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Puget Sound Clean Air Agency

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2015
Air Quality
Data Summary

August 2015

Working Together for Clean Air

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The 2015 Air Quality Data Summary is available
for viewing or download on the internet at:

www.pscleanair.org

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

This material is available in alternate formats for people with disabilities. Please call Joanna Cruse at (206) 689-4067 (1-800-552-3565, ext. 4067).

Executive Summary

The Puget Sound Clean Air Agency (the Agency) summarizes air quality data from our core monitoring network every year. This report summarizes 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 (monitoring discontinued due to very low levels)

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 Air Quality Index (AQI) is a nationwide reporting standard for the criteria pollutants. The AQI is used to relate air quality levels to health effects in a simplified way. "Good" AQI days continued to dominate our air quality in 2015. However, air quality degraded into "moderate" or "unhealthy for sensitive groups" for brief periods.

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/airquality/ourairquality/Pages/currentaq.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/contact/Pages/connect.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.

Data included in this report are for our core monitoring network. We also perform local, seasonal monitoring studies – you can see reports on these study results at the library on our website at http://www.pscleanair.org/.

The Agency and Ecology continued to monitor the region's air quality in 2015. Over the last two decades, many pollutant levels have declined and air quality has improved. While air quality is improving, we face new challenges. The Environmental Protection Agency (EPA) regularly revises national ambient air quality standards as directed by the Clean Air Act to protect public health.

[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.

Elevated fine particle levels pose the greatest air quality challenge in our jurisdiction. While fine particle levels met EPA's health-based standard of 35 micrograms per cubic meter in 2015, sites in all four counties (King, Kitsap, Pierce and Snohomish) exceeded the Agency's more stringent local $PM_{2.5}$ health goal of 25 micrograms per cubic meter.

Ozone levels remain a concern in our region. The Enumclaw Mud Mountain monitor has the highest regional ozone concentrations, at levels close to the federal standard.

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

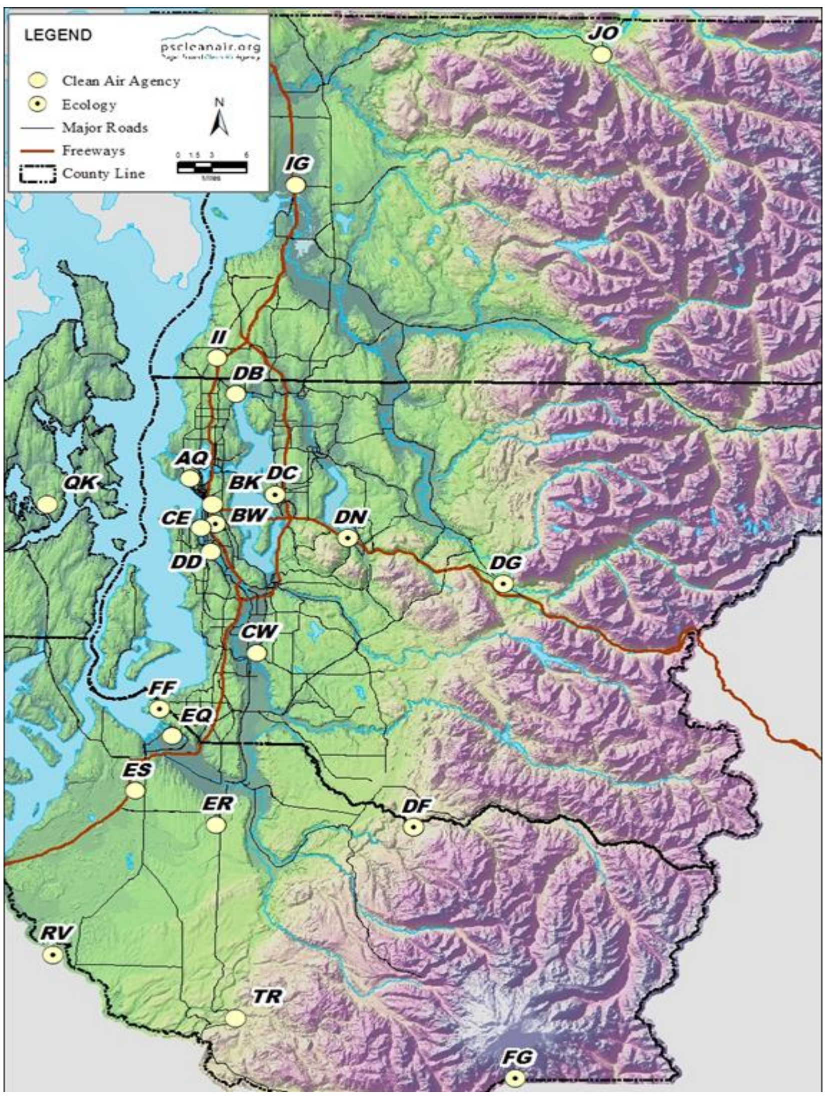
Increasingly, our air quality monitoring program is moving towards local, short-term studies that inform on a very local scale what air quality is like in communities with specific impacts (for example, communities located near major roadways). These studies, using new sensor technology, are available on our website in the "Library" section.

Monitoring Network

The Agency and Ecology operated the Puget Sound region's monitoring network in 2015. 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.

Map 1 and Table 1 show King, Pierce, Snohomish, and Kitsap County monitoring sites used in 2015. A more interactive map is available at http://www.pscleanair.org/airquality/ourairquality/Pages/NetworkMap.aspx.

Map 1: Active Air Quality Monitoring Station Locations 2015



AQ Seattle Queen Anne
BK Seattle 10th & Weller
BW Seattle Beacon Hill
CE Seattle Duwamish
CW Kent
DB Lake Forest Park
DC Bellevue
DD Seattle South Park
DF Enumclaw Mud Mt Dam
DG North Bend
DN Lake Sammamish State Park
EQ Tacoma Alexander
ER Puyallup South Hill
ES Tacoma South L Street
FG Mount Rainier
FF Tacoma Indian Hill
II Lynnwood
IG Marysville
JO Darrington
QK Bremerton Spruce
RV – Yelm
TR - Eatonville

Table 1: Air Quality Monitoring Network Parameters 2015

Station ID	Location	$PM_{2.5}$ ref	$PM_{2.5}$ Spec	$PM_{2.5}$ FEM	$PM_{2.5}$ ls	$PM_{2.5}$ 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
BK ⦿	10th & Weller, Seattle		●	●		●			●	●		●	●			a
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
QK	Spruce, 3250 Spruce Ave, Bremerton			●	●						●	●	●		●	b, f
TR	Eatonville, 560 Center St, Eatonville				●						●	●			●	d, 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, IG, ES)
$PM_{2.5}$ bc	Particulate matter <2.5 micrometers black carbon (light absorption aethalometer)	AT	Air Toxics
O_3	Ozone (May through September except Beacon Hill and Mt Rainier)	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. A summary of the monitoring stations and parameters used over the history of the program is on page A-7 of the Appendix. The network changes periodically because the Agency and Ecology regularly re-evaluate monitoring objectives, resources and logistics.

Page A-6 of the Appendix shows a list of the methods used for monitoring the criteria pollutants. 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 a simplified 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 2015. Snohomish County registered the highest daily AQI value of 158 on August 23rd, 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 2015

	AQI Rating (% of year)				
County	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	**Highest AQI**
Snohomish	76.0 %	20.9 %	2.2 %	0.8 %	158
King	58.5 %	39.8 %	1.6 %	0 %	131
Pierce	81.9 %	16.4 %	1.6 %	0 %	140
Kitsap	97.2 %	2.8 %	0 %	0 %	82

EPA's main intent with development of the AQI is that it is used as a daily indicator or forecast of air quality – it's most useful when used this way. This local, almost-real-time information can be found here: pscleanair.org/airquality/ourairquality.

Most days in the Puget Sound region are in the "Good" category, but local meteorological conditions, along with polluting sources, cause levels to rise into "Moderate" or above. See the appendix for more information on the AQI.

Pages A-1 through A-5 of the Appendix present summaries for each county which include "good", "moderate", "unhealthy for sensitive groups", and "unhealthy" days from 1990 to 2015.

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 direct 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 which is available upon request.

$PM_{2.5}$ Health and Environmental Effects

An extensive body of scientific evidence shows that exposure to particle pollution 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. Older adults, children, pregnant women, and those with pre-existing health conditions are more at risk from exposure to particle pollution. 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 quality and consistency. EPA 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 further defined several federal equivalent methods (FEM), which are continuous instruments operated under specific standard operating procedures. The continuous FEM's advantage 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.

- There are now three FEM methods used in the network: (1) 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. (2) The beta attenuation monitor (BAM) method measures the attenuation of beta radiation as pollution is collected on a filter tape. The attenuation is converted to PM 2.5. (3) The TEOM 1405 F model is a new model that replaces (TEOM-FDMS) instruments. All three of these are considered 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 $PM_{2.5}$. While light scattering has been proven to correlate well with $PM_{2.5}$, this is an "unofficial" method using a surrogate.

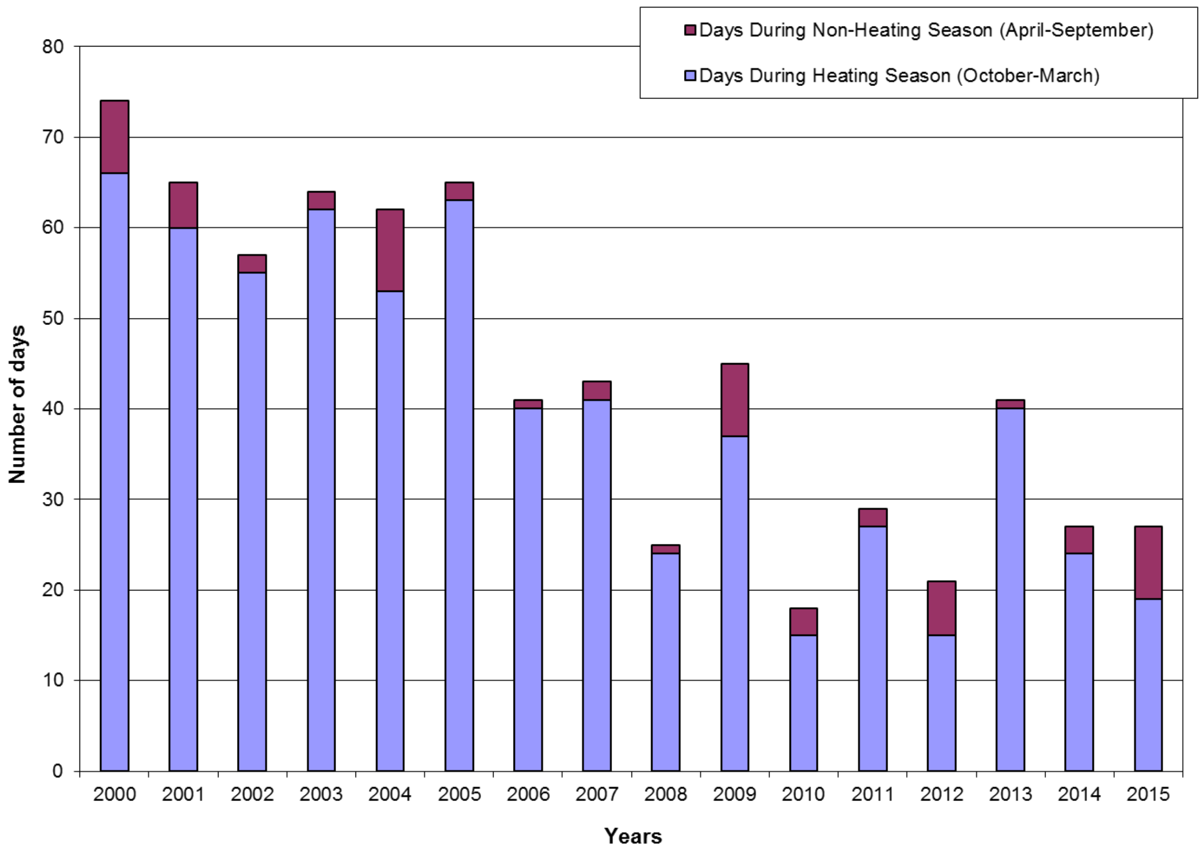
The Agency and Ecology work together to quality assure the FEM technology as compared to the reference method.

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

The EPA set a daily health-based fine particle standard of 35 micrograms per cubic meter ($\mu g/m^3$). Monitors in all four counties met this standard in 2015. In addition to the federal standard, our Board of Directors adopted a more stringent health goal in 1999, based on recommendations from our Particulate Matter Health Committee. Monitors in King, Pierce and Snohomish exceeded the local health goal of 25 $\mu g/m^3$ during the 2015 winter season. Our monitor in Kitsap County exceeded the local health goal of 25 $\mu g/m^3$ once, on July 4th.

Figure 1 shows the number of days the health goal was exceeded annually in the region, from 2000 to 2015. The shading demonstrates that our highest fine particulate days overwhelmingly take place during the winter wood heating months. While the graph indicates that we have made progress reducing the number of days we exceed the health goal, it also shows that we are falling short of our goal of having zero days exceeding the health goal, especially during winter months.

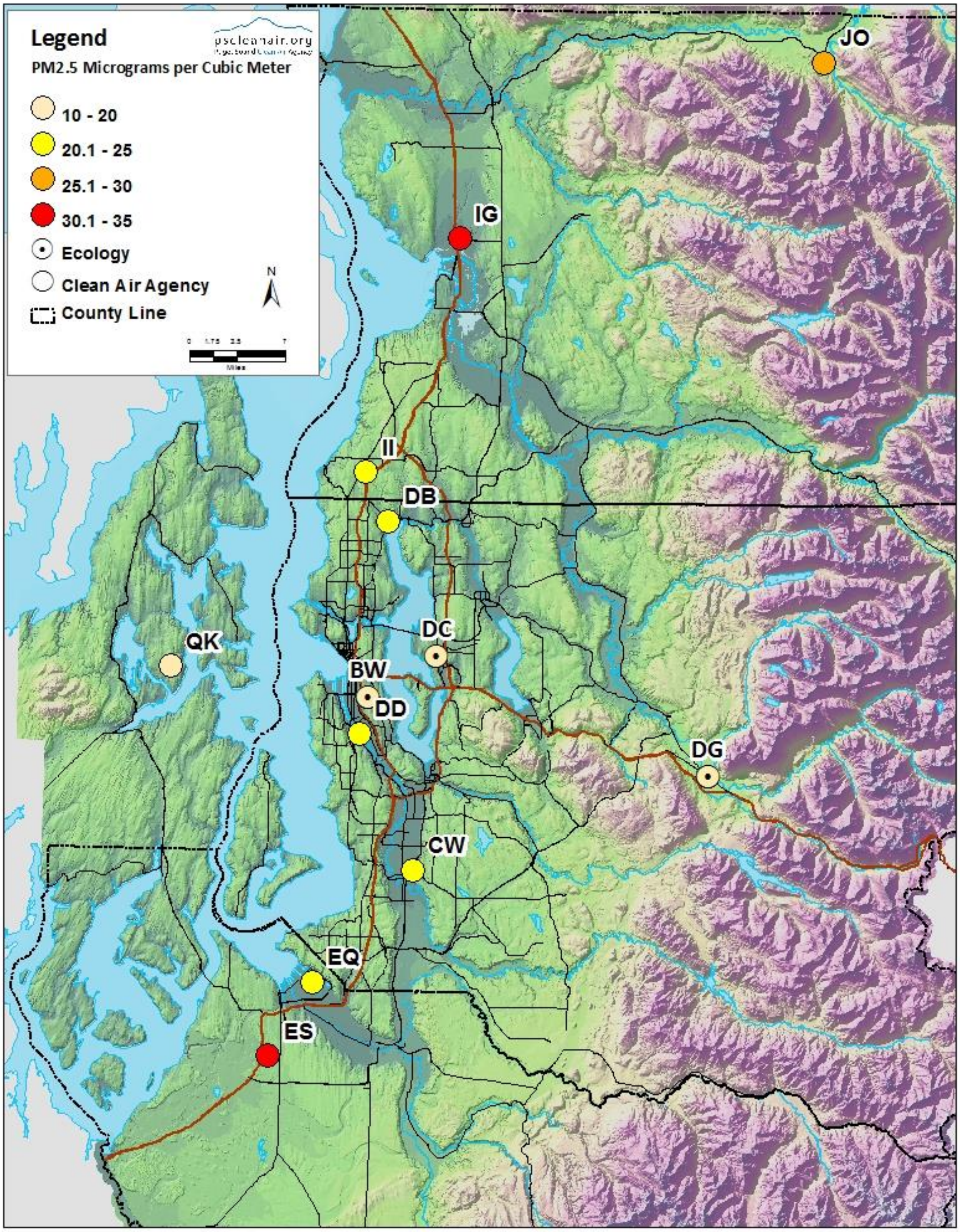
Figure 1: Days Exceeding the PM2.5 Health Goal at One or More Monitoring Sites



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

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 2013 to 2015. This map incorporates data collected from federal reference, federal equivalent, and nephelometer estimate methods.

Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2015

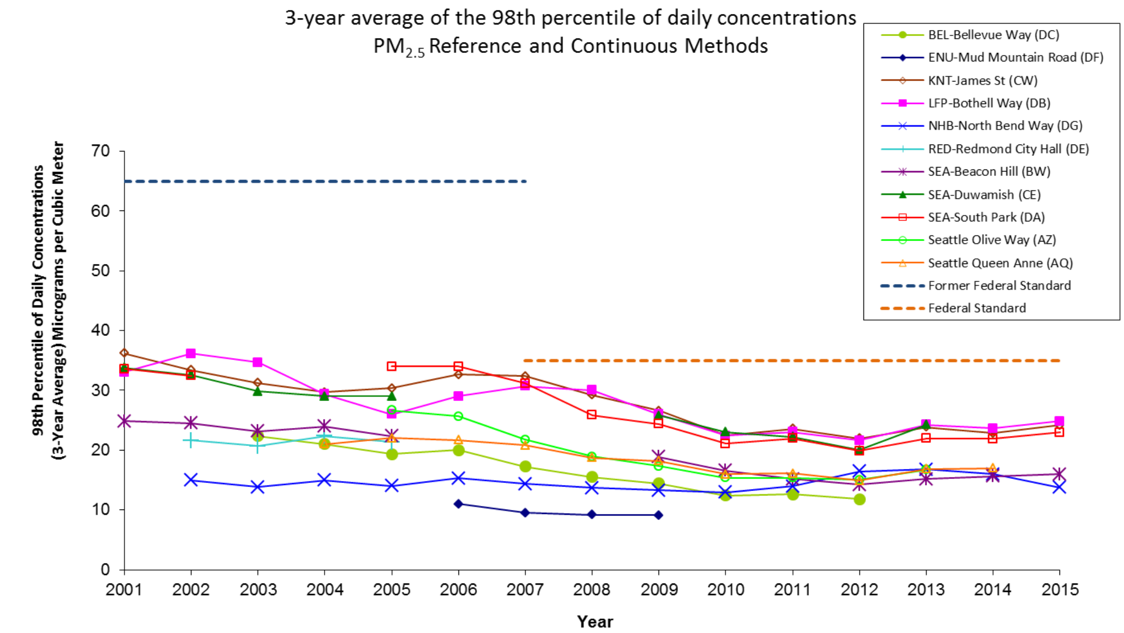


Figures 2 through 5 show daily 98th percentile 3-year averages at each monitoring station in King, Kitsap, Pierce, and Snohomish Counties compared to the current daily federal standard – all are below the standard in 2015. Points on the graphs represent averages for three consecutive years. For example, the value for 2015 is the average of the 98th percentile daily concentration for 2013, 2014, and 2015. These figures incorporate data collected from federal reference, federal equivalent, and nephelometer estimate methods.

Figure 3 does not include a three-year average for Kitsap County in 2008-2010 or 2012-2014 because the monitor did not meet data completeness criteria, and the monitoring site was moved. Kitsap County data shows that PM2.5 levels are below the federal standard.

