PUGET SOUND
Clean Air Agency

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

2020

Air Quality

Data Summary

October 2021

Table of Contents

List of Figures

List of Maps

List of Tables

Appendix – Data Tables

The 2020 Air Quality Data Summary is available for viewing or download on the internet at:

www.pscleanair.gov

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

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 smaller [PM_{10}] and 2.5 micrometers and smaller in diameter [$PM_{2.5}$])
- 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)[2] 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, and is intended mainly for forecasting and real-time communication. "Good" AQI days continued to dominate our air quality in 2020. However, air quality degraded into "moderate" and "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. The Agency's jurisdiction includes King, Kitsap, Pierce, and Snohomish Counties. Real-time air monitoring data are available for pollutants at www.pscleanair.gov/157/Request-Air-Quality-Data.

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

[2] https://www.airnow.gov/aqi/aqi-basics/

To receive the Agency's most updated news and stay current on air quality issues in King, Kitsap, Pierce and Snohomish counties, visit www.pscleanair.gov/258/Connect-With-Us 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 www.pscleanair.gov.

Over the last two decades, many pollutant levels have declined, and air quality has improved overall. In 2020, the overall air quality remained good, continuing the trend of improvement, though we still face challenges due to wildfire smoke. Elevated fine particle levels ($PM_{2.5}$) pose the greatest air quality challenge in our jurisdiction. While fine particle levels met the U.S. Environmental Protection Agency's (EPA's) health-based standard of 35 micrograms per cubic meter in 2020 when days with wildfire smoke are excluded, the Agency's more stringent local $PM_{2.5}$ health goal of 25 micrograms per cubic meter was exceeded on 25 days which were during wildfire smoke and winter months at various sites.

Ozone levels remain a concern in our region, however it has shown improvement as values have reduced at various sites. In 2020, all sites met the U.S. Environmental Protection Agency's (EPA's) revised 2015 standard.

Some air toxics were measured at levels known to cause adverse health effects. These health effects include, but are not limited to, increased cancer risk, respiratory effects, and developmental effects.

Overall, the air quality in Puget Sound region has remained good in 2020 with the continuing improvement in meeting the standards. However, our region faced nine wildfire-impacted days in September this year which led to unhealthy and very unhealthy levels of air quality in the region. Increasingly, our air quality monitoring program is moving towards continuous data which provides better temporal and seasonal variability. We are also undertaking local, short-term studies that inform on a local scale what air quality is like in communities with specific impacts (for example, communities located near major roadways).

Monitoring Network

The Puget Sound Clean Air Agency (the Agency) and the Washington State Department of Ecology (Ecology) operated the monitoring network within the Agency's jurisdiction of King, Kitsap, Pierce, and Snohomish Counties in 2020. The network is comprised of meteorological and pollutant-specific monitors, as well as instruments dedicated to special studies. Data from the network are normally collected automatically via Ecology's 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, Kitsap, Pierce, and Snohomish County monitoring sites used in 2020. An interactive map is available at www.pscleanair.gov/NetworkMap.

