pm2.5 Lc
Vanadium Pm2.5 Lc
Zinc Pm2.5 Lc
Zirconium Pm2.5 Lc
Elemental Carbon TOR
Organic Carbon TOR
Total Carbonaceous Mass
Soil
Reconstructed Fine Mass - Urban PM2.5

Additional information can be obtained at: epa.gov/ttn/airs/aqsdatamart/

$PM_{2.5}$ BLACK CARBON

micrograms per cubic meter

Sampling Method: Light Absorption by Aethalometer

2011

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Marysville JHS, 1605 7th St, Marysville	304	0.8	0.5		1.1	0.8	3.7
Duwamish, 4401 E Marginal Way S, Seattle	330	1.1	0.7	1.1	1.8	1.2	5.1
James St & Central Ave, Kent	348	1.1	0.5	0.8	1.6	1.0	4.0
7802 South L St, Tacoma	350	1.1	0.4	0.5	1.5	0.9	4.7
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	363	1.5	0.6	1.0	1.7	1.2	6.4
South Hill, 9616 128th St E, Puyallup	358	0.7	0.4	0.7	1.1	0.7	3.4

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

Summary of Maximum Observed Concentrations

Location	Jan 3 Mon	Jan 5 Wed	Jan 27 Thu	Nov 9 Wed	Dec 10 Sat
Marysville JHS, 1605 7th St, Marysville	- -	- -			3.7
Duwamish, 4752 E Marginal Way S, Seattle			- -	5.1	
James St & Central Ave, Kent			4.0		
7802 South L St, Tacoma	4.7				
Tacoma Tideflats, 2301 Alexander Ave, Tacoma		6.4			
South Hill, 9616 128th St E, Puyallup			3.4		

- - Indicates no sample on specified day

OZONE

(parts per million)

2011

Location / Continuous Sampling Period(s)	2011 Four Highest Daily 8-Hour Concentrations		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2009	2010	2011	2009 – 2011
Beacon Hill, 15th S & Charlestown	.046	18 May				
Seattle, WA	.046	24 May				
1 Jan – 31 Dec	.044	23 Mar				
	.044	25 Mar	.049	.043	.044	.045
20050 SE 56th	.057	21 Aug				
Lake Sammamish State Park, WA	.056	5 Sep				
1 May – 30 Sep	.054	24 Jul				
	.054	20 Aug	.064	.053	.054	.057
42404 SE North Bend Way,	.061	5 Sep				
North Bend, WA	.059	21 Aug				
1 May – 30 Sep	.057	6 Sep				
	.052	18 May	.063	.063	.052	.059
30525 SE Mud Mountain Road,	.069	21 Aug				
Enumclaw, WA	.063	5 Sep				
1 May – 30 Sep	.061	10 Sep				
	.059	20 Aug	.076	.068	.059	.067
931 Northern Pacific Rd SE,	.057	10 Sep				
Yelm, WA	.055	19 May				
1 May – 30 Sep	.055	20 Aug				
	.054	20 May	.060	.054	.054	.056

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)

2011

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	.016			.010	.009	.010	.008	.013	.015	.013	.014	.016	7929	.012

Maximum and Second Highest Concentrations

Location / Continuous Sampling Periods(s)	1-Hour Average		
	Value	Date	End Time
Beacon Hill, 15th S & Charlestown, Seattle	.054	23 Apr	1900
1 Jan - 31 Dec	.053	8 Sep	1800

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)

2011

Location / Continuous Sampling Period(s)	Six Highest Concentrations					Number of 8-Hour Averages Exceeding 9 ppm	Number of Days 8-Hour Averages Exceeded 9 ppm
	1 Hour Average			8 Hour Average			
	Value	Date	End Time	Value	Date		
Beacon Hill, 15th S & Charlestown, Seattle 1 Jan – 31 Dec	1.1	27 Jan	1700	0.9	27 Jan	0	0
	1.1	27 Jan	1100	0.8	9 Dec		
	1.0	9 Dec	1900	0.8	13 Dec		
	1.0	27 Jan	1800	0.7	11 Feb		
	1.0	13 Dec	1700	0.7	10 Feb		
	1.0	27 Jan	1600	0.7	3 Dec		

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)

2011

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	8242	.001

Maximum and Second Highest Concentrations for Various Averaging Periods

Location / Continuous Sampling Period(s)	1 Hour Average			24 Hour Average	
	Value	Date	End Time	Value	Date
Beacon Hill, 15th S & Charlestown, Seattle 1 Jan – 31 Dec	.028	27 Jul	0100	.011	11 Sep
	.026	5 Jun	1800	.008	5 Jun

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.