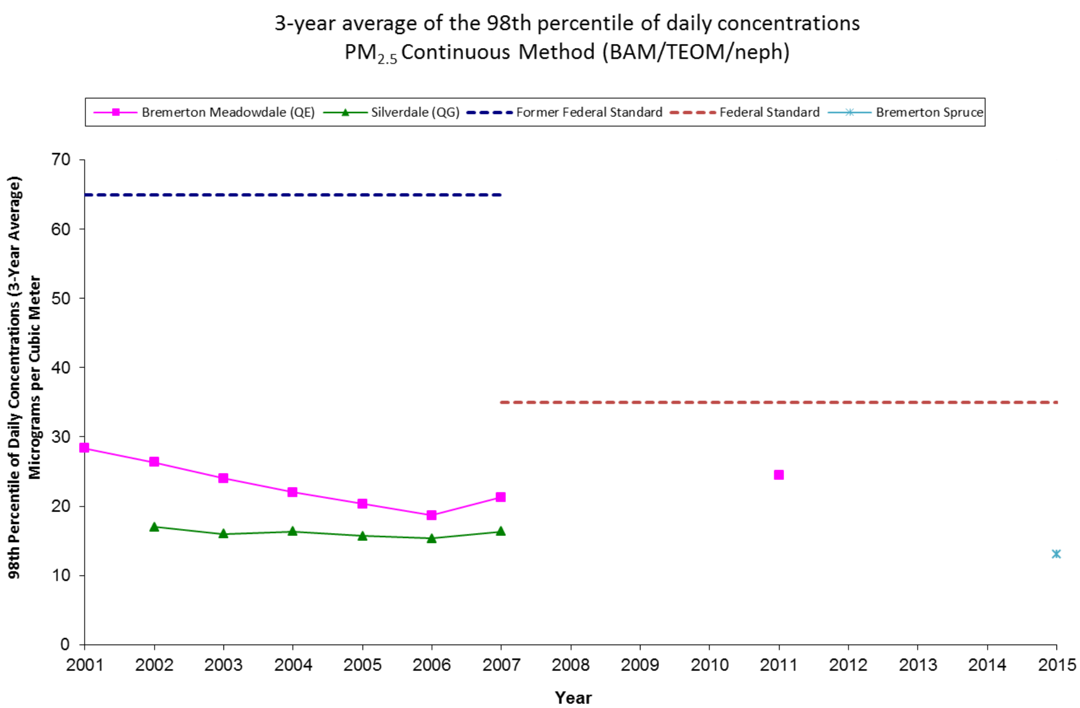
Statistical summaries for 98th percentile daily concentrations for 2015 data are provided on page A-12 through A-14 of the Appendix.

Figure 2: Daily $PM_{2.5}$ for King County



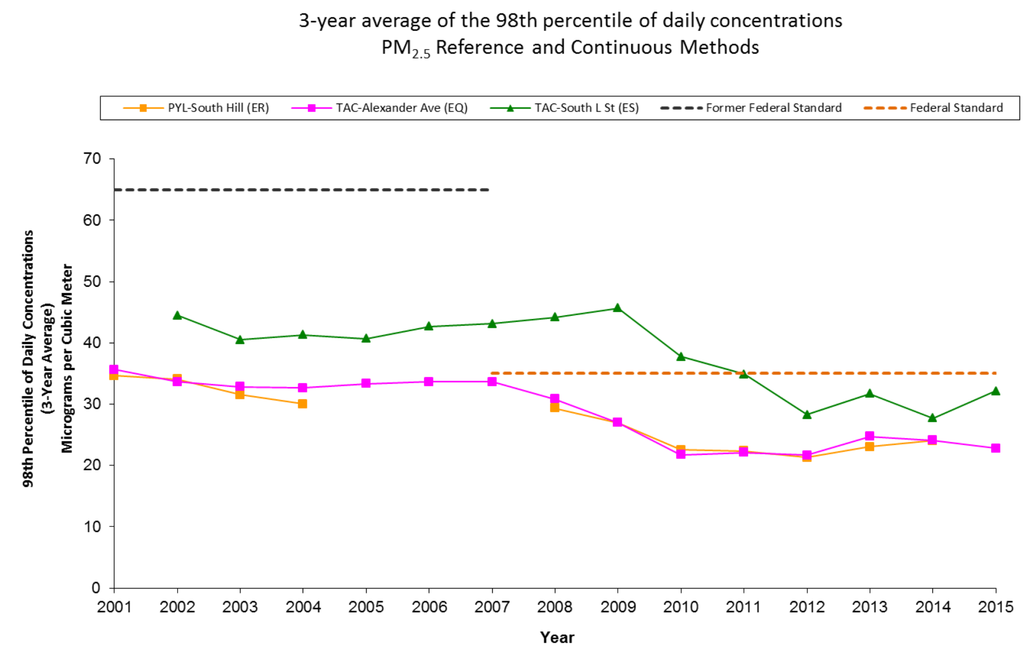
Note: Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2015. Beacon Hill (BW) data are FRM from 1999-2015. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-2015. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2015. Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-12. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2015. Olive Way (AZ) data are neph from 2003-2013, site disc 8/5/14. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2015. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010, TEOM-FEM 2011-2015. Enumclaw (DF) data are from neph in 2000-2009.

Figure 3: Daily $PM_{2.5}$ for Kitsap County



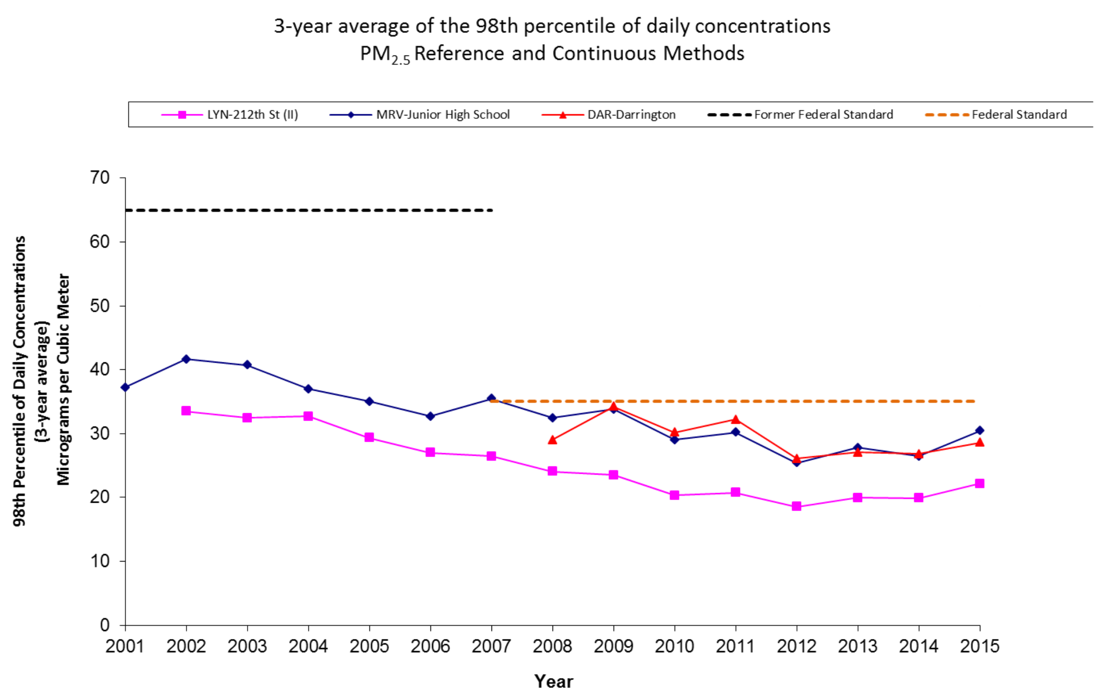
Note: 75% of data is required to calculate 98th percentile. Insufficient data available for 2008 so 3 year calculation not available for 2008-2010. 2011-2014 data are TEOM-FEM. Meadowdale site ended 4/30/12, Spruce site began 5/1/2012.

Figure 4: Daily $PM_{2.5}$ for Pierce County



Note: All South L data are FRM from 2000- 2015. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2015.
South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-20145 incomplete nephelometer data was collected from South Hill in 2005.

Figure 5: Daily $PM_{2.5}$ for Snohomish County



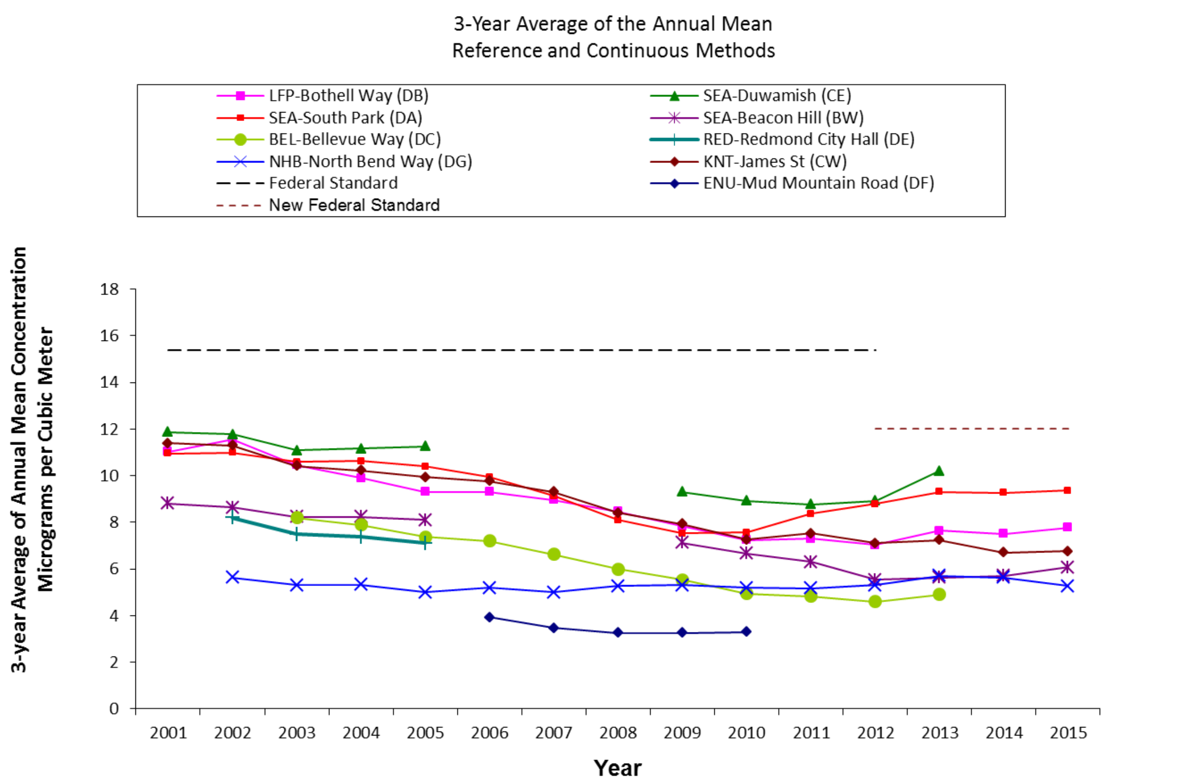
Note: Marysville (IG) data are FRM 999-2011, TEOM-FEM 2012-2015. Lynnwood (II) data are FRM except 2004, 2007-2010 which were nephelometer, TEOM-FEM 2011-2015. Darrington (JO) data are neph in 2006, FRM in 2007-2011, TEOM-FEM 2012-2015.

$PM_{2.5}$ Annual Federal Standard

Figures 6 through 9 show 3-year annual averages at each monitoring station for King, Kitsap, Pierce and Snohomish Counties. In 2012, the EPA strengthened the annual standard from 15 micrograms per cubic meter to 12 micrograms per cubic meter. All counties have levels below the annual standard of 12 micrograms per cubic meter and all counties are in attainment for the annual standard. Figure 7 does not show any 2008, 2009, 2010, or 2012-2014 data for Kitsap County because the monitor did not achieve data completeness criteria or the monitoring site was relocated.

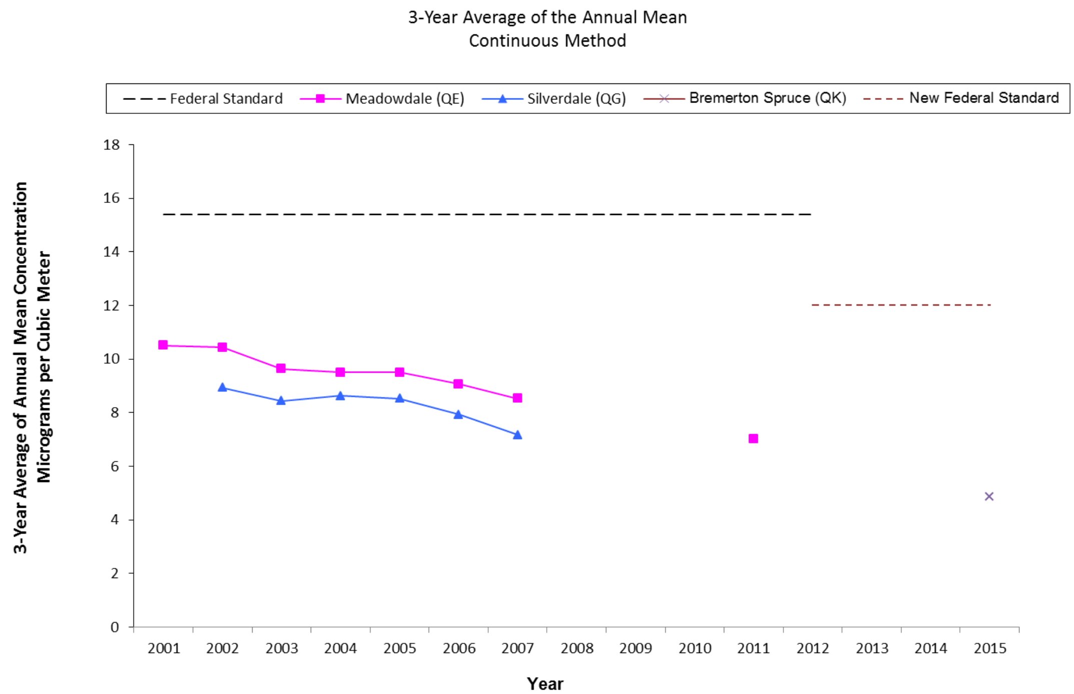
Figures 6 through 9 show data from the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, so each value on the graph is an average for three consecutive years. For example, the value shown for 2015 is the average of the annual averages for 2013, 2014, and 2015.

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



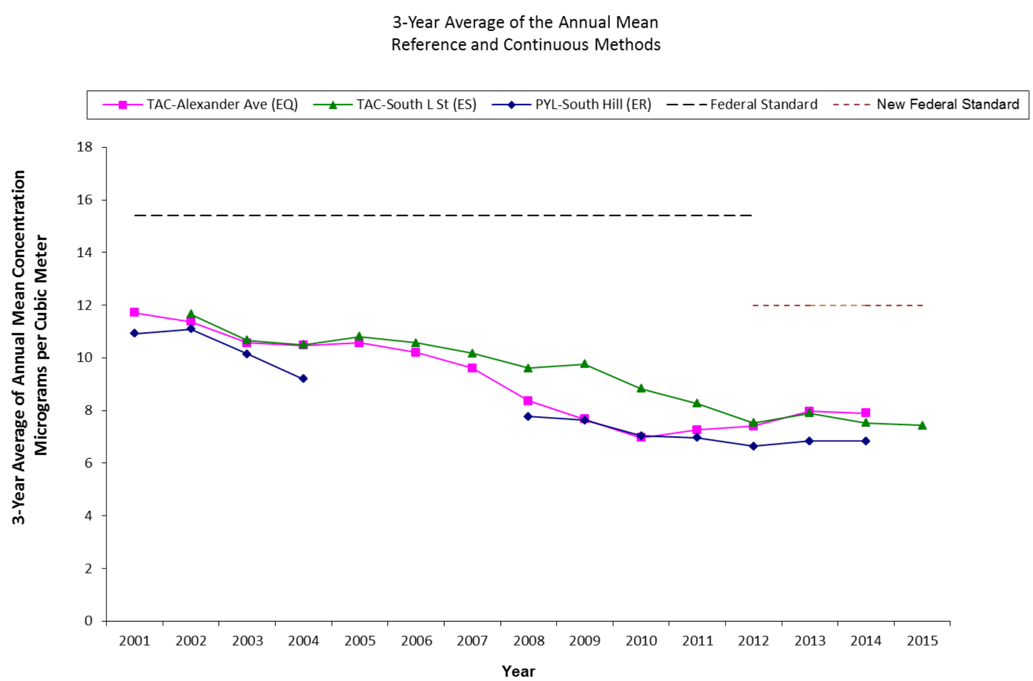
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2015. Beacon Hill (BW) data are FRM from 1999-2015. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2015. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2015. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2015. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2010, TEOM-FEM 2011-2015. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2015.

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



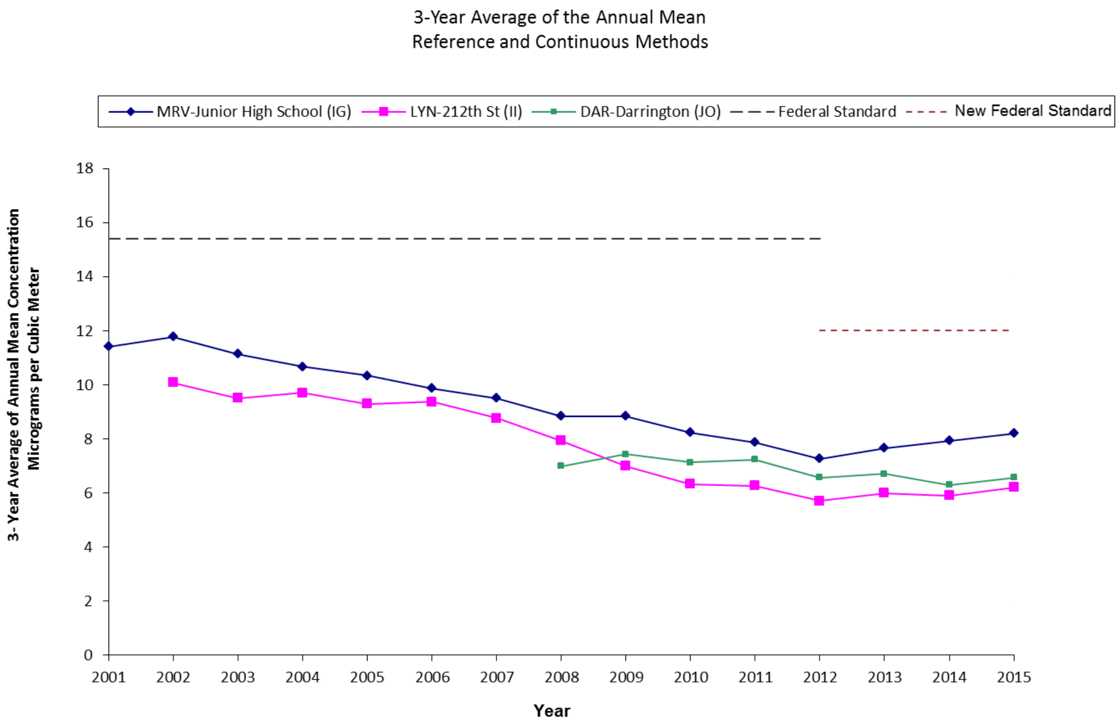
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010, TEOM-FEM 2011-2015. Insufficient data in 2008 resulted in the inability to calculate a 3 year average for 2008, 2009, 2010.

Figure 8: 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, 2008-2015 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002, nephelometer from 2003-2010, and TEOM-FEM 2011-2015.

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



Note: Marysville (IG) data are FRM from 1999-2011, TEOM-FEM 2014. Lynnwood (II) data are FRM except 2004, 2007-2011, TEOM-FEM 2012-2015. The 2004, 2007-2011 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2011, TEOM-FEM 2012-2015.

$PM_{2.5}$ Continuous Data and Seasonal Variability

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

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

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.[3,4,5]

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. Speciation filters are analyzed to determine the makeup of fine particulate at that site. Over 40 species are measured at speciation monitors in the area. These data are 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.

Ecology conducted speciation monitoring at four monitoring sites in the Puget Sound region in 2015:

- Seattle Beacon Hill – typical urban impacts, mixture of sources (speciation samples collected every third day, operated by Ecology)
- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day, operated by Ecology)
- Marysville – residential area, impacts from wood combustion (speciation samples collected every sixth day, operated by Ecology). This monitor was discontinued and moved in March 2015.
- Seattle 10th & Weller – Near Road micro-scale monitoring site (speciation samples collected every sixth day, operated by Ecology).

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 $PM_{2.5}$analytes measured at these sites, please see Appendix A-15.

Aethalometer Data

Aethalometers provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption to estimate carbon concentrations using two

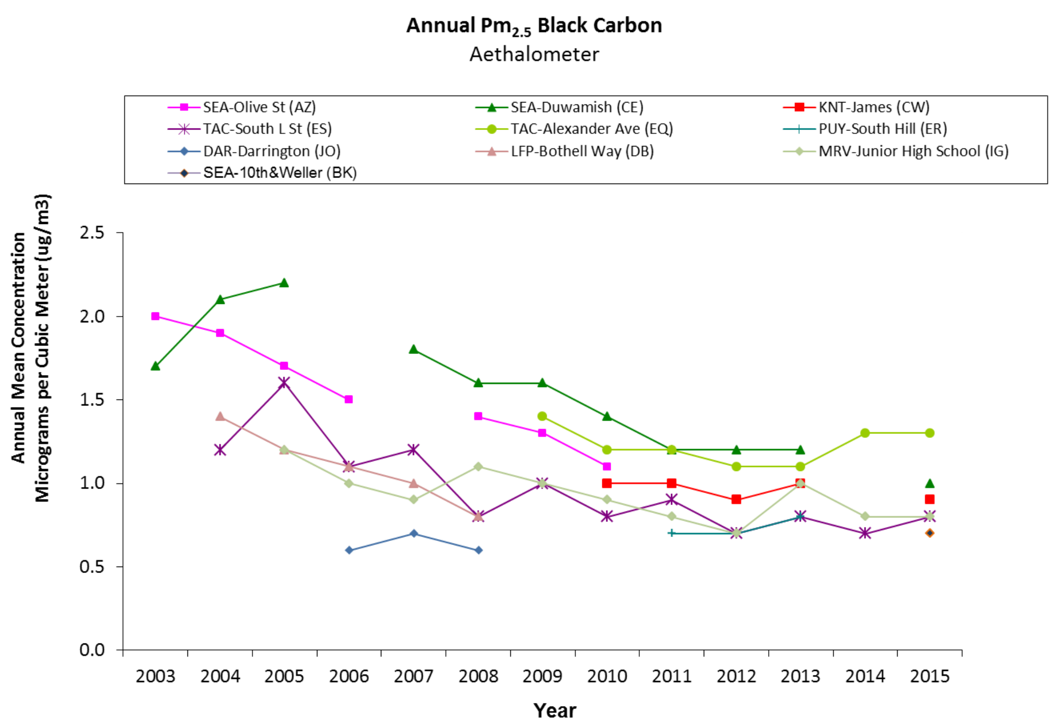
[3] Puget Sound Air Toxics Evaluation, October 2003.
[4] Tacoma and Seattle Air Toxics Evaluation, October 2010: epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf.
[5] Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley $PM_{2.5}$ Nonattainment Area". PublicationNumber 10-02-009.