Map 1: Active Air Quality Monitoring Station Locations in 2020

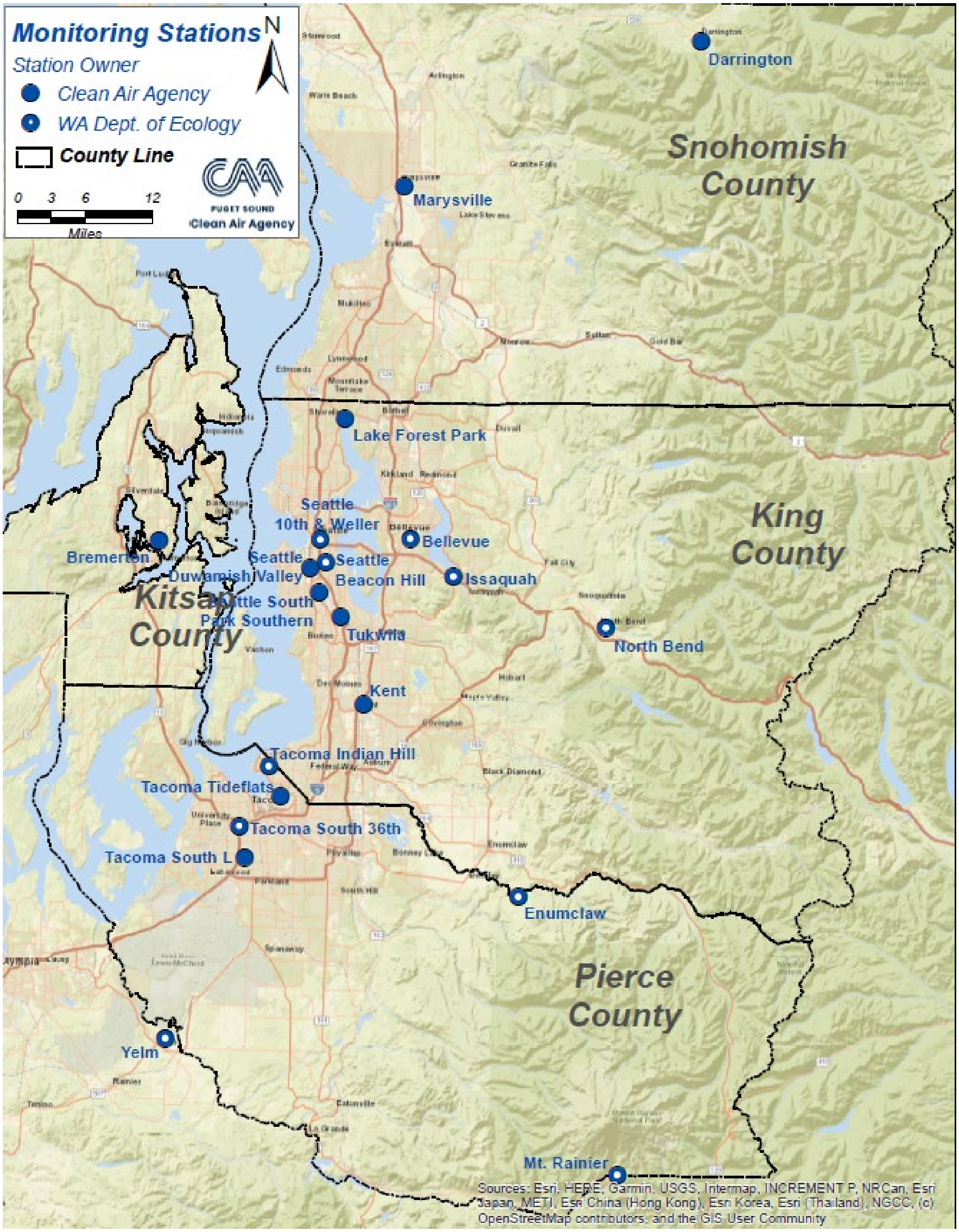


Table 1: Air Quality Monitoring Network Parameters 2020

Station ID	Location	PM2.5					O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
		Ref	Spec	FEM	ls	bc										
BK⦿	10th & Weller, Seattle SPECIATION SITE		●	●		●			●	●		●	●			a
BL	11675 44th Ave S, Tukwila Allentown			●	●	●					●	●	●		●	b, e, f
BW⦿	Beacon Hill, 15th S & Charlestown, Seattle SPECIATION SITE	●	●	●			●	●	●	●		●	●	●		b, d, f
CE	Duwamish, 4700 E Marginal Way S, Seattle SPECIATION SITE		●	●	●	●					●	●	●		●	a, e
CW	James St & Central Ave, Kent			●	●	●					●	●	●		●	b, d
DB	17171 Bothell Way NE, Lake Forest Park				●						●	●			●	b, d, f
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, SPECIATION SITE		●		●	●					●	●			●	a, e
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
IG	Marysville JHS, 1605 7th St, Marysville SPECIATION SITE			●	●						●	●	●		●	b, d

2020 Air Quality Data Summary

Station ID	Location	PM2.5					O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
		Ref	Spec	FEM	ls	bc										
IK	14310 SE 12th St, Bellevue				●						●				●	a, d
JO	Darrington High School, Darrington 1085 Fir St			●	●						●	●	●		●	d, f
PA	1802 S 36th St, Tacoma			●					●			●	●			a, f
QK	Spruce, 3250 Spruce Ave, Bremerton			●	●						●	●	●		●	b, f