2011 Beacon Hill Air Toxics Statistical Summary for Air Toxic Gases (units in parts per billion)

	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Carbon Tetrachloride	Chloroform	Dichloromethane	Ethylbenzene	Formaldehyde	Tetrachloroethylene
2011 Count	61	60	61	61	61	61	61	61	60	61
NDs (reported as 0)	9	0	0	0	0	5	0	0	0	17
Median (ppb)	0.030	0.475	0.205	0.177	0.104	0.024	0.437	0.055	0.635	0.013
Mean (ppb)	0.040	0.522	0.270	0.223	0.103	0.025	0.834	0.068	0.683	0.013
95%tile (ppb)	0.097	0.951	0.550	0.455	0.136	0.047	2.60	0.136	1.28	0.031
Max (ppb)	0.216	1.09	0.905	0.794	0.152	0.053	10.6	0.277	1.50	0.081
MDL (ppb)	0.007	0.008	0.050	0.029	0.024	0.009	0.010	0.017	0.012	0.018
# Below MDL	9	0	0	0	0	5	0	0	0	46
% Below MDL	15%	0%	0%	0%	0%	8%	0%	0%	0%	75%

2011 Beacon Hill Air Toxics Statistical Summary for PM_{10} Metals (units in nanograms per cubic meter)

	Arsenic	Cadmium	Cr+6 TSP	Manganese	Naphthalene	Nickel
2011 Count	61	61	61	61	60	61
NDs (reported as 0)	0	0	2	0	0	0
Median (ng/m3)	0.495	0.062	0.027	4.01	51.1	1.16
Mean (ng/m3)	0.664	0.099	0.033	8.17	72.9	1.90
95%tile (ng/m3)	1.72	0.221	0.091	32.4	169	5.87
Max (ng/m3)	2.04	0.852	0.133	48.7	316	7.97
MDL (ng/m3)	0.058	0.021	0.004	0.208	0.112	0.506
# Below MDL	0	8	2	0	0	9
% Below MDL	0%	13%	3%	0%	0%	15%

Toxics in gray are over 50% below the method detection limit.
ND's were replaced with 1/2 the method detection limit.

Estimates of Air Toxics Risk
2011 Air Toxics Unit Risk Factors

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

*Potential cancer risk = ambient concentration (µg/m^3) * unit risk factor (risk/µg/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 System[2] (IRIS) as well as California EPA's Office of Environmental Health and Hazard Assessment[3] (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, and B2 = probable carcinogen, based on adequate animal data.[5]

2011 Air Toxics Unit Risk Factors

AIR TOXIC	WA ASIL 460 UNIT RISK FACTOR RISK/µg/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

[1]Washington State Administrative Code. apps.leg.wa.gov/wac/default.aspx?cite=173-460-150.
[2]Integrated Risk Information System, EPA; epa.gov/iris/.
[3]California EPA, Consolidated Table of OEHHA/ARB-Approved Risk Assessment Health Values, June 25, 2008; arb.ca.gov/toxics/healthval/healthval.htm.
[4]For details on the ASIL, see: ecy.wa.gov/laws-rules/wac173460_400/February/ASIL_20list_20pollutants2-8-08-5pm1.pdf.
[5]International Agency for Research on Cancer; http://monographs.iarc.fr/.
[6]Ratings per 1986 EPA guidelines.

2011 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 95th Percentile Concentrations Washington ASIL	% of samples > ASIL screen
Benzene	1	42	100%
1,3-Butadiene	2	36	85%
Carbon Tetrachloride	3	36	100%
Acrolein	4	21	100%
Chromium VI (TSP)	5	14	93%
Formaldehyde	6	9	100%
Dichloromethane	7	9	57%
Naphthalene	8	6	85%
Arsenic (PM10)	9	6	79%
Chloroform	10	5	92%
Acetaldehyde	11	5	98%
Nickel (PM10)	12	3	23%
Ethylbenzene	14	1	15%
Tetrachloroethylene	15	1	13%
Cadmium (PM10)	16	1	3%
Manganese (PM10)	17	1	3%

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	1.8
Formaldehyde	9	0.093
Manganese (PM10)	0.09	0.091
Arsenic (PM10)	0.015	0.044
Nickel (PM10)	0.05	0.038
Carbon Tetrachloride	40	0.016
Benzene	60	0.012
Dichloromethane	400	0.007
Acetaldehyde	140	0.007
Cadmium (PM10)	0.02	0.005
1,3-Butadiene	20	0.004
Tetrachloroethylene	35	0.003
Beryllium (PM10)	0.007	0.001
Chloroform	300	< 0.001
Chromium VI (TSP)	0.2	< 0.001
Trichloroethylene	600	< 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.

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 ($\mu g/m^3$).
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 epa.gov/air/criteria.html. Washington State air quality regulations are available at ecy.wa.gov/laws-rules/ecywac.html#air.[7] The air quality standards that apply to the Puget Sound air shed are summarized below.

[7] Washington Administrative Code chapters 173-470, 173-474, and 173-475.

Puget Sound Region Air Quality Standards for Criteria Pollutants for 2011

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
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]	$PM_{2.5}$	primary and secondary	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}	primary and secondary	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 epa.gov/air/criteria.html.

The Agency has developed an air quality health goal for daily $PM_{2.5}$ concentrations. The Agency convened a Particulate Matter Health Committee, comprised of local health professionals, who examined the fine particulate health research.[8] 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 25μg/m^3 for a daily average, more protective than the current federal standard of 35μg/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.[9,10] The Agency did not adopt a separate health goal for the annual average.

[8] Puget Sound Clean Air Agency. Final Report of the Puget Sound Clean Air Agency $PM_{2.5}$ Stakeholder Group; pscleanair.org/news/library/reports/pm2_5_report.pdf.
[9] American Lung Association; lungusa.org/assets/documents/publications/state-of-the-air/state-of-the-air-report-2006.pdf.
[10] EPA Clean Air Science Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; epa.gov/sab/panels/casacpmpanel.html.