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.[6] Unfortunately, neither is uniquely attributed 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 which is available upon request.

Figure 10 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-16 of the Appendix.

Figure 10: Annual $PM_{2.5}$ Black Carbon



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[6] Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area

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 conducts the ozone monitoring in our counties.

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.[7] Ozone has also been linked to immune system impairment.[8] 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.[9]

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 (mostly by cars and trucks). 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 the Enumclaw monitor southeast of the urban area.

[7] EPA, Air Quality Index: A Guide to Air Quality and Your Health; epa.gov/airnow/aqi_brochure_02-14.pdf.
[8] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ozone-pollution/ozone-basics.
[9] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ozone-pollution/ozone-basics.

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2015

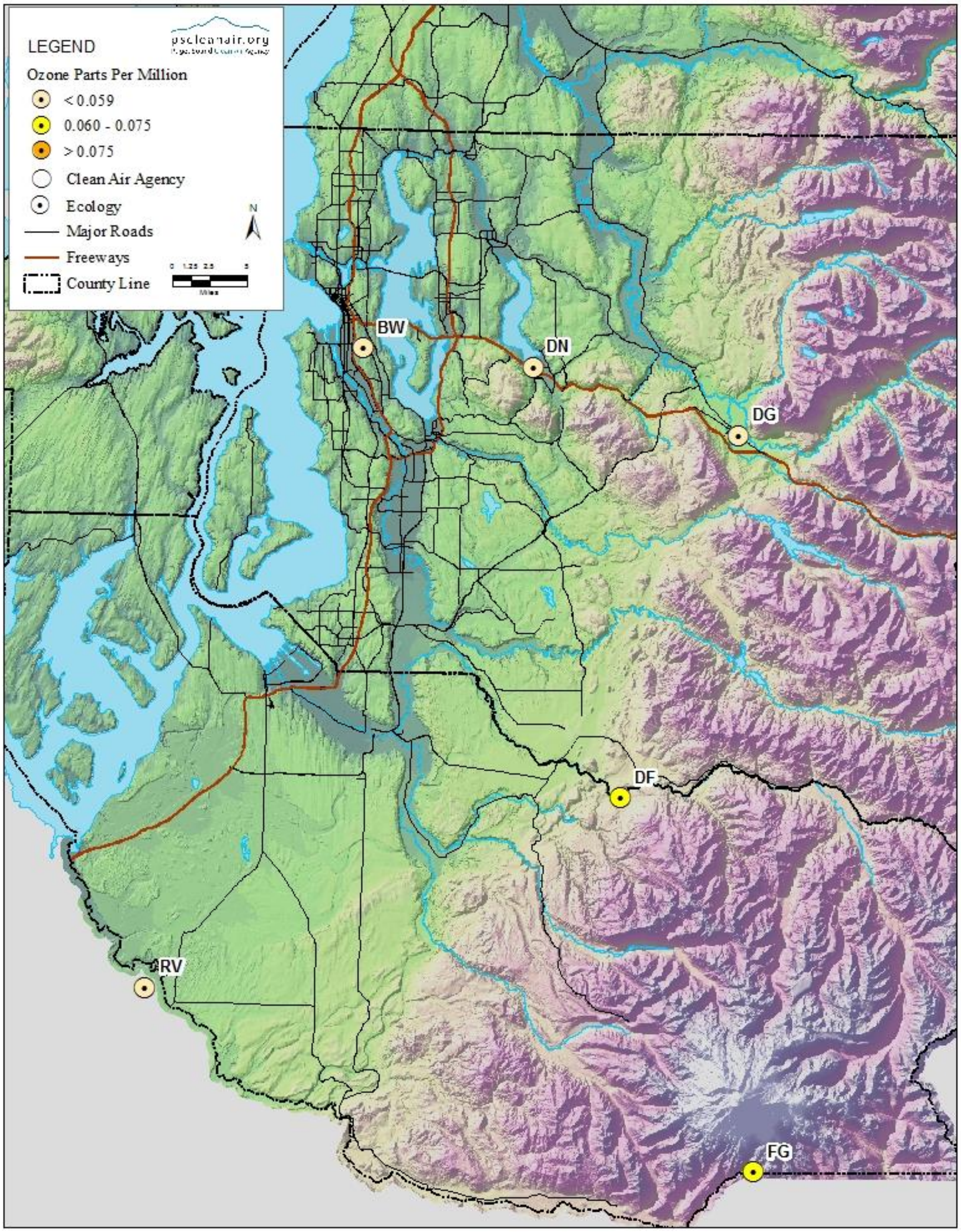


Figure 11 presents data for each monitoring station and the 8-hour federal standard. The EPA recently revised its 8-hour standard from 0.075 parts per million (ppm) to 0.070 ppm in December 2015. This change will be reflected in next year's data summary. The federal standard is based on the 3-year average 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 highest 2015 site design value is 0.066 ppm at the Enumclaw site, below the standard. The highest 2015 8-hour ozone concentration of 0.079 ppm was recorded at the Enumclaw Mud Mountain monitor.

For 2015, the Puget Sound area is below EPA's 0.075 ppm 8-hour standard.

Figure 12 presents 8-hour average data for the months of April 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-17 of the Appendix.

For additional information on ozone, visit https://www.epa.gov/ozone-pollution.

Figure 11: Ozone for Puget Sound Region

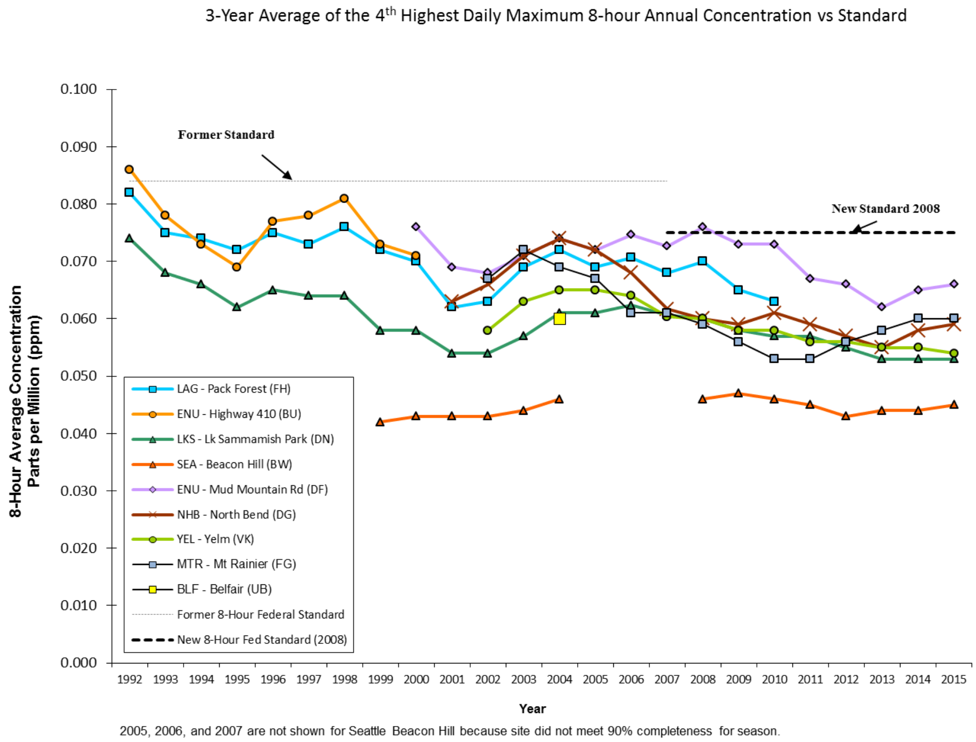
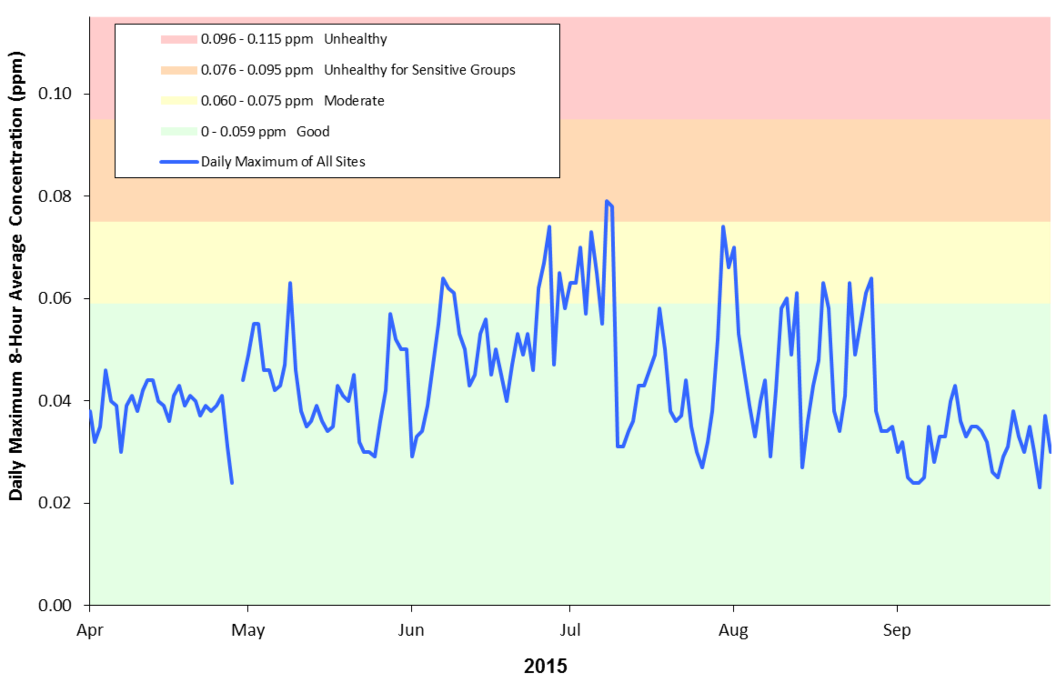


Figure 12: Ozone (O_3) for Puget Sound Region April-September 2015



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.[10] 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 runs equipment measuring nitrogen dioxide at the Beacon Hill station. The monitoring method now records 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. An additional Seattle site began in June 2014 at 10th & Weller. This site is a "near road" site, located very close to Interstate 5 in the Seattle Chinatown International District. To learn more about the monitoring method visit https://www3.epa.gov/ttn/amtic/nearroad.html

Figure 13 shows NO_2 concentrations for Beacon Hill 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. Figure 13 shows NO_2 concentrations for Seattle 10th & Weller. The annual average for each year has consistently been less than half of the federal standard, as shown in Figure 13 and in the statistical summary on page A-18 of the Appendix.

Visit epa.gov/airquality/nitrogenoxides/ for additional information on NO_2.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010.[11] The new 1-hour standard is 100 ppb, and is based on the 98th percentile of 1-hour daily maximum concentrations, averaged over three years. Nitrogen dioxide levels in the Puget Sound region, as currently monitored by Ecology, are typically below (cleaner than) the 1-hour standard. The 1-hour standard is depicted in Figure 14 with historical data since 1998. The years prior to 2010 have been included on the graphs for historical comparison. The Seattle 10th and Weller site is not included in Figure 14 because 3 years of data are required.

[10] EPA, Airnow, NO_X Chief Causes for Concern; epa.gov/airquality/nitrogenoxides/
[11] EPA. New 1-hour National Ambient Air Quality Standards for Nitrogen Dioxide; epa.gov/airquality/nitrogenoxides/actions.html.

Figure 13: Annual Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-Present)

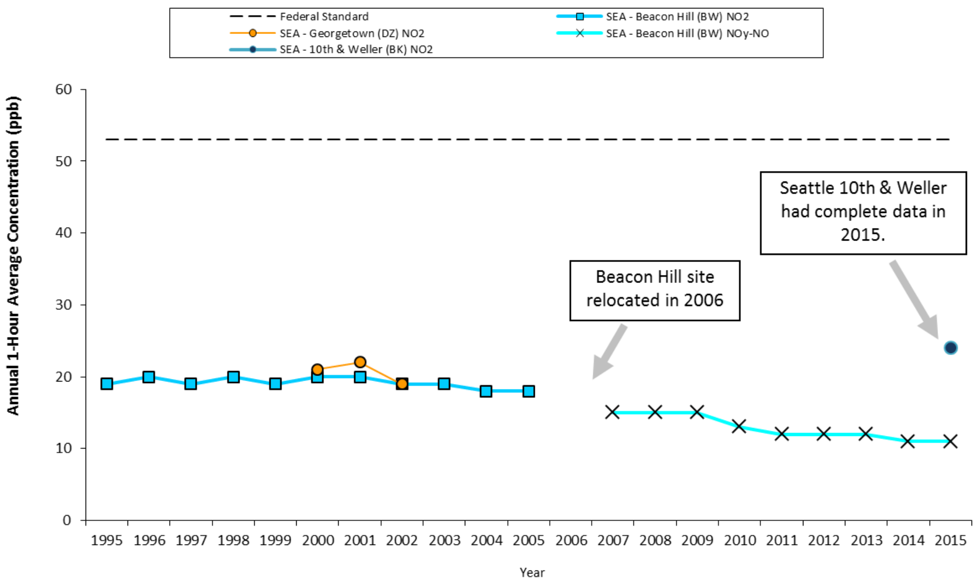
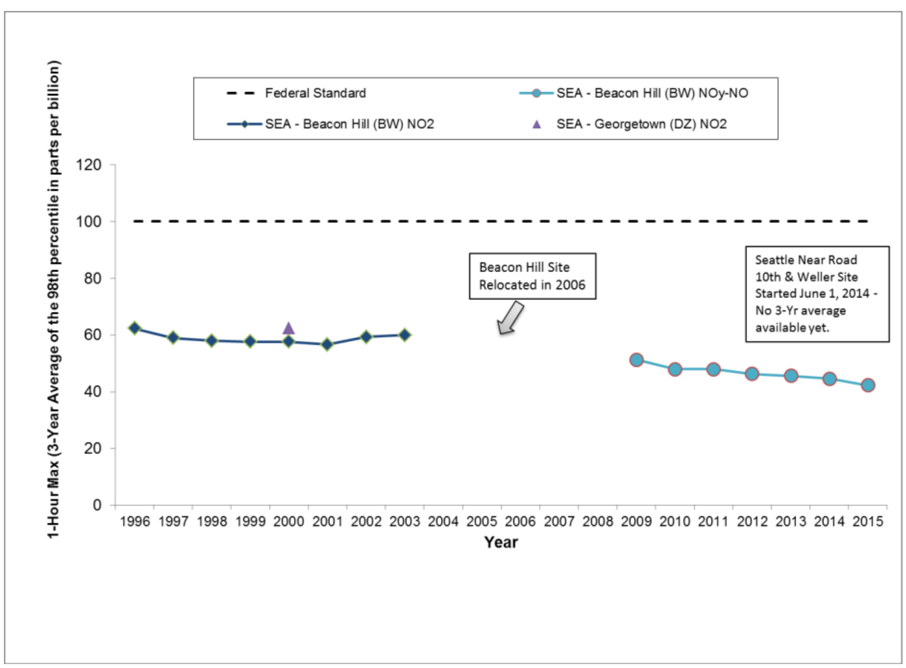


Figure 14: 2010 1-Hour Maximum Standard for Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-Present)



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.

Although urban portions of the Puget Sound region historically violated the CO standard, CO levels have decreased significantly 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 remains from the historical network. The near road site at 10th & Weller began operation in June 2014.

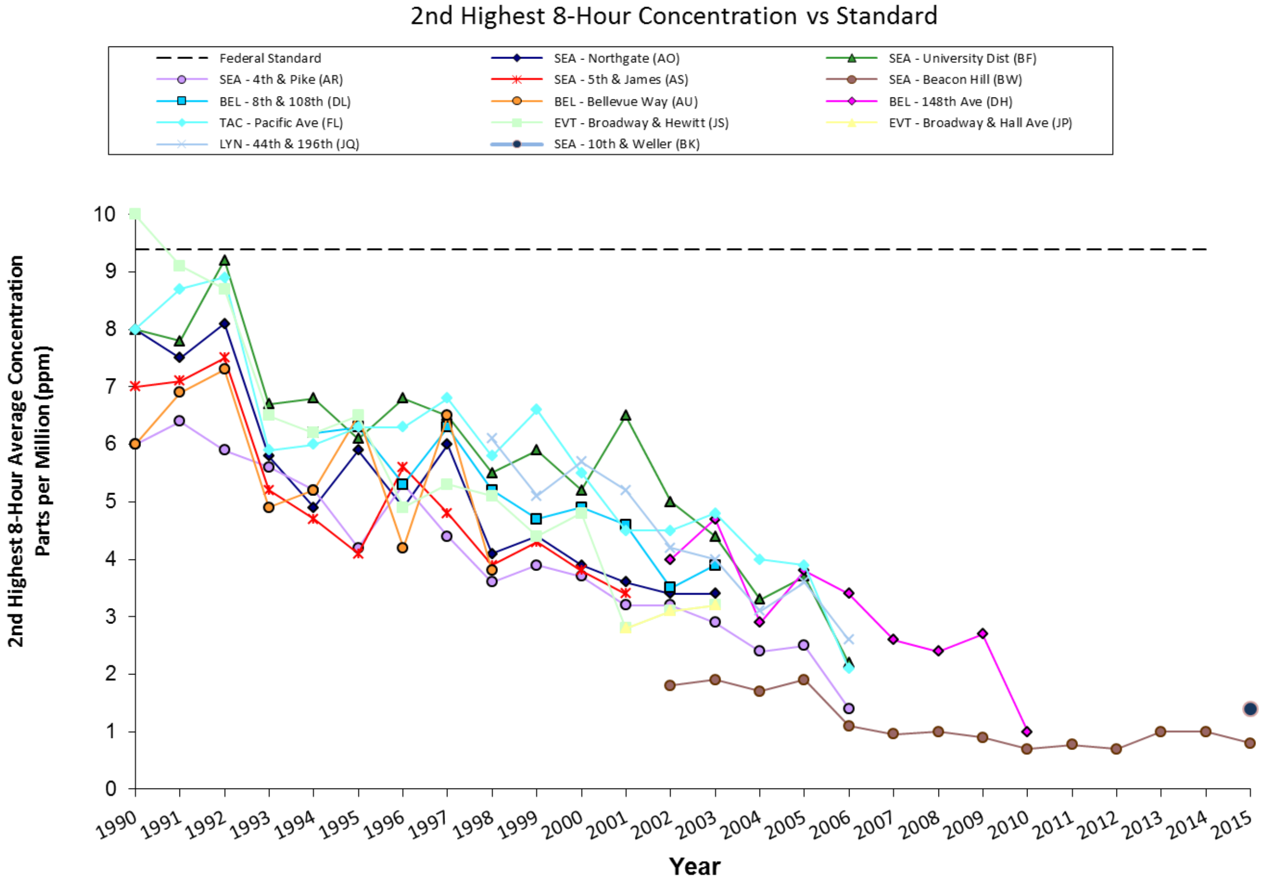
The CO national ambient air quality standard is based on the 2nd highest 8-hour average using the procedures in the federal register. Figure 15 shows the 2nd highest 8-hour concentrations and the federal standard (9 ppm) for the Puget Sound region. There currently are no CO monitoring stations in Kitsap, Pierce, or Snohomish Counties.

The maximum 8-hour concentration for CO in 2015 was 1.8 parts per million (ppm) and occurred on January 9 at the 10th & Weller 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.

Statistical summaries for 8-hour average CO data are provided on page A-19 of the Appendix. For additional information on CO, visit epa.gov/airquality/carbonmonoxide.

Figure 15: 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

EPA changed the SO_2 standard in June of 2010 to a more short-term (1-hour) standard and revoked the former annual and daily average standards. Historic comparisons to federal and Washington State standards can be seen in our 2009 data summary which is available upon request.