⦿	Station operated by Ecology	SO_2	Sulfur Dioxide
●	Indicates parameter currently monitored	NO_y	Nitrogen Oxides
$PM_{2.5}$ ref	Particulate matter <2.5 micrometers (reference)	CO	Carbon Monoxide
$PM_{2.5}$ Spec	Speciation	b_{sp}	Light scattering by atmospheric particles (nephelometer)
$PM_{2.5}$ FEM	Particulate matter <2.5 micrometers (TEOM-fdms continuous or beta attenuation 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			
a	Urban Center	d	Commercial
b	Suburban	e	Industrial
c	Rural	f	Residential

Page A-2 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.

The Agency has been conducting air quality monitoring as early as 1965. A summary of the monitoring stations and parameters used over the history of the program is on page A-3 of the Appendix. The network changes periodically because the Agency and Ecology regularly re-evaluate monitoring objectives, resources, and logistics.

Air Quality Index

EPA established the air quality index (AQI) as a simplified tool for communicating daily air quality forecasts and near real-time information. It is intended to help people plan their daily activities. The AQI indicates how clean or polluted air is and what associated health effects might be a concern. It focuses on health effects that may be experienced 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 or PM), carbon monoxide, sulfur dioxide, and nitrogen dioxide.

EPA mainly developed the AQI as a daily indicator or forecast of air quality. To view the real-time AQI for your area, visit http://www.airnow.gov. For more information about local air quality, visit www.pscleanair.gov/27/Air-Quality.

A higher AQI indicates higher levels of air pollution and greater health concern. 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. It's important to note that health effects can be experienced even at "good" or "moderate" levels.

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**

Table 2 shows the percentage of days in each AQI category by county for 2020. The maximum AQI value from all of our network monitors in a county determines its AQI category for the day. Most days were in the "Good" air quality category with some "Moderate" days, some "Unhealthy for Sensitive Groups" days, four wildfire-impacted days that were "Unhealthy" and four wildfire-impacted days that were "Very Unhealthy".

Table 2: Air Quality Index (AQI) Ratings for 2020

	AQI Rating (% of year)					
County	**Good**	**Moderate**	**Unhealthy for Sensitive Groups**	**Unhealthy**	**Very Unhealthy**	**Highest AQI**
King	81.1%	15.1%	2%	1%	1%	238
Kitsap	94.2%	3.3%	1%	1%	1%	221
Pierce	80.5%	16.4%	1.1%	1%	1%	231
Snohomish	80%	17.3%	0.8%	2%	0%	225

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 several components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. PM can be categorized into three broad classes based on size: Coarse—with a diameter of 10 µm or less (PM_{10}); Fine—with a diameter of 2.5 µm or less ($PM_{2.5}$) and Ultrafine—with a diameter of less than 0.1 µm (UFP).

PM_{10}

PM_{10} is particulate matter with a diameter of 10 micrometers (or microns) or less. These particles can include larger particles like dust, and smaller particles ($PM_{2.5}$) that come mainly from combustion sources. Studies show that the finer $PM_{2.5}$ particles have more significant health risks. With levels well below the federal standard for years, the Agency ceased direct PM_{10} monitoring in 2006. For a historic look at the PM_{10} levels in the Puget Sound Region, please request a copy of the 2007 data summary, pages 32-35.[3]

$PM_{2.5}$ Health and Environmental Effects

$PM_{2.5}$ (or fine particulate matter) has a diameter of 2.5 microns or less. 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, 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 reduces visibility 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.

[3] To request a document, please visit www.pscleanair.gov/272/2396/Records-Request

Ultrafine Particulate Matter (UFP)

Emerging health studies indicate that very tiny ultrafine particles with a diameter of 0.1 micron and less may be linked with negative health effects. Currently, there are no health-based standards on what a healthy level of ultrafine particles is. We are exploring new methods for measuring and assessing ultrafine particles, but this technology is not yet ready to add to our core monitoring network.

$PM_{2.5}$: 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 has defined a filter-based method as the federal reference method (FRM)—the primary method used to determine $PM_{2.5}$ concentrations. EPA further defined several federal equivalent methods (FEM), which are continuous instruments operated under specific standard operating procedures. The main advantage of continuous FEMs is to provide PM concentrations at a higher temporal resolution (hourly averages) compare to the FRM (24-hour averages).

The Agency uses the FRM, FEMs, and a nephelometer estimation method to provide data. These methods determine fine particulate matter concentrations differently:

- The FRM involves pulling in air (at a given flow rate) for a 24-hour period and collecting particles with a diameter of 2.5 microns or smaller 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 different FEM instruments used in the network: (1) The tapered element oscillating microbalance-filter dynamic measurement system (TEOM-FDMS), (2) The TEOM 1405F, a newer model that replaced the TEOM-FDMS, and (3) The Met-One BAM, a beta attenuation monitor which uses the attenuation of beta radiation to assess the $PM_{2.5}$ mass on a filter tape.
- The nephelometer measures the scattering of light in a photomultiplier tube; its results are then compared to FRM and FEM method data to produce an estimate of $PM_{2.5}$. While light scattering has been proven to correlate well with direct $PM_{2.5}$ measurements, this is an "unofficial" method because it does not measure particle mass directly.

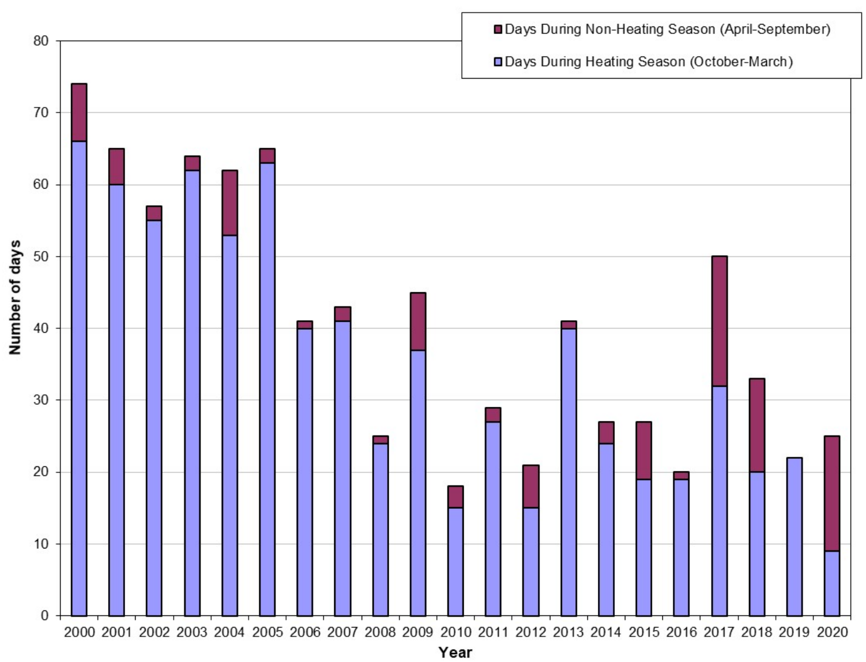
The Agency and Ecology work together on quality assurance to ensure the FEM-generated data are directly comparable to those generated by the reference method.

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

The EPA set a daily health-based fine particle standard of 35 micrograms per cubic meter ($\mu g/m^3$). All monitors in our four counties reported values below this standard in 2020 when days with wildfire smoke are excluded. In addition to the federal standard, our Board of Directors adopted a more stringent health goal of 25 $\mu g/m^3$ in 1999, based on recommendations from our Particulate Matter Health Committee. Monitors in King, Kitsap, Pierce, and Snohomish Counties exceeded the local health goal of 25 $\mu g/m^3$ on 25 days which were during wildfire-impacted days in September and winter months in 2020.

Figure 1 shows the number of days the health goal was exceeded annually in the region, from 2000 to 2020. Our highest fine particulate days overwhelmingly take place during the wildfire smoke days in September and winter wood heating months, when our region exceeded the health goal. However, we have made progress reducing the number of days exceeding the health goal in 2020.