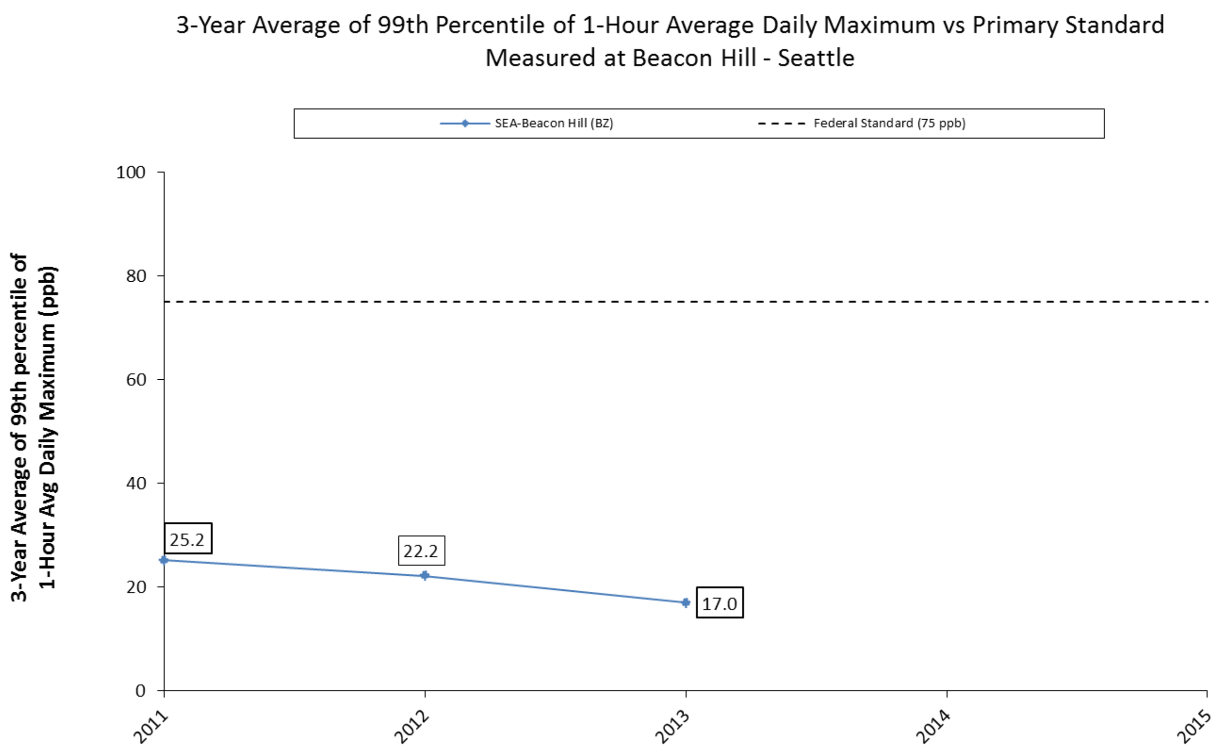
The 2010 standard is a 3-year average of the 99^{th} percentile of the daily 1-hour maximum concentrations. Levels must be below 75 ppb. Sulfur dioxide levels at the Seattle Beacon Hill site are below the 2010 standard.

Figure 16 shows the maximum 3-year average of the 99^{th} percentile of 1-hour maximum concentrations at Beacon Hill. Seattle Beacon Hill did not meet data completeness requirements and it would not be appropriate to compare the available data to the current standard.

Statistical summaries for SO_2 data from the Beacon Hill site are available on page A-20 of the Appendix.

Additional information on SO_2 is available at https://www.epa.gov/so2-pollution.

Figure 16: Sulfur Dioxide (SO_2) 1-Hour Maximum Concentrations (3-Year Average of the 99th Percentile) for the Puget Sound Region



Note: 2011 was the first year that the Design Value has been calculated and compared to the revised primary SO2 standard.
2014 data did not meet the data completeness requirements to calculate an annual 99th percentile value.
2015 data did not meet the data completeness requirements to calculate an annual 99th percentile value.

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 which is available upon request.

In October 2008, EPA strengthened the lead standard from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$ (rolling three-month average).[12] 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 https://www.epa.gov/lead-air-pollution.

Washington Department of Ecology conducted monitoring of lead at two airports as part of a national EPA study. Results of the study are available at
https://fortress.wa.gov/ecy/publications/SummaryPages/1302040.html

[12] US EPA, National Ambient Air Quality Standard for Lead, Final Rule. Federal Register, November 12, 2008; http://www.gpo.gov/fdsys/pkg/FR-2008-11-12/pdf/E8-25654.pdf

Visibility

Visibility data is presented as an indicator of air quality. Visibility is 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 one approach to measuring visibility at a specific location.

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. Figures 17 through 21 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 estimates of visibility in miles. Nephelometer data are shown on page A-14 of the Appendix.

The red line represents the monthly average visibility. The large fluctuations are due to seasonal variability. 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. For the 24-year period from December 1990 through December 2015, the 12-month moving average increased from 47 miles to 80 miles.

For additional information on visibility, visit https://www.epa.gov/visibility.

Figure 17: Puget Sound Visibility

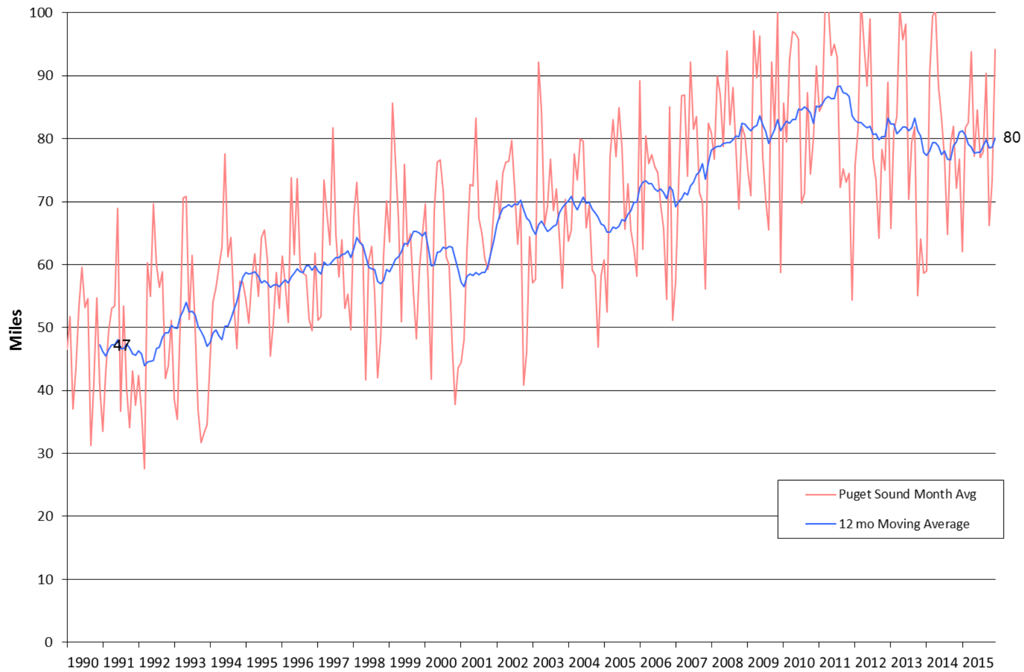


Figure 18: King County Visibility

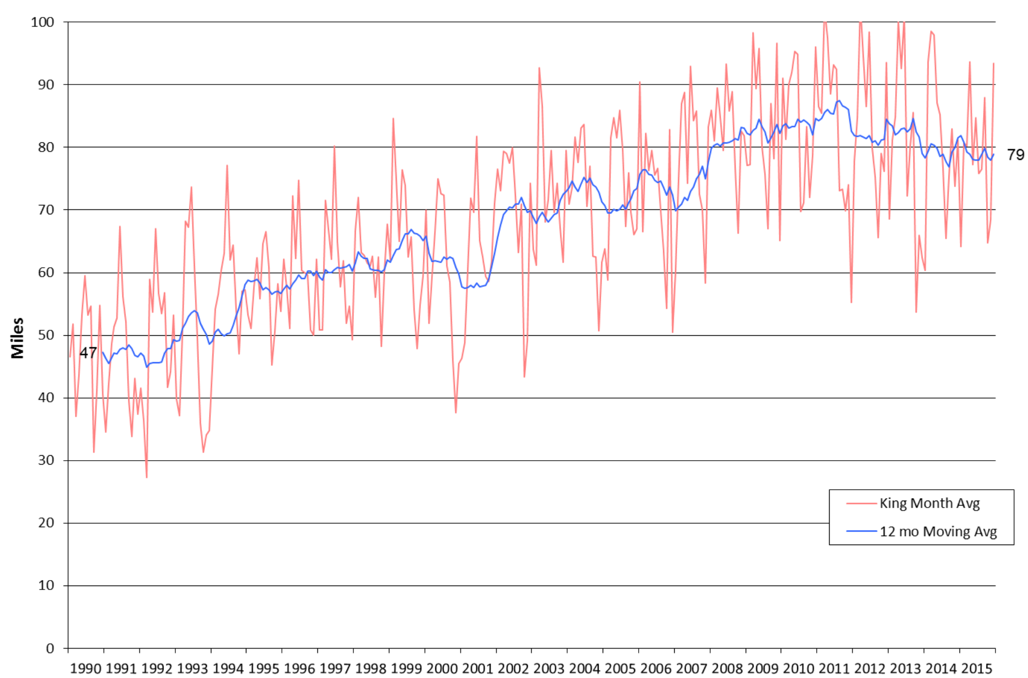


Figure 19: Kitsap County Visibility

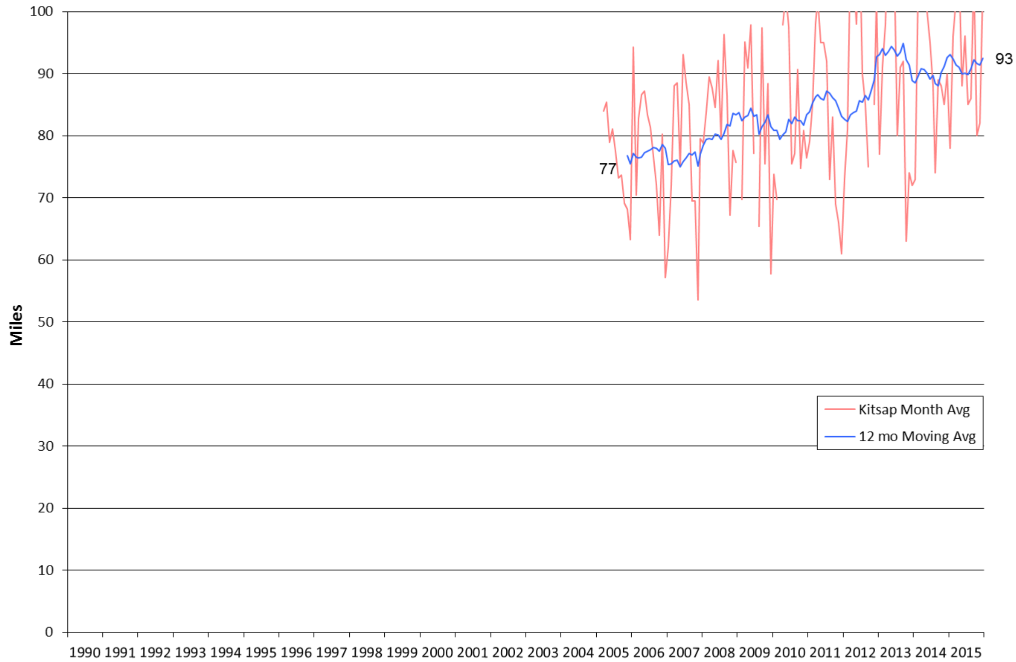


Figure 20: Pierce County Visibility

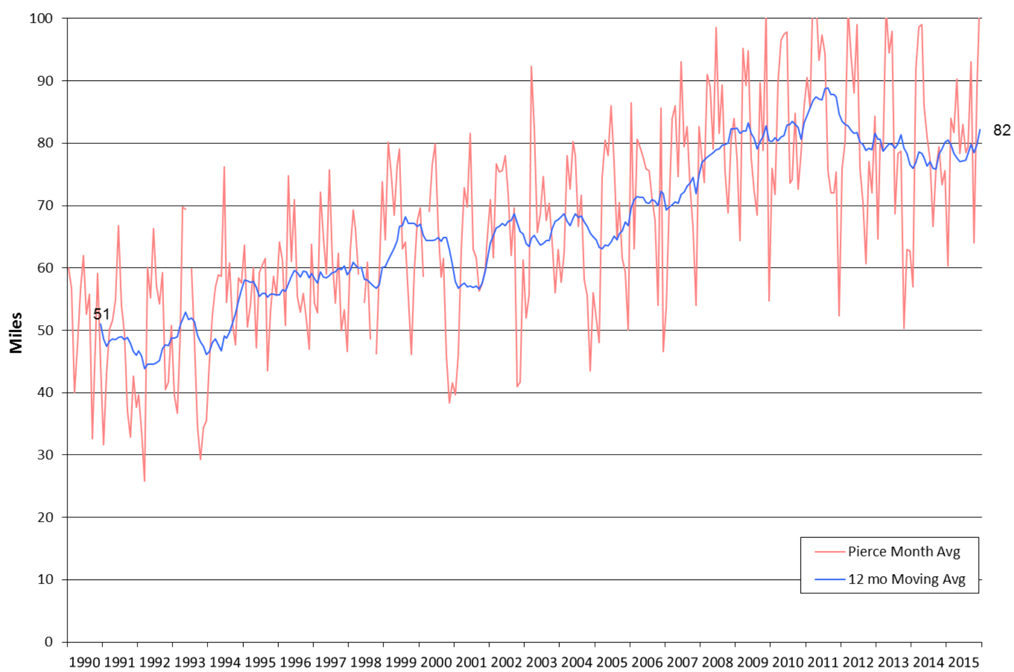
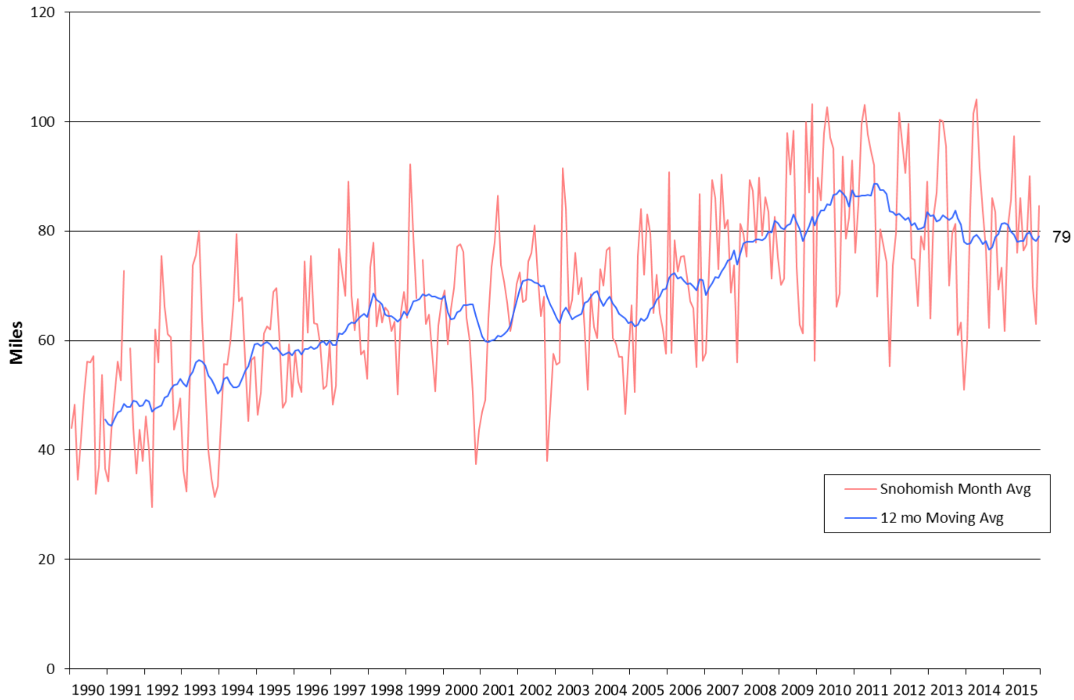


Figure 21: Snohomish County Visibility



Air Toxics

"Air toxics" are air pollutants known or suspected to cause health problems. Potential health effects include cancer, birth defects, lung damage, immune system damage, and nerve damage.[13] The Agency considers over 400 different air pollutants as air toxics.

This section presents a relative ranking of these toxics based on potential cancer health risks, as well as trends over time. We provide a short description of each air toxic of concern, including their health effects and sources.

The Washington State Department of Ecology (Ecology) monitors for air toxics annually at the Seattle Beacon Hill site. The Beacon Hill site is one of 30 EPA-sponsored National Air Toxic Trends Sites. As in previous years, Ecology monitored toxics every six days. The 2006 dataset is incomplete due to relocation of the Beacon Hill site that year. For general information on air toxics, see pscleanair.org/airquality/airqualitybasics/airtoxics/Pages/default.aspx. Air toxics statistical summaries are provided starting on page A-21 of the Appendix.

Relative ranking based on cancer risk & unit risk factors

Table 3 below ranks 2015 air toxics from the Beacon Hill monitoring site according to mean potential cancer risk per million. It shows monitored pollutants ranked from highest concern (#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 is an estimate of 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.[14]

For details on how air toxics were ranked, please see pages A-22 and A-23 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-23 of the Appendix. Page A-23 also lists the frequency (percentage) of samples that were over the cancer screening level of one in a million risk.

[13] Ref 13: US EPA, Risk Assessment for Toxic Air Pollutants: A Citizen's Guide: https://www3.epa.gov/airtoxics/3_90_024.html.
[14] US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, February 2006; https://archive.org/details/APreliminaryRisk-basedScreeningApproachForAirToxicsMonitoringDataSets

Table 3: 2015 Beacon Hill Air Toxics Ranking
(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk[a]
Carbon Tetrachloride	1	28
Benzene	2	15
1,3-Butadiene	3	11
Formaldehyde	4	4
Chloroform	5	3
Arsenic (PM_{10})	5	3
Acetaldehyde	8	2
Ethylene Dichloride	8	2
Naphthalene	8	2
Dichloromethane	11	1
Cadmium (PM_{10})	11	1
Nickel (PM_{10})	11	1
Ethylbenzene	11	1
Tetrachloroethylene	11	1

[a]Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level (WAC 173-460-150)[15]

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.

[15]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.[16] Unfortunately, acrolein measurements have large uncertainty and is one of the most difficult pollutants to measure.[17] Therefore, for acrolein, we did not explore a trend analysis as the results are likely all within the uncertainty of the measurement.

Reference concentrations and hazard indices are shown for each air toxic on page A-24 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 trends

Annual average potential cancer risks are shown on the following pages for air toxics collected from 2000 to 2015 at Beacon Hill. For many air toxics, our analysis of the trends shows a statistically significant decrease in annual average concentrations.

EPA has not set ambient air standards for air toxics, so graphs do not include reference lines for federal standards. The statistical results can be found on page A-25 of the Appendix.

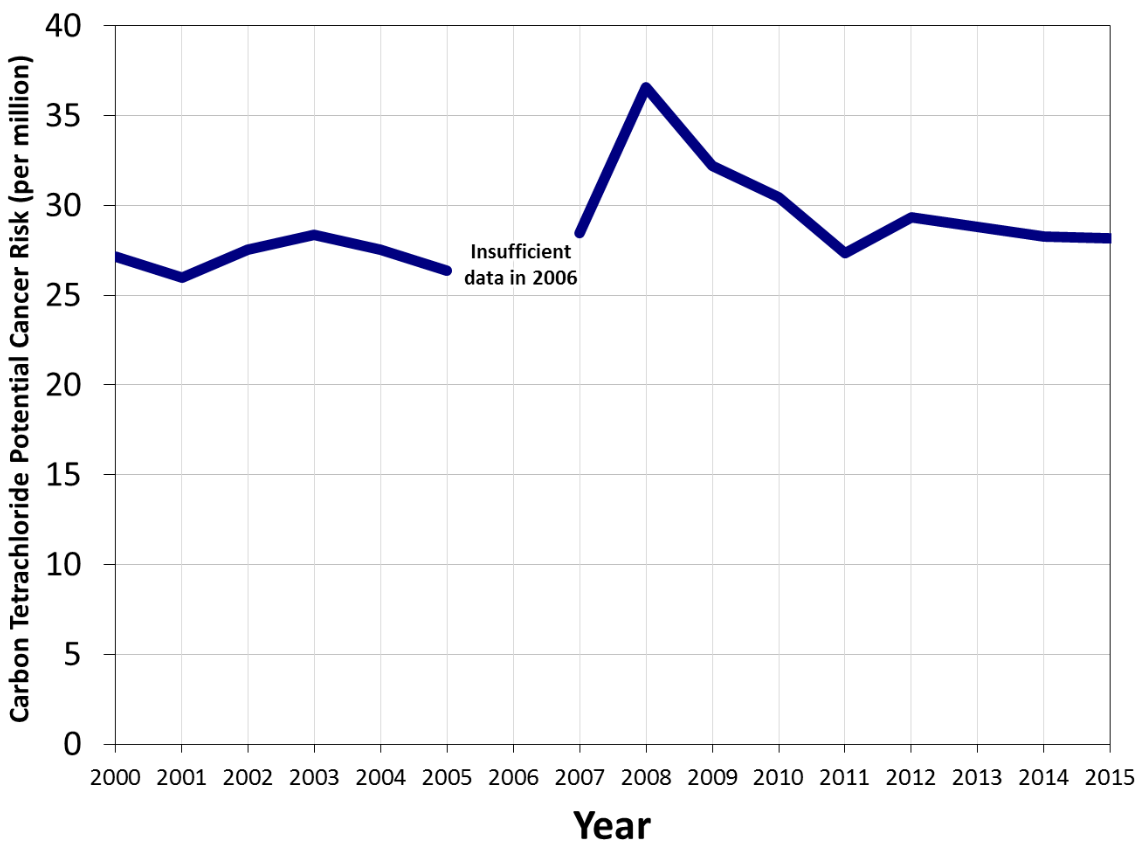
[16] EPA, Acrolein Hazard Summary; epa.gov/ttn/atw/hlthef/acrolein.html.
[17] EPA, Schools Monitoring Acrolein Update, https://www3.epa.gov/air/sat/pdfs/acroleinupdate.pdf.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[18] 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 2015 average potential cancer risk estimate at Beacon Hill was 28 in a million.