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



Map 2 shows the 98th percentile of the 3-year average of daily $PM_{2.5}$ concentrations from 2018 to 2020. This map incorporates data collected from federal reference, federal equivalent, and nephelometer estimation methods.

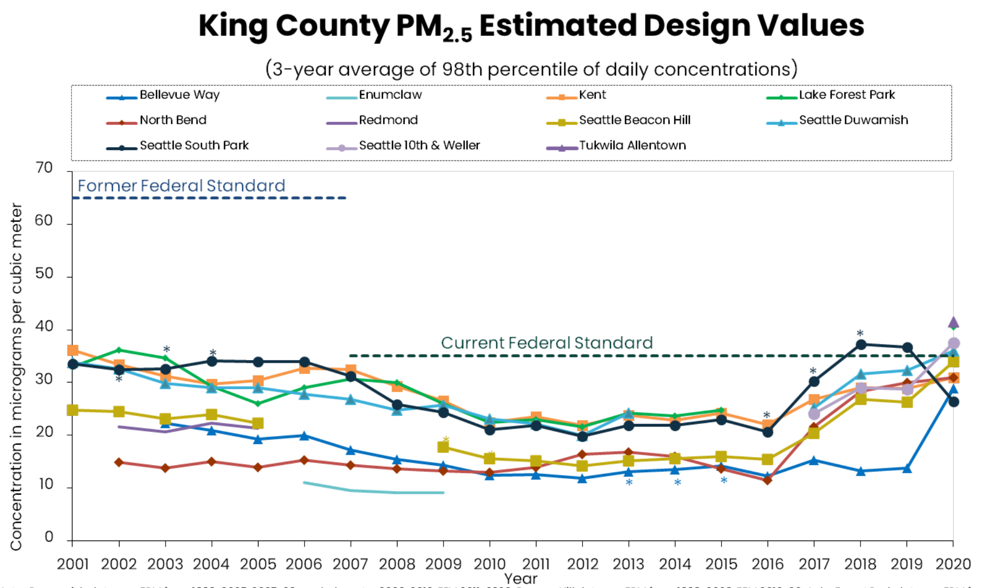
Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2020

Figures 2 through 9 show daily 98th percentile 3-year averages at each monitoring station in King, Kitsap, Pierce, and Snohomish Counties compared to the current daily federal standard. Points on the graphs represent averages for three consecutive years. For example, the value for 2020 is the average of the 98th percentile daily concentration for 2018, 2019, and 2020. These figures incorporate data collected from federal reference, federal equivalent, and nephelometer estimation methods. Due to Covid-19, federal reference monitoring could not be conducted from mid-March to July 2020, hence for these months only federal equivalent and nephelometer monitoring data has been used.

For each county, we include two figures: the first shows the entire dataset, and the second shows levels with wildfire smoke-impacted days removed in 2017, 2018 and 2020. The EPA allows data from days that were influenced by exceptional events that are beyond the ability of air agencies to control, such as wildfires or dust storms, to be excluded from regulatory calculations. There were nine wildfire-impacted days in September 2020. With wildfire smoke-impacted days excluded from 2018 and 2020, all monitors in our four counties fall below the federal standard of 35 $\mu g/m^3$. Without excluding wildfire smoke-impacted days, monitors in King, Pierce and Snohomish Counties equaled or exceeded the standard in 2020.

Figures 4 and 5 do not show any 2012-2014 data for Kitsap County because the Bremerton monitoring site moved to a new location and design values could not be computed until three complete years of data were collected at the new site. Statistical summaries for 98th percentile daily concentrations for 2020 data are provided on pages A-10 through A-12 of the Appendix.