The Agency does not target efforts at reducing carbon tetrachloride emissions, as carbon tetrachloride has already been banned. We did not find a statistically significant trend in carbon tetrachloride levels over time.

Figure 22: Carbon Tetrachloride Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



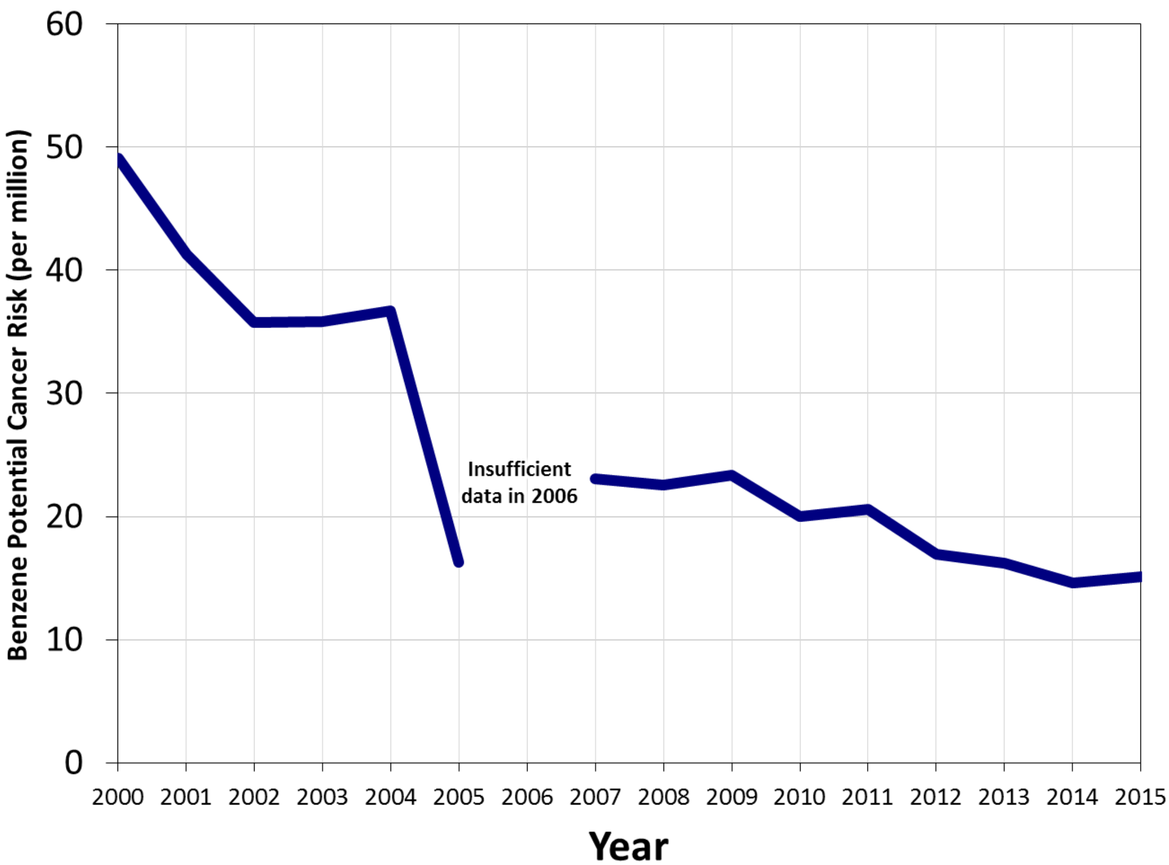
[18]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/carbonte.html.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune and nervous system disorders.[19] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvent and other combustion. Benzene's 2015 average potential cancer risk range estimate at Beacon Hill was 15 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). We found a statistically significant drop in risk from benzene at a rate of about two per million per year since 2000.

Figure 23: Benzene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



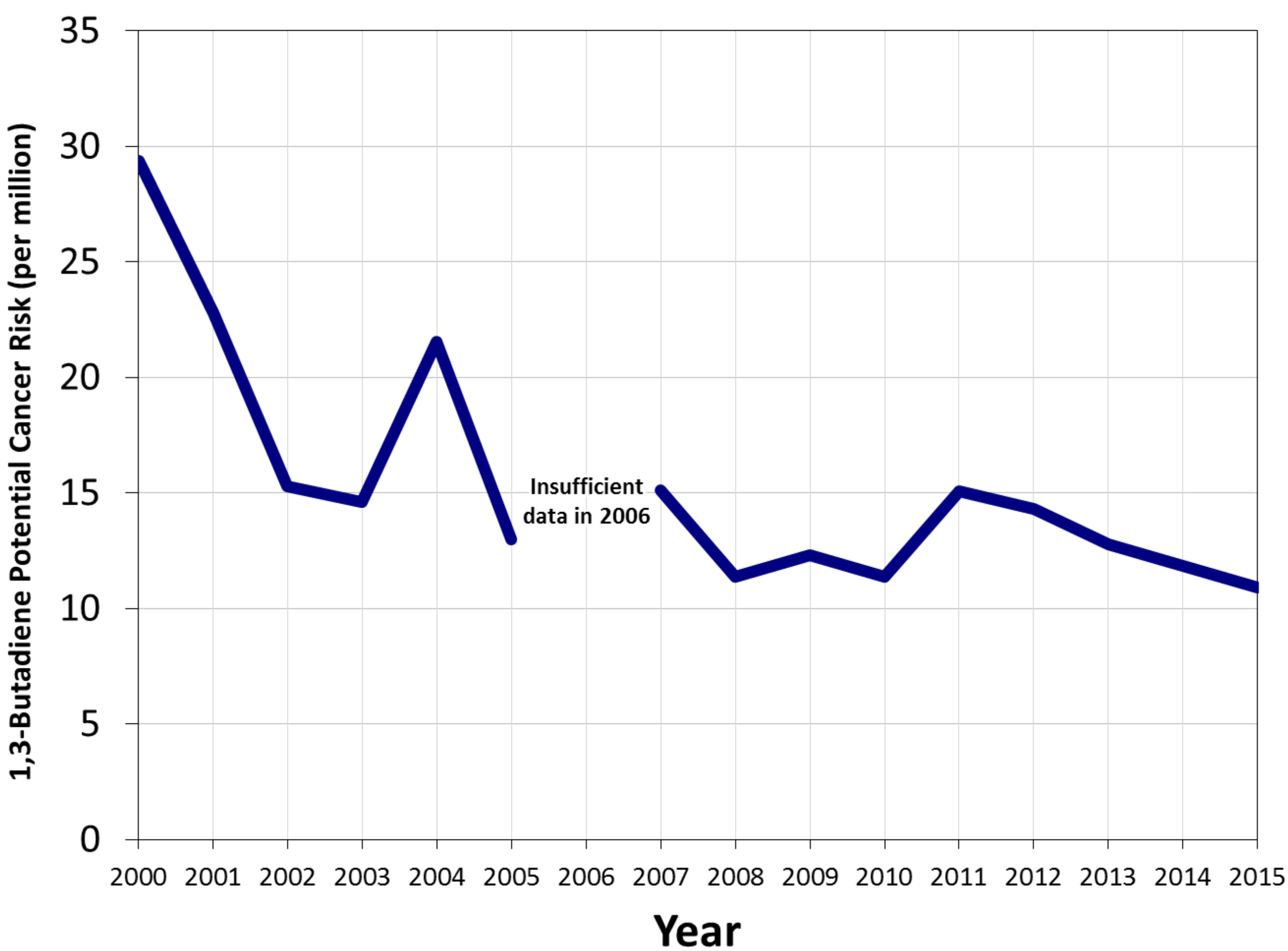
[19] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/benzene.html.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.[20] Primary sources of 1,3-butadiene include cars, trucks, buses and wood burning. 1,3-butadiene's 2015 average potential cancer risk estimate at Beacon Hill was 11 in a million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce 1,3-butadiene emissions. Since 2000, we found a statistically significant drop in risk from 1,3-butadiene at a rate of about one per million per year.

Figure 24: 1,3-butadiene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



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

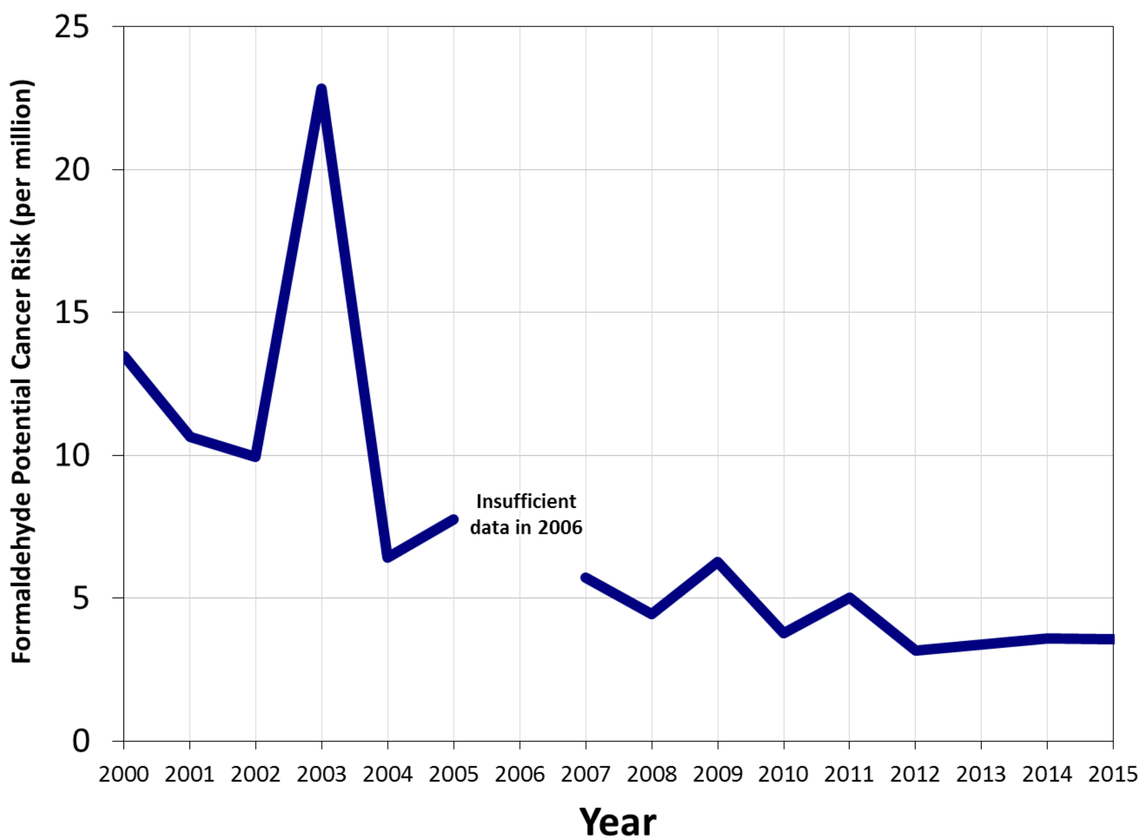
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat and lung irritation.[21] Sources of ambient formaldehyde include automobiles, trucks, wood burning and other combustion. Formaldehyde's 2015 average potential cancer risk range estimate at Beacon Hill was 4 in a million.

The increase in formaldehyde 2003 concentrations is due to 9 anomalous sampling days in July 2003 when levels were roughly ten times the normal levels. It is possible that a local formaldehyde source was present at the Beacon Hill reservoir during this month and inadvertently affected the monitors.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce formaldehyde emissions. Since 2000, we found a statistically significant drop in risk from formaldehyde at a rate of about one per million per year.

Figure 25: Formaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



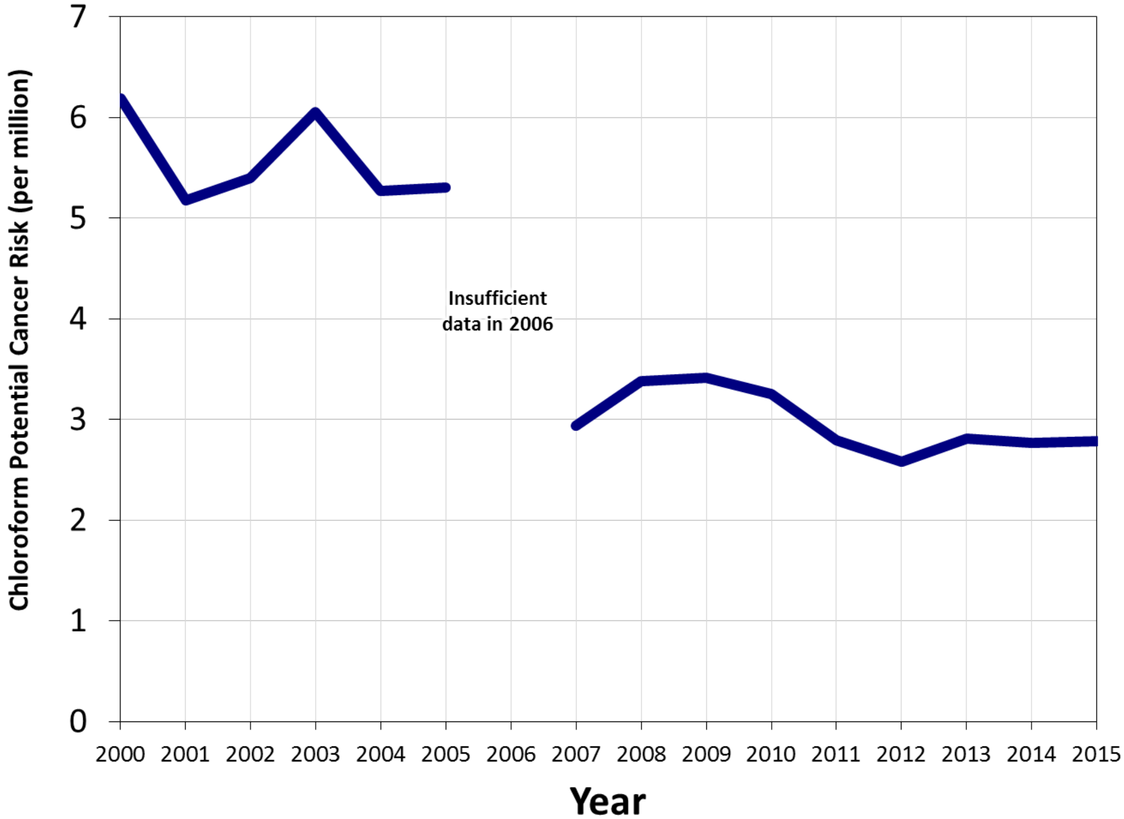
[21]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/formalde.html.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.[22] 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 2015 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.[23] Since 2000, we found a statistically significant drop in risk from chloroform at a rate of about 0.3 per million per year.

Figure 26: Chloroform Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



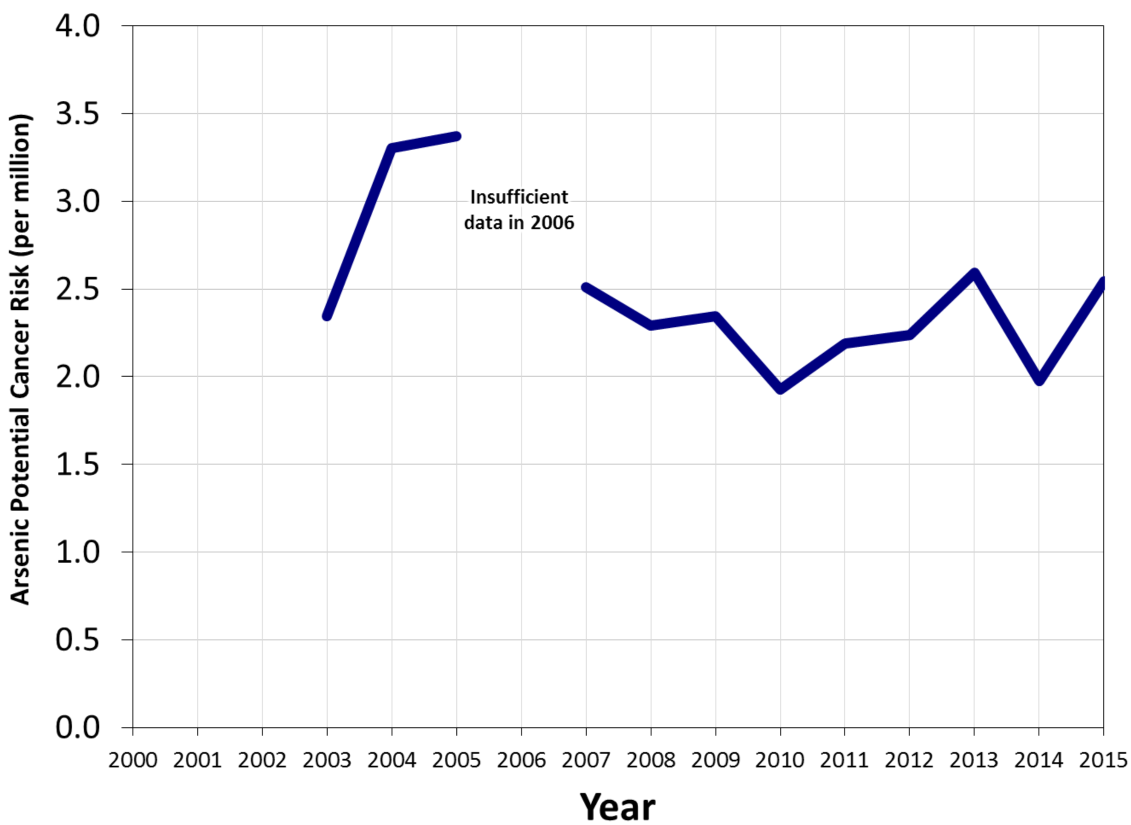
[22]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/chlorofo.html.
[23]Seattle Public Utilities. 2011Water Quality Analysis shows detectable levels of trihalomethanes; Seattle Public Utilities. 2015 Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/cs/groups/public/@spu/@water/documents/webcontent/1_051907.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform.

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation and liver and kidney damage.[24] Arsenic is used to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2015 average potential cancer risk range estimate at Beacon Hill was 3 in a million. We no longer find a statistically significant trend in arsenic levels over time.

We enforce illegal burning practices to limit arsenic emissions in Puget Sound. The Agency's permitting program also works with and regulates industrial producers of arsenic to reduce emissions.

Figure 27: Arsenic Annual Average Potential Cancer Risk at Beacon Hill, 2003-2015



[24] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/arsenic.html.

Hexavalent Chromium

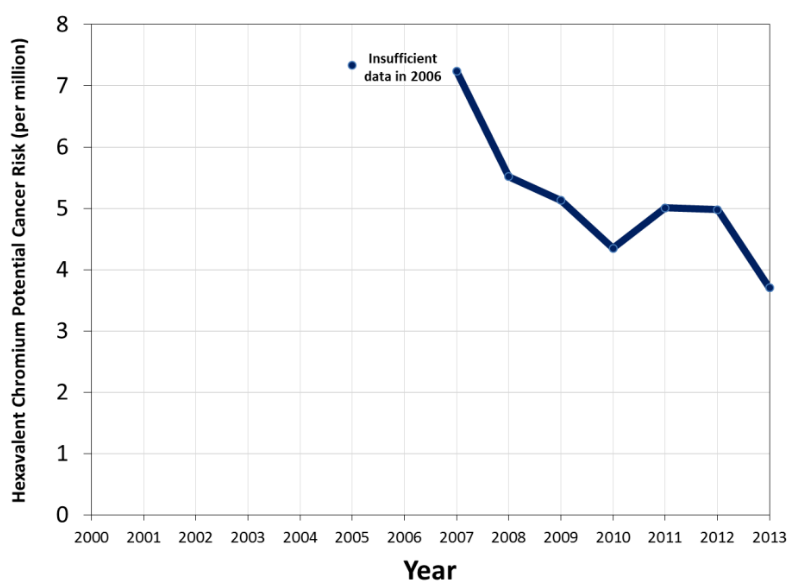
Chromium is present in two chemical states (trivalent and hexavalent) in our air. Trivalent chromium occurs naturally, while hexavalent comes from human activities and is much more toxic. EPA lists hexavalent chromium as a known carcinogen, associated primarily with lung cancer. Hexavalent chromium is often abbreviated as chromium +6 or chromium VI.

Exposure to hexavalent chromium is also associated with adverse respiratory, liver, and kidney effects.[25] 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).

Due to the significant cost of monitoring for this pollutant, monitoring for total suspended particulate (TSP) hexavalent chromium was stopped in 2013. The 2013 estimated average potential cancer risk range for hexavalent chromium at Beacon Hill was 3 in a million. Sampling has been discontinued for hexavalent chromium and the last sample was collected on June 30th, 2013. This estimate only includes the first half of 2013.

In some years, up to 20% of the samples were below method detection limits. For the trend below, we used the Kaplan-Meier method to estimate the mean to better account for potential left-sensored data biases for each year and changes in detection limits. Since 2000, we found a statistically significant drop in risk from hexavalent chromium at a rate of about 0.4 per million per year. The Agency's permitting program works with and regulates industrial chromium plating operations to reduce hexavalent chromium emissions.

Figure 28: Hexavalent Annual Average Potential Cancer Risk at Beacon Hill, 2005-2013



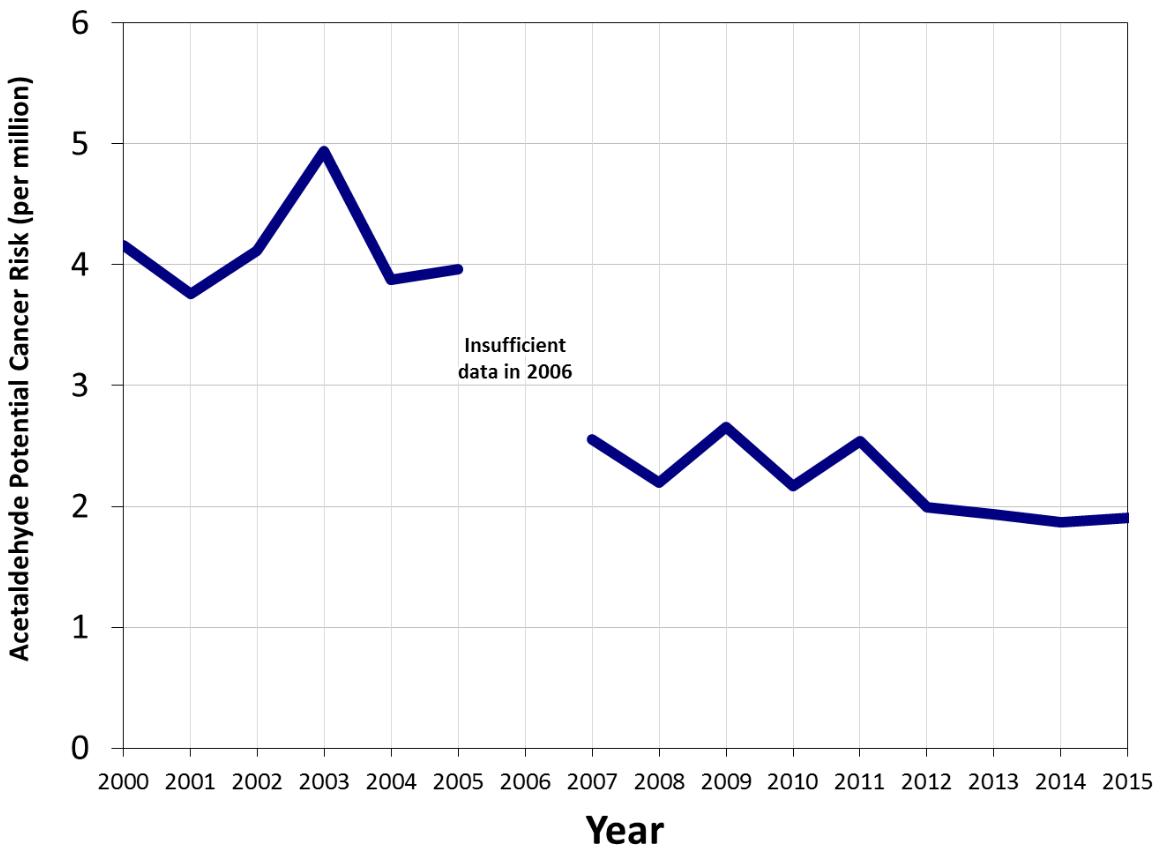
[25] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/chromium.html.

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.[26] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2015 average potential cancer risk estimate at Beacon Hill was 2 in a million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce acetaldehyde emissions. Since 2000, we found a statistically significant drop in risk from acetaldehyde at a rate of about 0.2 per million per year.

Figure 29: Acetaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



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

Ethylene Dichloride

EPA lists ethylene dichloride as a probable human carcinogen. It is primarily used as a solvent in the production of other chemicals like vinyl chloride. It is also added to leaded gas.[27]

We estimated ethylene dichoride's 2015 average potential cancer risk estimate at Beacon Hill at 2 in a million.

There is no useful trend information for this air toxic since this estimate includes samples near the practical quantitation limit of the measurement method. That is, all of the samples in 2015 were within twice the method detection limit. Additionally, in prior years, most of the samples were below the method detection limits. Through the years, the detection limits for this air toxic is near the one in a million potential cancer risk level.

The Agency's permitting program works with and regulates industrial producers of ethylene dichloride to reduce emissions.

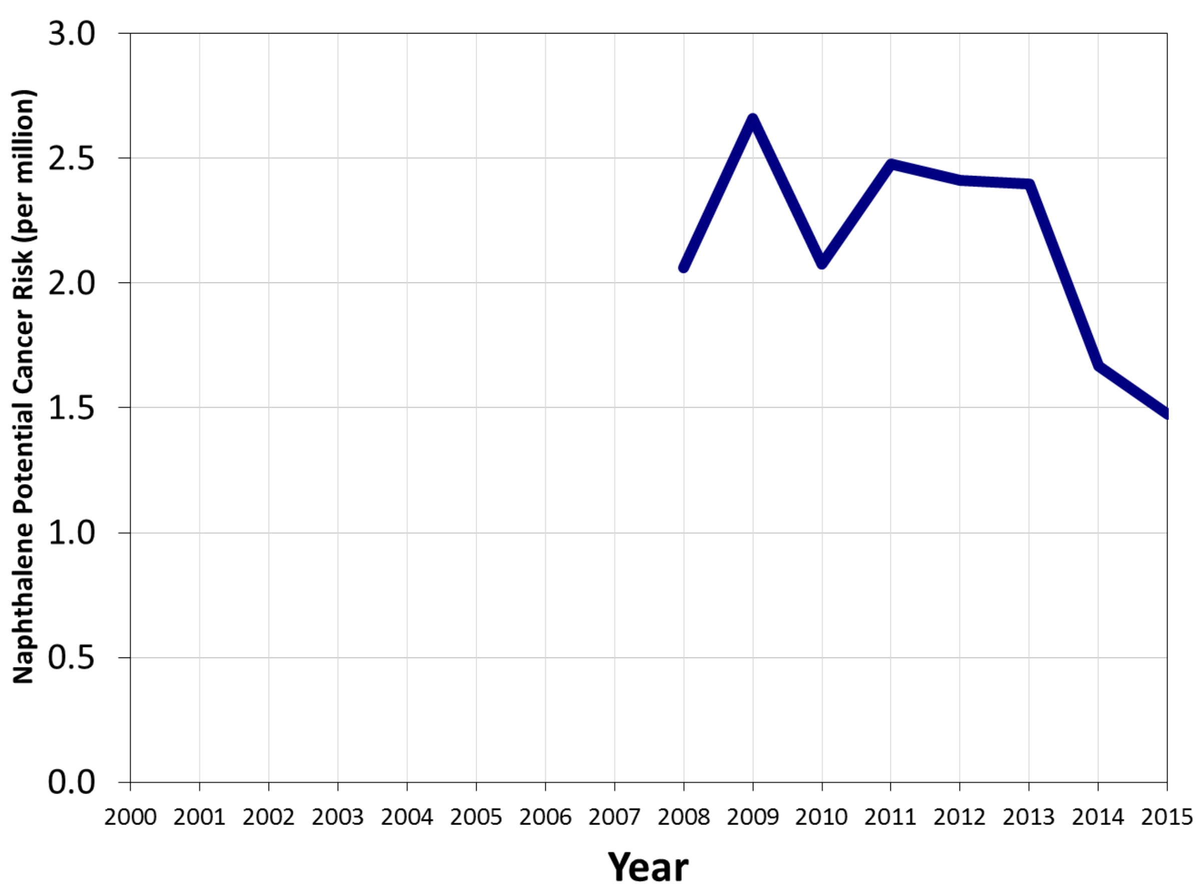
[27] EPA Hazard Summary, http://www.epa.gov/ttnatw01/hlthef/di-ethan.html.

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 2015 average potential cancer risk estimate at Beacon Hill was at 2 in a million.

The Agency works with and regulates wood burning through burn bans and wood stove replacement programs to reduce naphthalene emissions. We did not find a statistically significant trend in naphthalene levels over time. Monitoring for naphthalene and other polycyclic aromatic hydrocarbons started in 2008.

Figure 30: Naphthalene Annual Average Potential Cancer Risk at Beacon Hill, 2008-2015



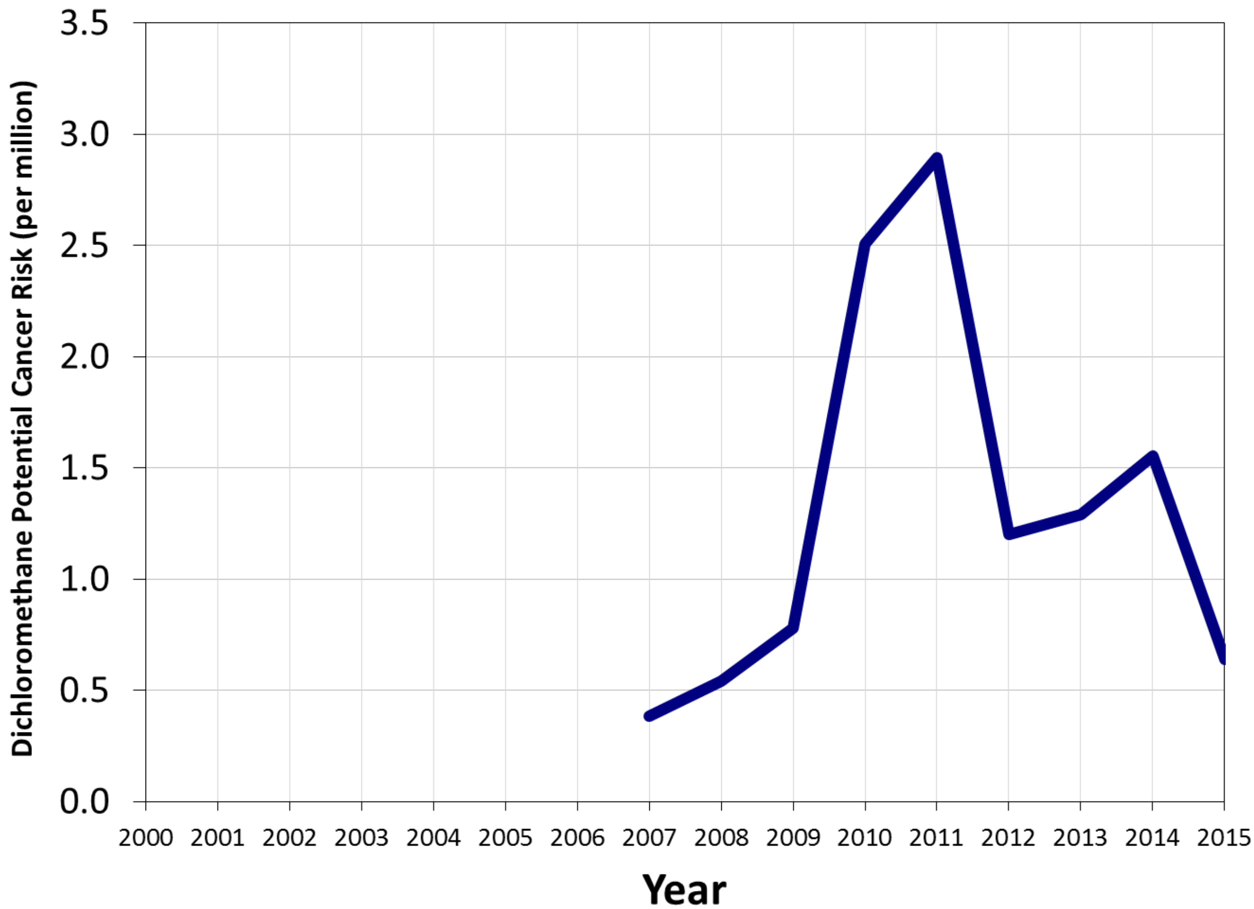
[28]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/naphthal.html.

Dichloromethane

EPA lists dichloromethane as a probable human carcinogen. Dichloromethane is also known as methylene chloride. Dichloromethane is a common solvent used for paint, extraction, and cleaning processes.[29] Dichloromethane's 2015 average potential cancer risk estimate at Beacon Hill was 1 in a million. We did not find a statistically significant trend in dichloromethane levels over this time frame.

The Agency's permitting program works with and regulates industrial producers of dichloromethane to reduce emissions. We do not have a program that addresses emissions from household products like paint strippers that may contain dichloromethane.

Figure 31: Dichloromethane Annual Average Potential Cancer Risk at Beacon Hill, 2007-2015



[29] EPA Hazard Summary, http://www.epa.gov/ttnatw01/hlthef/methylen.html.

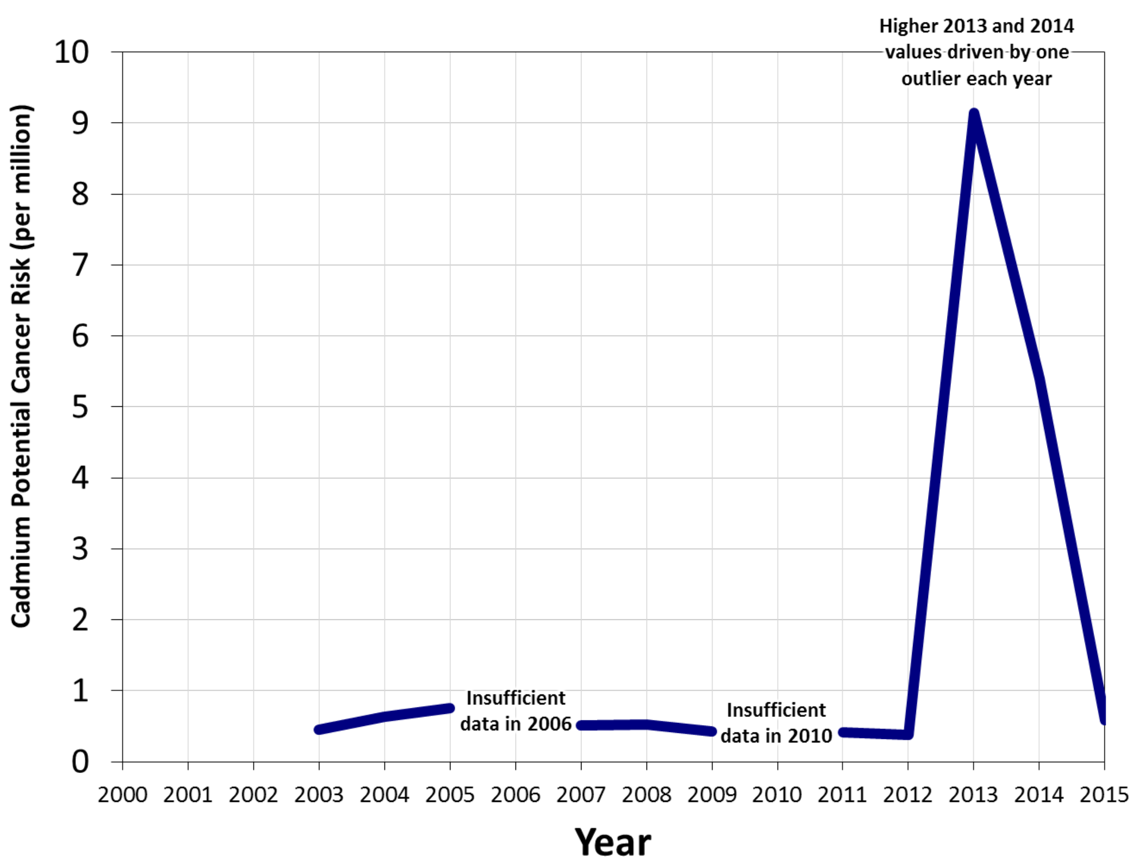
Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[30] Combustion of distillate oil is a main source of cadmium in the Puget Sound area.

Cadmium's 2015 average potential cancer risk estimate at Beacon Hill was less than 1 in a million. Over half the samples in 2010 were below the detection limits and did not have sufficient data to make a comparible average. We found sampled outliers on 9/8/14 and 11/18/13. On those days, no other metal concentrations were statistical outliers compared to their respective annual variability. With the outliers excluded for both years, the estimated annual potential cancer risk for cadmium would be < 1. With or without the outliers included, we found no statistically significant trend for cadmium.

The Agency's permitting program works with and regulates industrial producers of cadmium to reduce emissions.

Figure 32: Cadmium Annual Average Potential Cancer Risk at Beacon Hill, 2003-2015

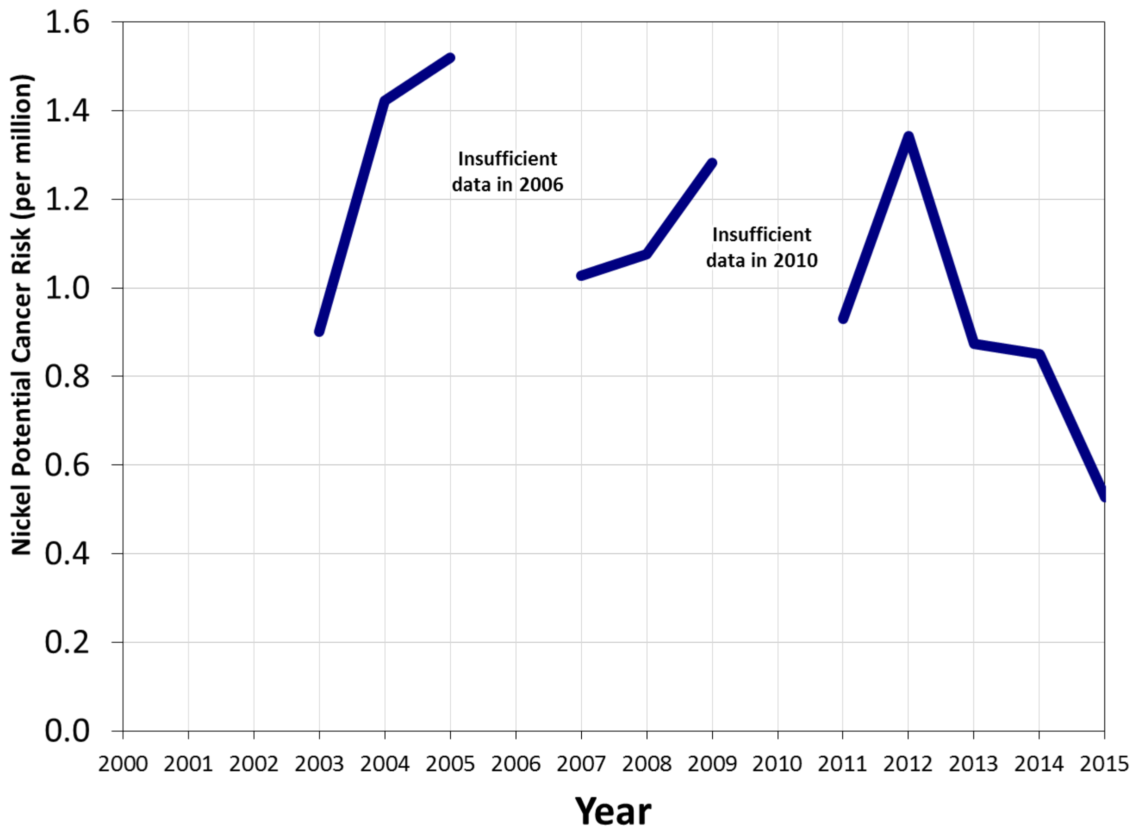


[30] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/cadmium.html.

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 2015 average potential cancer risk estimate at Beacon Hill was below one in a million. We did not find a statistically significant trend in nickel levels over this time frame. Agency efforts that target reducing vehicle exhaust also reduce nickel emissions.