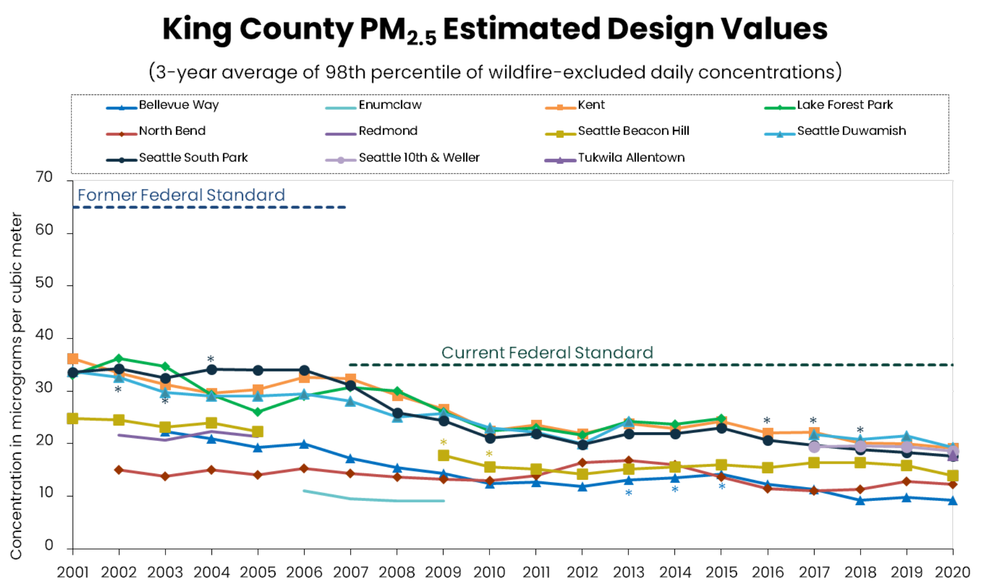
Figure 2: Daily $PM_{2.5}$ Design Values for King County



Note: Duwamish data are FRM from 1999-2005, 2007-09, nephelometer 2006, 2010, FEM 2011-2020 Beacon Hill data are FRM from 1999-2009, FEM 2010-20. Lake Forest Park data are FRM from 1999-2007, nephelometer in 2008-2020. South Park data are FRM from 1999-2004, nephelometer in 2005-2020. Bellevue Way data are FRM from 2001-2004, nephelometer 2005-20. Redmond data are FRM from 2000-2002, nephelometer from 2003-2005. Queen Anne data are nephelometer from 2002-2015. Olive Way data are nephelometer from 2003-2013. North Bend data are FRM from 2000-2004, nephelometer in 2005-2020. Kent data are FRM from 1999-2004, nephelometer in 2005-2010, FEM 2011-2020. Enumclaw data are from nephelometer in 2000-2009.

* Indicates an estimate based on incomplete data. Data less than 75% in a quarter at South Park in 2002 & 2016, Beacon Hill in 2008, Bellevue way in 2013

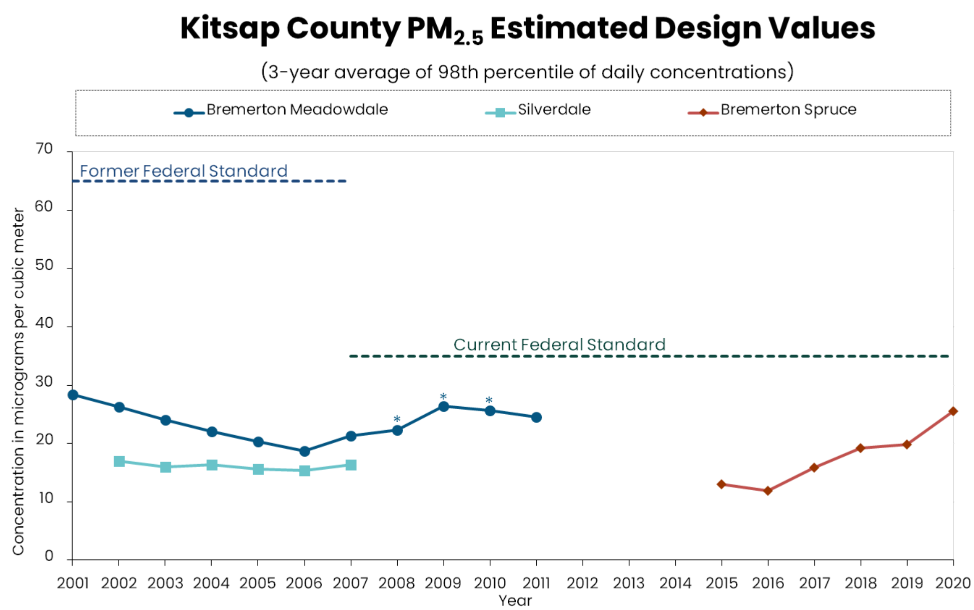
Figure 3: Daily $PM_{2.5}$ Design Values for King County with wildfire-impacted days removed