Figure 33: Nickel Annual Average Potential Cancer Risk at Beacon Hill, 2003-2015

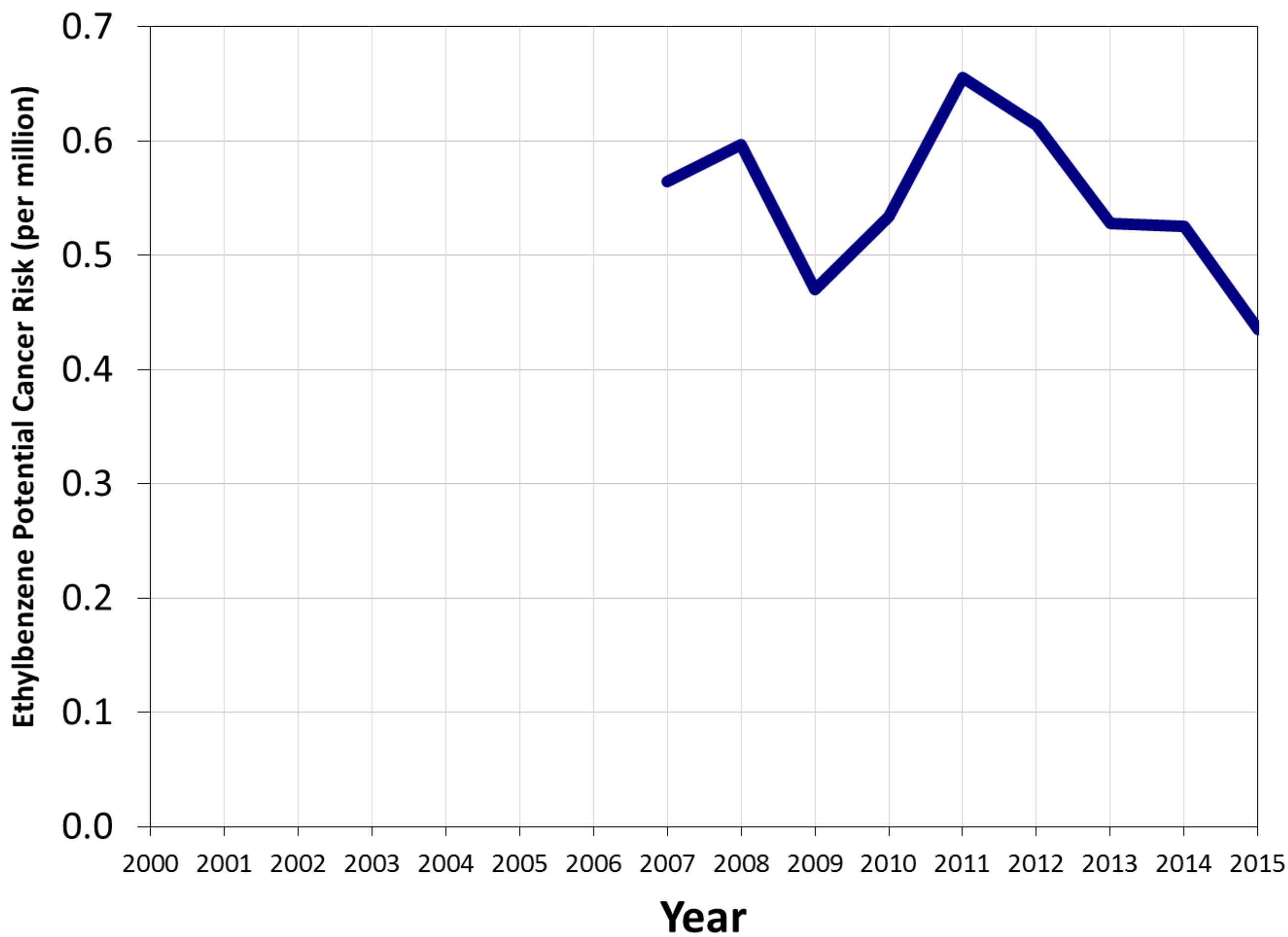


[31] EPA Hazard Summary; epa.gov/iris/subst/0273.htm.

Ethylbenzene

EPA lists ethylbenzene as a Group D pollutant, which is not classifiable as to human carcinogenicity due to limited information available.[32] 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 2015 average potential cancer risk estimate at Beacon Hill was below one in a million, however near one in the 95th percentile table in the appendix. We did not find a statistically significant trend in ethylbenzene levels over this time frame. The Agency works with and regulates solvent-using businesses to reduce ethylbenzene emissions.

Figure 34: Ethylbenzene Annual Average Potential Cancer Risk at Beacon Hill, 2007-2015



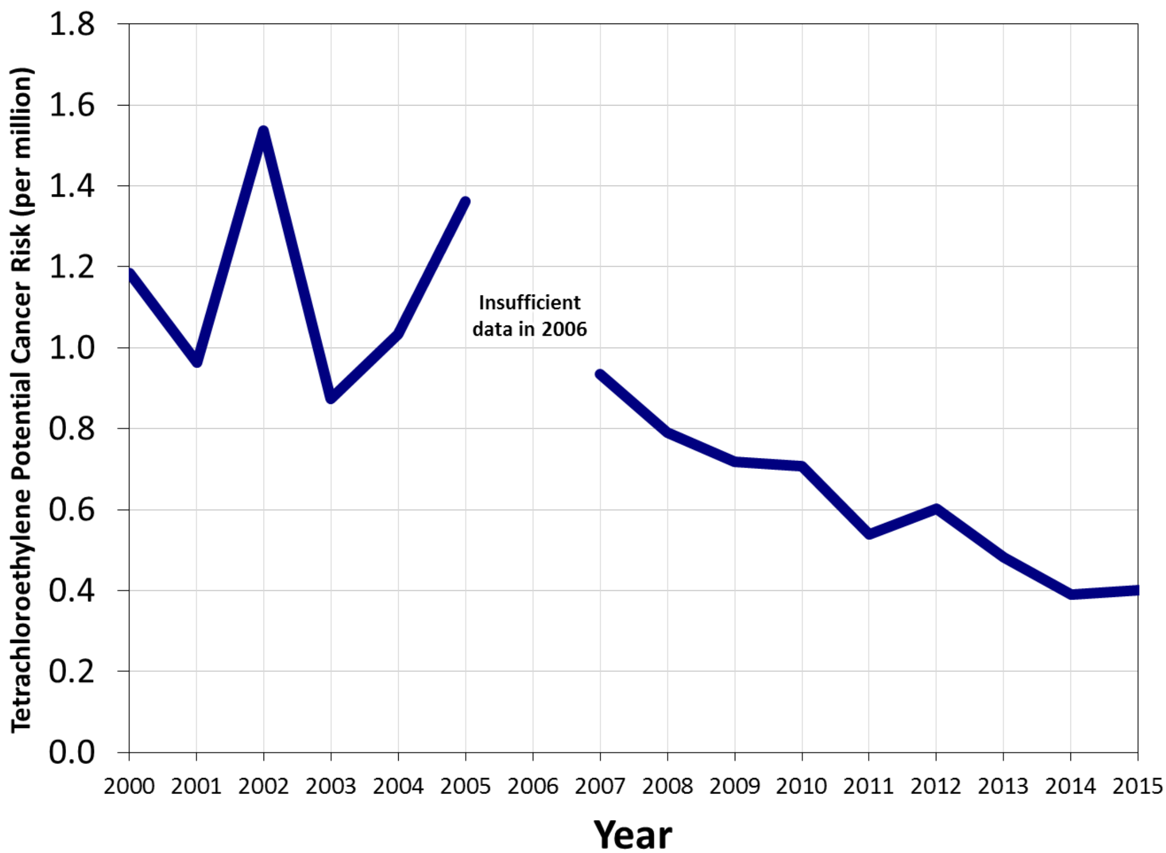
[32]EPA Hazard Summary: epa.gov/ttn/atw/hlthef/ethylben.html.

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.[33] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2015 average potential cancer risk estimate at Beacon Hill was below one in a million, however is near one in the 95th percentile table in the appendix.

Recently, we've been working with dry cleaners to monitor for and repair leaks in their equipment to reduce the release of tetrachloroethylene. Since 2000, we found a statistically significant drop in risk from tetrachloroethylene at a rate of about 0.1 per million per year.

Figure 35: Tetrachloroethylene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2015



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

Definitions

General Definitions

Air Quality Index

Table 4: 2015 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
O_3 (ppm) 8-hour[(d)]	O_3 (ppm) 1-hour[(a)]	$PM_{2.5}$(µg/m^3) 24 hour	PM_{10}(µg/m^3) 24 hour	CO (ppm) 8 hour	SO_2[(c)](ppb) 1 hour	NO_2 (ppb) 1 hour	AQI value	Category
0.000–0.059	—	0.0–12.0	0–54	0.0–4.4	0–35	0–53	0–50	Good
0.060–0.075	—	12.1–35.4	55–154	4.5–9.4	36–75	54–100	51–100	Moderate
0.076–0.095	0.125–0.164	35.5–55.4	155–254	9.5–12.4	76–185	101–360	101–150	Unhealthy for sensitive groups
0.096–0.115	0.165–0.204	55.5–150.4	255–354	12.5–15.4	186–304	361–649	151–200	Unhealthy
0.116–0.374	0.205–0.404	150.5–250.4	355–424	15.5–30.4	305–604	650–1249	201–300	Very unhealthy
(b)	0.405–0.504	250.5–350.4	425–504	30.5–40.4	604–804	1250–1649	301–400	Hazardous
(b)	0.505–0.604	350.4–500.4	505–604	40.5–50.4	805–1004	1650–2049	401–500	

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

[(b)]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.

[(c)]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.

[(d)]EPA tightened the O_3 standard Oct 26, 2015 (effective 12/28/15) and new values are not reflected in this chart.

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. See appendix page A-27 for more information.

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.

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2015

Air Quality Data Summary Appendix

August 2015

Working Together for Clean Air

Air Quality Index
1980 – 2015

King County

	Days in Each Air Quality Category					Pollutant Determining the AQI									Highest Value		
						All Days					Unhealthy Days						
Year	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	PM	CO	SO_2	O_3	NO_2	PM	CO	O_3	NO_2	AQI	Date	Pollutant
1980	73	275		18		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		101	261	3				9			183	Jan 28	CO
1984	146	218		2		111	242	13			2				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		119	246				3	4			184	Feb 6	PM
1988	215	146		5		67	298	1			2	3			150	Dec 3	CO
1989	231	134				129	233	3							100	Jan 19 #	CO
1990	216	145		4		139	201	6	19				4		131	Aug 11	O_3
1991	229	136				140	190	8	27						100	Dec 15 #	CO
1992	206	159		1		103	230	1	32			1			167	Feb 3	CO
1993	240	125				118	235	1	11						88	Jan 11	PM
1994	293	70		2		72	270	1	22				2		134	Jul 21	O_3
1995	299	66				95	249	5	16						89	Jan 3	CO
1996	297	69				85	252	2	27						100	Oct 9	CO
1997	302	63				117	230		18						94	Jan 16	PM
1998	317	46		2		111	228		26				2		114	Jul 27 #	O_3
1999	267	92	6			251	60		54		5		1		134	Jan 4	PM
2000	241	118	7			288	25		53		5		2		114	Nov 21	PM
2001	273	86	6			295	10		60		6				118	Nov 10	PM
2002	262	99	4			275	11		79		4				113	Nov 27	PM
2003	268	95	2			250	5		110				2		132	Jun 6	O_3
2004	256	105	5			280	2		84		4		1		132	Dec 18	PM
2005	254	106	5			302	3		60		5				117	Dec 11	PM
2006	268	87	6	4		273	2		90		6		4		169	Jul 22	O_3
2007	285	77	3			278			87		2		1		115	Jan 29	PM
2008	287	76	3			306			60				3		140	Jun 29	O_3
2009	272	88	4	1		254			111		1		4		154	Jul 5	PM
2010	320	44	1			261			104				1		104	Aug 17	O_3
2011	316	49				192			173						98	Dec 10	PM
2012	315	47	4			206			160		2		2		116	Aug 5	O_3
2013	221	139	4	1		308			53	4	5				152	Nov 28	PM
2014	264	99	2			187			101	77	1		1		124	Jul 12	O_3
2015	213	145	6			220			59	85	3		2	1	131	Aug 23	PM
Totals	8299	4663	68	112	6	6502	4723	61	1696	166	70	83	32	1			

PM = Particulate Matter CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone # = 1st Occurrence NO_2 = Nitrogen Dioxide

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 and NO_2 data added beginning 2013

Air Quality Index
1990 – 2015

Kitsap County

	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
						All Days				Unhealthy Days					
Year	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1990															
1991															
1992	353	8				361							68	Nov 25	PM
1993	343	12				355							62	Jan 11	PM
1994	364	1				248	117						54	Dec 23	CO
1995	361	4				86	279						57	Jan 5	CO
1996	361	1				206	156						51	Mar 2	PM
1997	361	1				362							55	Jan 15	PM
1998	347	9				356							87	Nov 8	PM
1999	333	32				365							81	Jan 5 #	PM
2000	290	75		1		366				1			159	Jul 4	PM
2001	320	42				362							91	Dec 25	PM
2002	324	41				365							78	Nov 2	PM
2003	318	47				365							78	Nov 3	PM
2004	340	26				366							80	Jul 4	PM
2005	328	35	2			365				2			136	Jul 4	PM
2006	339	25	1			365				1			105	Dec 17	PM
2007	322	42				364							92	Nov 24	PM
2008	342	24				366							78	Dec 23	PM
2009	300	37	2			339				2			111	Dec 3	PM
2010	321	31				352							88	Dec 31	PM
2011	340	22	1			363				1			111	Jan 1	PM
2012	345	11				356							68	Jan 1	PM
2013	352	13				365							75	Jul 4	PM
2014	354	11				365							70	Jul 4	PM
2015	350	10				360							82	Jul 4	PM
Totals	8108	560	6	1	0	8123	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 and

Air Quality Index
1980 – 2015

Pierce 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	83	271		12		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		255	101	9			4		167	Dec 30	CO
1983	140	222		3		228	128	9		1	2		137	Dec 23	PM
1984	162	198		6		207	149	10			6		117	Jan 19 #	CO
1985	140	213		12		252	109	4		1	11		165	Dec 13	PM
1986	161	197		7		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		184	175	7		3	5		183	Jan 27	CO
1989	260	103		2		217	121	27			2		117	Nov 30 #	CO
1990	271	91		3		219	87	41	18	1		2	118	May 5	PM
1991	261	103		1		247	85	12	21		1		117	Jan 31	CO
1992	260	106				231	83	27	25				100	Feb 3 #	CO
1993	289	76				247	82	23	13				89	Feb 1	CO
1994	313	51		1		235	75	31	24			1	105	Jul 21	O_3
1995	307	58				239	97	13	16				83	Jan 3	PM
1996	322	44				206	119	23	18				78	Oct 9	CO
1997	316	49				262	75	16	12				84	Jan 16	PM
1998	338	25		2		213	112	25	15			2	120	Jul 27	O_3
1999	265	97	3			318	1	1	45	3			139	Jan 4	PM
2000	242	110	13	1		318	2		46	14			153	Dec 6	PM
2001	271	83	11			306	2		57	11			139	Nov 10	PM
2002	267	88	9	1		291	1		73	10			158	Nov 27	PM
2003	265	92	8			264	1		100	8			122	Jan 7	PM
2004	251	110	5			272			94	5			133	Nov 5	PM
2005	275	82	8			276	2		87	8			120	Dec 10	PM
2006	283	71	7	4		270			95	8		3	170	Dec 17	PM
2007	298	57	10			261			104	9		1	137	Jan 29	PM
2008	295	63	8			259			107	5		3	129	Aug 16	O_3
2009	284	66	14	1		250			115	15			158	Jul 5	PM
2010	324	41				259			106				83	Dec 5	PM
2011	307	47	10	1		365				11			152	Jan 1	PM
2012	322	39	5			366				5			144	Jan 20	PM
2013	286	72	7			365				7			116	Jan 13	PM
2014	306	57	2			365				2			114	Jul 5	PM
2015	299	60	6			365				6			140	Jan 1	PM
Totals	9055	3871	126	92	5	9564	2101	293	1191	145	66	12			

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

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Air Quality Index
1980 – 2015

Snohomish County

	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
						All Days				Unhealthy Days					
Year	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	PM	CO	SO_2	O_3	PM	CO	SO_2	AQI	Date	Pollutant
1980	340	19				356		3					60	Jan 23	PM
1981	350	11				340		21					62	Jan 16	PM
1982	334	30		1		277	70	18			1		117	Dec 30	CO
1983	308	56		1		191	150	24			1		117	Nov 30	CO
1984	309	57				105	217	44					92	Sep 28	PM
1985	300	64		1		152	166	47			1		117	Dec 11	CO
1986	324	41				169	148	48					89	Jan 25	CO
1987	203	158		3		96	250	18			3		117	Jun 26 #	CO
1988	174	184		8		15	345	6			8		133	Sep 13 #	CO
1989	150	213		2		26	338	1			2		133	Feb 10	CO
1990	166	197		2		29	335	1			2		117	Mar 2 #	CO
1991	188	176		1		32	333				1		117	Dec 16	CO
1992	180	186				34	332						100	Feb 4 #	CO
1993	237	128				56	306		3				79	Jan 11	PM
1994	294	71				28	334	1	2				78	Dec 30	CO
1995	316	49				59	294	1	11				78	Jul 7	CO
1996	340	26				54	299		13				67	Jul 26	O_3
1997	348	17				210	151		4				67	Jan 14	PM
1998	353	11		1		143	219	3		1			153	Dec 22	PM
1999	300	62	3			260	105			3			129	Jan 3	PM
2000	253	79	5			301	36			5			113	Jul 4	PM
2001	290	73	2			356	9			2			111	Nov 10	PM
2002	288	69	8			343	22			8			116	Nov 4	PM
2003	282	80	3			364	1			3			108	Nov 4	PM
2004	290	74	2			364	2			2			107	Nov 5	PM
2005	288	72	5			360	5			5			139	Dec 11	PM
2006	301	57	7			364	1			7			143	Dec 17	PM
2007	288	70	6	1		365				7			155	Jan 15	PM
2008	294	72				366							96	Dec 19	PM
2009	269	84	12			365				12			117	Jul 5	PM
2010	324	41				365							98	Nov 24	PM
2011	304	53	8			365				8			147	Jan 1	PM
2012	321	43	1	1		366				2			156	Jul 4	PM
2013	271	92	2			365				2			115	Nov 24	PM
2014	293	68	4			365				4			133	Jul 5	PM
2015	276	76	8	3		363				11			158	Aug 23	PM
Totals	10146	2859	76	25	0	8369	4468	236	33	82	19	0			

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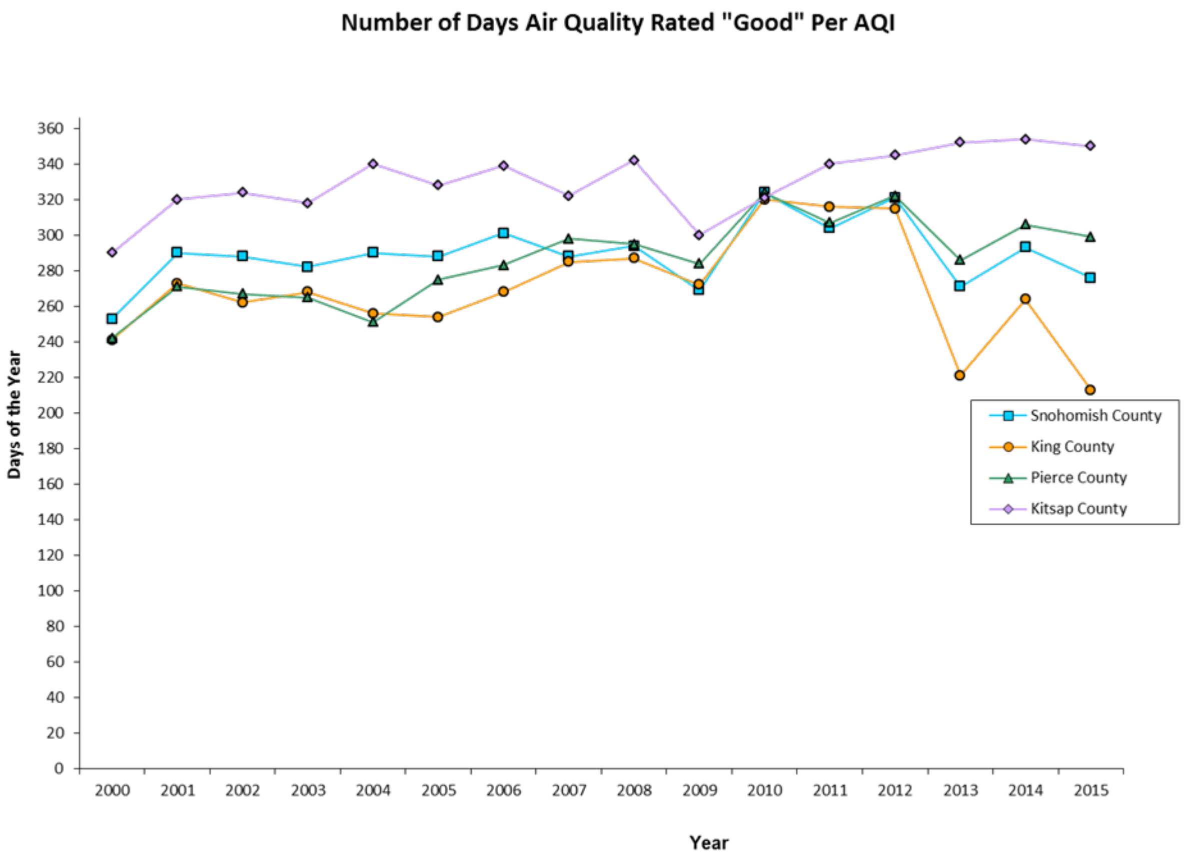
In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008 and late 2015.



Number of Days Air Quality Rated "Good" Per AQI
Days of the Year
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
Snohomish County
King County
Pierce County
Kitsap County

Monitoring Methods Used from 1999 to 2015 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 SPECIATION SITE							**X**	X					**X**	**X**	**X**		**X**	a, d
BF⦿	University District, 1307 NE 45th St, Seattle (ended Jun 30, 2006)												X						b, d
BK⦿	10th & Weller, Seattle SPECIATION SITE						●		●			●	●		●	●			a
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 (ended April 2010)							X						X					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												X						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		●	**X**					●	●	●		●	b, f
ES	7802 South L St, Tacoma SPECIATION SITE				●		●	●	●					●	●	●		●	b, f
FF◉	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma														●	●			b, f
FG◉	Mt Rainier National Park, Jackson Visitor Center									●									c

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
FH⦿	Charles L Pack Forest, La Grande									X									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		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				X		●	●	●					●	●	●		●	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
TR	Eatonville, 560 Center St, Eatonville							●							●	●			b, 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, IG, ES)
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		e	Industrial
a	Urban Center	f	Residential
b	Suburban		
c	Rural		
d	Commercial		

Burn Bans 1988 - 2015

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

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

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

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

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

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

1994 None

1995 Jan 4 - Jan 7

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

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

1998 None

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

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

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

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

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

2004 None

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

2006 None

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

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

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) – 31 Dec (2400)*
* continued to Jan 4 (1700)

2011 Jan 1 (0000) – Jan 4 (1700)
Nov 30 (1700) – Dec 7 (1300)
Dec 11 (1700) – Dec 14 (1600)

2012 Jan 11 (1600) – Jan 14 (1000)
Jan 27 (1200) – Jan 28 (1700)
Feb 3 (1600) – Feb 6 (1600)
Nov 25 (1300) – Nov 28 (0900)
Dec 29 (1700) – Dec 31 (2400)*
* continued to Jan 3 (1200)

2013 Jan 1 (0000) – Jan 3 (1200)
Jan 12 (1300) – Jan 22 (1000)
Nov 22 (1600) – Nov 29 (1000)
Dec 7 (1400) – Dec 9 (1000)
Dec 25 (1700) – Dec 26 (1100)

2014 Jan 26 (1200) – Jan 27 (1000)
Nov 14 (1700) – Nov 20 (0600)
Nov 30 (1300) – Dec 2 (1200)
Dec 30 (1600) – Dec 31 (2400)*
* continued to Jan 3 (1200)

2015 Jan 1 (0000) – Jan 3 (1200)
Jan 10 (1200) – Jan 10 (1900)
Jan 11 (1200) – 12 Jan (1100)
Nov 25 (1600) – Dec 1 (0800)
24 Dec (1600) – 25 Dec (0830)

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

Micrograms per Cubic Meter

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

2015

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
7802 South L St, Tacoma	355	8.6	5.1	6.3	9.3	7.3	32.8	50.3
15th S & Charlestown, Beacon Hill, Seattle	118	6.4	5.2	6.5	6.7	6.2	20.8	28.5

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 is at least 75 percent of each of the 4 quarterly averages.

(3) Data from primary sampler at site

Summary of Maximum Observed Concentrations

Location	Jan 1 Thu	Jul 5 Sun
7802 South L St, Tacoma	50.3	
Beacon Hill	--	28.5

- - Indicates no sample on specified day

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
7802 South L St, Tacoma	310	40	5	0
15th S & Charlestown, Beacon Hill, Seattle	107	11	0	0

PARTICULATE MATTER (PM2.5) – Continuous -TEOM

Micrograms per Cubic Meter

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

2015

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	331	10	3.6	5.3	8.1	6.8	28.4	61.0
Marysville JHS, 1605 7th St, Marysville	354	9.9	5.8	7.1	10.3	8.3	34.8	65.0
6120 212th St SW, Lynnwood	359	7.6	4.0	4.3	7.2	5.8	21.5	35.8
10th and Weller, Seattle	359	12.5	9.7	7.1	8.1	9.4	20.8	26.6
Beacon Hill, 15th S and Charlestown, Seattle	318	6.5	6.1		6.5			22.3
Duwamish, 4752 E Marginal Way S, Seattle	351	11.2	8.5	9.2	10.5	9.9	22.6	31.8
James St & Central Ave, Kent	318	7.8	5.4	6.2	7.7	6.8	26.3	40.8
7802 South L St, Tacoma	330	9.3	5.7	6.2	9.2	7.6	27.9	51.5
Spruce, 3250 Spruce Ave, Bremerton	358	4.9	4.3	4.9	5.8	5.0	13.7	26.9

Notes
(1) Sampling occurs continuously for 24 hours each day.
(2) Quarterly averages are shown only if 75 percent or more of the data for the quarter is available.
(3) Annual averages are shown only if 75 percent or more of the data for each of the 4 quarters is available.
(4) Data from primary sampler at site.

Summary of Maximum Observed Concentrations

Location	Jan 1 Thur	Jul 4 Sat	Aug 23 Sun	Nov 29 Sun
Darrington HS, 1085 Fir St, Darrington		- -	61.0	
Marysville JHS, 1605 7th St, Marysville		65.0		
6120 212th St SW, Lynnwood				35.8
10th and Weller, Seattle				26.6
Beacon Hill, 15th S and Charlestown, Seattle		- -		22.3
Duwamish, 4401 E Marginal Way S, Seattle				31.8
James St & Central Ave, Kent	40.8	- -		
7802 South L St, Tacoma	51.5	- -		
Spruce, 3250 Spruce Ave, Bremerton		26.9		

- - Indicates no sample on specified day

PARTICULATE MATTER (PM2.5) – Continuous - Nephelometer

Sampling Method: Equivalent – Ecotech Nephelometer Micrograms per Cubic Meter

2015

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	326	10.5	4.1	7.4	7.5	7.4	27.6	69.8
Marysville JHS, 1605 7th St, Marysville	363	8.9	5.1	6.3	10.0	7.6	32.8	39.1
6120 212th St SW, Lynnwood	361	7.5	4.4	5.1	7.8	6.2	20.8	32.5
17171 Bothell Way NE, Lake Forest Park	358	8.8	5.5	6.4	9.5	7.6	24.3	39.0
Queen Anne Hill, 400 W Garfield St, Seattle *	71	7.4						16.9
Duwamish, 4752 E Marginal Way S, Seattle	343	12.4	8.1	9.2	11.1	10.2	27.4	41.2
South Park, 8025 10th Ave S, Seattle *	341	10.5	7.3	9.0	9.9	9.2	22.8	34.2
305 Bellevue Way NE, Bellevue	347	5.3	4.7	5.3	5.6	5.2	15.3	26.8
42404 SE North Bend Way, North Bend	354	4.7	4.4	5.6	4.1	4.7	14.5	44.6
James St & Central Ave, Kent	362	8.0	5.8	7.5	8.3	7.4	22.5	47.5
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	315	8.2	6.0		8.0			39.1
7802 South L St, Tacoma	360	8.6	5.0	6.3	8.7	7.2	25.9	47.8
South Hill, 9616 128th St E, Puyallup	304	6.8		6.2				46.3
Spruce, 3250 Spruce Ave, Bremerton *	360	5.2	4.2	5.2	5.6	5.1	13.4	22.2
560 Center St, Eatonville *	73				1.6			5.9

Notes
(1) Sampling occurs continuously for 24 hours each day.
(2) Quarterly averages are shown only if 75 percent or more of the data for the quarter is available.
(3) Annual averages are shown only if 75 percent or more of the data for each of the 4 quarters is available.
(4) All data values are calculated using site-specific relationships with Federal Reference Method samplers when available. * Not available at these sites.
(5) Data from primary sampler at site.

Summary of Maximum Observed Concentrations

Location	Jan 9 Fri	Jul 8 Wed	Aug 23 Sun	Oct 24 Sat	Nov 29 Sun
Darrington HS, 1085 Fir St, Darrington			69.8		--
Marysville JHS, 1605 7th St, Marysville					39.1
6120 212th St SW, Lynnwood					32.5
17171 Bothell Way NE, Lake Forest Park					39.0
Queen Anne Hill, 400 W Garfield St, Seattle	16.9	--	--	--	--
Duwamish, 4752 E Marginal Way S, Seattle					41.2
South Park, 8025 10th Ave S, Seattle					34.2
305 Bellevue Way NE, Bellevue			26.8		
42404 SE North Bend Way, North Bend			44.6		
James St & Central Ave, Kent			47.5		
Tacoma Tideflats, 2301 Alexander Ave, Tacoma			39.1		
7802 South L St, Tacoma			47.8		
South Hill, 9616 128th St E, Puyallup			46.3		--
Spruce, 3250 Spruce Ave, Bremerton		22.2			
560 Center St, Eatonville	--	--	--	5.9	

- - Indicates no sample on specified day

$PM_{2.5}$ Speciation Analytes Monitored in 2015
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: aqs.epa.gov/aqsweb/documents/data_mart_welcome.html

$PM_{2.5}$ BLACK CARBON

Micrograms per Cubic Meter

Sampling Method: Light Absorption by Aethalometer

2015

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Marysville JHS, 1605 7th St, Marysville	359	1.0	0.5	0.5	1.0	0.8	3.5
Duwamish, 4401 E Marginal Way S, Seattle	357	1.5	0.7	0.8	1.2	1.0	4.5
James St & Central Ave, Kent	358	1.3	0.7	0.8	1.0	0.9	3.8
7802 South L St, Tacoma	356	1.0	0.4	0.5	1.1	0.8	3.9
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	353	1.8	0.8	1.1	1.5	1.3	6.9
10th and Weller, Seattle	314	0.8	0.5	0.5	1.2	0.7	3.7

Notes

(1) Sampling occurs continuously for 24 hours each day.

(2) Quarterly averages are shown only if 75 % or more of the data is available.

(3) Annual averages are shown only if there is at least 75 percent of each 4 quarterly averages.

Summary of Maximum Observed Concentrations

Location	Jan 9 Fri	Jan 21 Wed	Aug 30 Sun	Nov 22 Sun	Nov 27 Fri	Nov 28 Sat
Marysville JHS, 1605 7th St, Marysville				3.5		
Duwamish, 4752 E Marginal Way S, Seattle	4.5					
James St & Central Ave, Kent						3.8
7802 South L St, Tacoma					3.9	
Tacoma Tideflats, 2301 Alexander Ave, Tacoma			6.9	--		
10th and Weller, Seattle		3.7			--	--

-- indicates no sample on specified day

OZONE
(parts per million)

2015

Location / Continuous Sampling Period(s)	2014 Four Highest Daily 8-Hour Concentrations		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2013	2014	2015	2013 – 2015
Beacon Hill, 15th S & Charlestown Seattle, WA 1 Jan – 6 Jan, 22 Jan – 30 Jun 5 Aug – 4 Sep, 16 Sep – 31 Dec	.050 .050 .049 .048	3 May 9 May 2 May 1 May	.045	.044	.048	.045
20050 SE 56th Lake Sammamish State Park, WA 1 May – 30 Sep	.063 .061 .059 .059	5 Jul 8 Jul 27 Jun 11 Aug	.048	.052	.059	.053
42404 SE North Bend Way, North Bend, WA 1 May – 30 Sep	.077 .068 .065 .061	9 Jul 8 Jul 29 Jun 2 Jul	.056	.060	.061	.059
30525 SE Mud Mountain Road, Enumclaw, WA 1 May – 30 Sep	.079 .078 .074 .074	8 Jul 9 Jul 27 Jun 30 Jul	.057	.067	.074	.066
931 Northern Pacific Rd SE, Yelm, WA 1 May – 30 Sep	.062 .060 .059 .058	27 Jun 11 Aug 31 Jul 9 May	.050	.056	.058	.054
Jackson Visitors Center Mt Rainier National Park 14 Jan – 31 Dec	.068 .066 .063 .063	1 May 1 Aug 3 Jul 31 Jul	.058	.060	.063	.060

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)

2015

Maximum and Second Highest Hourly Concentrations

Location / Continuous Sampling Periods(s)	1-Hour Average		
	Value	Date	End Time
Beacon Hill, 15th S & Charlestown, Seattle	54.1	3 May	2200
1 Jan - 31 Dec	52.4	4 Jul	2200
10th & Weller, Seattle	106.1	13 Feb	1500
1 Jan – 10 Jun, 24 Jun - 31 Dec	71.9	15 Jan	0800

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) Reactive nitrogen and nitrogen dioxide were measured using the continuous chemiluminescence method.

CARBON MONOXIDE

(parts per million)

2015

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 - 17 May, 1 Jun - 31 Dec.	1.1	9 Jan	2200	0.9	10 Jan	0	0
	1.0	7 Jan	0800	0.8	8 Oct		
	1.0	7 Jan	0900	0.8	29 Nov		
	1.0	7 Jan	1200	0.7	7 Jan		
	1.0	9 Jan	2100	0.7	9 Jan		
	1.0	10 Jan	0000	0.7	31 Jan		
10^{th} & Weller, Near Road Site, Seattle 1 Jan - 31 Dec.	2.2	9 Jan	1700	1.8	9 Jan	0	0
	2.2	9 Jan	1800	1.4	31 Dec		
	2.1	9 Jan	1900	1.3	21 Jan		
	1.9	14 Dec	2200	1.3	18 Feb		
	1.7	14 Jan	1600	1.3	23 Feb		
	1.7	23 Feb	1900	1.3	27 Oct		

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

TRACE SULFUR DIOXIDE

(parts per billion)

2015

Maximum and Second Highest Concentrations for Various Averaging Periods

Location / Continuous Sampling Period(s)	1 Hour Average		
	Value	Date	End Time
Beacon Hill, 15th S & Charlestown, Seattle 1 Apr – 6 Nov, 24 Nov - 31 Dec	9.3	24 Oct	1700
	9.2	1 Jun	0100

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) According to 40 CFR 53 part 7 subsection 3, *"Comparisons with the 1-Hour Primary SO2 NAAQS"*, the data from 2015 did not meet data completeness requirements. Therefore, it is not appropriate to assess highest concentrations for 1 Hour averaging periods as compared to the 75 ppb standard. The highest and second highest averages shown here demonstrate the highest concentrations measured are well below the 75 ppb standard.
(4) Trace sulfur dioxide was measured using the continuous ultraviolet fluorescence method.

2015 Beacon Hill Air Toxics Statistical Summary for Air Toxics (*units in parts per billion*)

	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Carbon Tetrachloride	Chloroform	Dichloromethane	Ethylbenzene	Ethylene Dichloride	Formaldehyde	Tetrachloro ethylene
2015 Count	56	59	52	56	56	56	56	56	56	59	56
ND's (reported as 0)	2	0	0	0	0	0	0	0	1	0	13
Median (ppb)	0.023	0.323	0.219	0.133	0.106	0.024	0.130	0.036	0.016	0.441	0.009
Mean (ppb)	0.029	0.391	0.231	0.163	0.107	0.025	0.184	0.045	0.016	0.484	0.010
95th Percentile (ppb)	0.060	0.834	0.454	0.296	0.123	0.034	0.422	0.084	0.023	1.01	0.024
Max (ppb)	0.129	0.946	0.546	0.522	0.130	0.044	1.01	0.207	0.025	1.50	0.048
# Below MDL	10	0	4	0	0	0	0	4	12	0	39
% Below MDL	18%	0%	8%	0%	0%	0%	0%	7%	21%	0%	70%

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

2015 Beacon Hill Air Toxics Statistical Summary for Air Toxics (*units in nanograms per cubic meter*)

	Arsenic (PM_{10})	Cadmium (PM_{10})	Naphthalene	Nickel (PM_{10})
2015 Count	58	58	57	58
ND's (reported as 0)	0	0	0	0
Median (ng/m^3)	0.599	0.069	37.8	0.865
Mean (ng/m^3)	0.771	.0140	43.3	1.07
95th Percentile (ng/m^3)	2.13	0.428	77.4	2.34
Max ng/m^3)	2.73	1.23	97.4	4.27
# Below MDL	1	0	0	4
% Below MDL	2%	0%	0%	7%

Estimates of Air Toxics Risk
2015 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/m³) * unit risk factor (risk/µg/m³)*

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, based on IARC definitions, refers to its "weight of evidence" ranking: 1 = carcinogenic to humans, 2A = probably carcinogenic to humans, and 2B = possibly carcinogenic to humans.[5]

2015 Air Toxics Unit Risk Factors

AIR TOXIC	WA ASIL 460 UNIT RISK FACTOR RISK/µg/m³	CANCER RATING[6]
1,3-Butadiene	1.7×10^{-4}	1
Acetaldehyde	2.7×10^{-6}	2B
Arsenic	3.3×10^{-3}	1
Benzene	2.9×10^{-5}	1
Cadmium	4.2×10^{-3}	1
Carbon Tetrachloride	4.2×10^{-5}	2B
Chloroform	2.3×10^{-5}	2B
Chromium (Hexavalent)	1.5×10^{-1}	1
Dichloromethane	1.0×10^{-6}	2B
Ethylbenzene	2.5×10^{-6}	2B
Ethylene Dichloride	2.1×10^{-5}	2B
Formaldehyde	6.0×10^{-6}	1
Naphthalene	3.4×10^{-5}	2B
Nickel (Subsulfide)	2.4×10^{-4}	1
Tetrachloroethylene	7.4×10^{-6}	2A

[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 International Agency for Research on Cancer, updated June 2016; http://monographs.iarc.fr/ENG/Classification/

2015 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
Carbon Tetrachloride	1	32	100%
Benzene	2	27	100%
1,3-Butadiene	3	23	96%
Formaldehyde	4	7	95%
Arsenic (PM_{10})	4	7	81%
Acetaldehyde	6	4	81%
Chloroform	6	4	100%
Naphthalene	8	3	68%
Ethylene Dichloride	9	2	68%
Cadmium (PM_{10})	9	2	16%
Dichloromethane	9	2	9%
Nickel (PM_{10})	12	1	7%
Tetrachloroethylene	12	1	4%
Ethylbenzene	12	1	2%

2015 Non-cancer Reference Concentrations (RfC) and Hazard Indices >1

Air toxic	Non-cancer RfC (*ug*/m^3)	Mean Hazard Index
Acrolein	**0.35**	**1.51**
Formaldehyde	9	0.066
Manganese (PM_{10})	0.09	0.064
Arsenic (PM_{10})	0.015	0.051
Nickel (PM_{10})	0.05	0.021
Carbon Tetrachloride	40	0.017
Benzene	60	0.009
Acetaldehyde	140	0.005
1,3-Butadiene	20	0.003
Tetrachloroethylene	35	0.002
Dichloromethane	400	0.002
Chloroform	300	< 0.001
Beryllium (PM_{10})	0.007	< 0.001

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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.

2000-2015 Air Toxics Trends Statistical Summary

The following table includes the statistical information for the potential cancer risk trends found in the data summary, including if the trend is statistically significant.

Air Toxic	Significance (p-value)	Slope (change in risk per million per year)	y-intercept	Correlation (R^2)	Number of years (N)
1,3-Butadiene	True (0.002)	-0.764	22.0	0.523	15
Acetaldehyde	True (0)	-0.190	4.61	0.810	15
Arsenic PM10	False (0.084)	-0.059	3.08	0.269	12
Benzene	True (0)	-1.991	42.9	0.793	15
Cadmium PM10	False (0.149)	0.321	-1.52	0.216	11
Carbon Tetrachloride	False (0.298)	0.156	27.5	0.083	15
Chloroform	True (0)	-0.254	6.19	0.835	15
Chromium VI Tsp	True (0.005)	-0.428	9.60	0.754	8
Dichloromethane	False (0.612)	0.063	0.553	0.039	9
Ethylbenzene	False (0.353)	-0.009	0.654	0.124	9
Formaldehyde	True (0.002)	-0.775	14.0	0.523	15
Naphthalene	False (0.135)	-0.097	3.37	0.332	8
Nickel PM10	False (0.063)	-0.041	1.49	0.332	11
Tetrachloroethylene	True (0)	-0.060	1.35	0.738	15

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 https://www.epa.gov/criteria-air-pollutants. 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 2015

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 $\mu g/m^3$ (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 of 1-hour daily maximum concentrations, 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 Dec 14, 2012	$PM_{2.5}$	primary	Annual	12 $\mu g/m^3$	annual mean, averaged over 3 years
		secondary	Annual	15 $\mu g/m^3$	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	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. Additional information is on EPA's website at https://www.epa.gov/criteria-air-pollutants .

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 25$\mu g/m^3$ for a daily average, more protective than the current federal standard of 35$\mu g/m^3$. This level is consistent with the American Lung Association's goal and the EPA Clean Air Science Advisory Committee's recommended lower range for the EPA's 2006 ambient air quality standard revision.'[9] 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; October 1999. Report available on request

[9] EPA Clean Air Science Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; epa.gov/sab/panels/casacpmpanel.html.