Note: Duwamish data are FRM from 1999-2005, 2007-09, nephelometer 2006,2010, FEM 2011-2020. Beacon Hill data are FRM from 1999-2009, FEM 2010-20. Lake Forest Park data are FRM from 1999-2007, nephelometer in 2008-2020. South Park data are FRM from 1999-2004, nephelometer in 2005-2020. Bellevue Way data are FRM from 2001-2004, nephelometer 2005-20. Redmond data are FRM from 2000-2002, neph from 2003-2005. Queen Anne data are nephelometer from 2002-2015. Olive Way data are nephelometer from 2003-2013. North Bend data are FRM from 2000-2004, nephelometer in 2005-2020. Kent data are FRM from 1999-2004, nephelometer in 2005-2010, FEM 2011-2020. Enumclaw data are from nephelometer in 2000-2009.

*Indicates an estimate based on incomplete data. Data less than 75% in a quarter at South Park in 2002 & 2016, Beacon Hill in 2008, Bellevue way in 2013

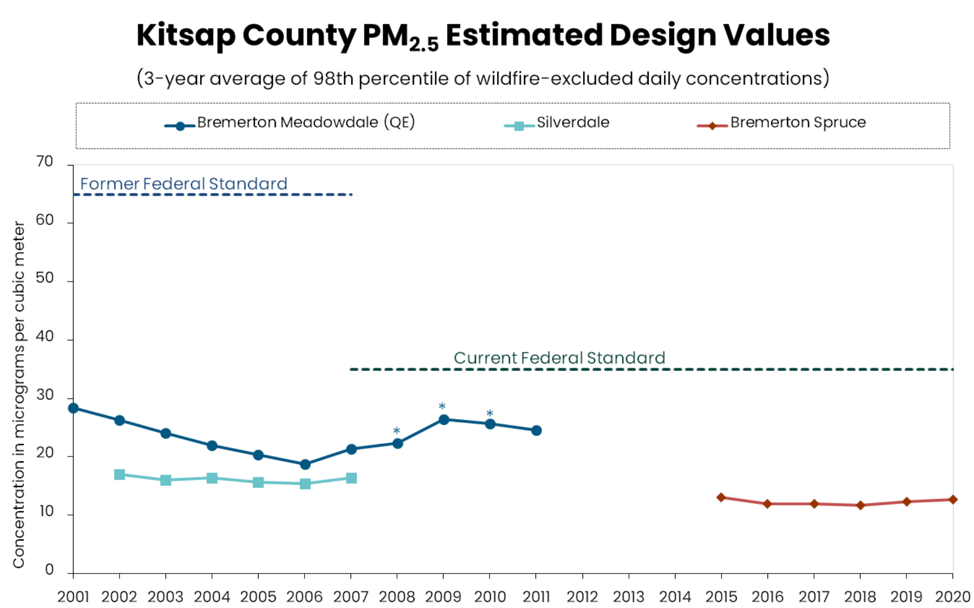
Figure 4: Daily $PM_{2.5}$ Design Values for Kitsap County



Note: Bremerton Meadowdale site ended 4/30/12 and Bremerton Spruce site began 5/1/2012. Bremerton Meadowdale data are nephelometer from 2006-12. Bremerton Spruce data are FEM from 2012-20.

* Indicates an estimate based on incomplete data. Data less than 75% in two quarters at Bremerton Meadowdale in 2008.

Figure 5: Daily $PM_{2.5}$ Design Values for Kitsap County with wildfire-impacted days removed



Note: Bremerton Meadowdale site ended 4/30/12 and Bremerton Spruce site began 5/1/2012. Bremerton Meadowdale data are neph from 2006-12. Bremerton Spruce data are FEM from 2012-20.

* Indicates an estimate based on incomplete data. Data less than 75% in two quarters at Bremerton Meadowdale in 2008.

Figure 6: Daily $PM_{2.5}$ Design Values for Pierce County

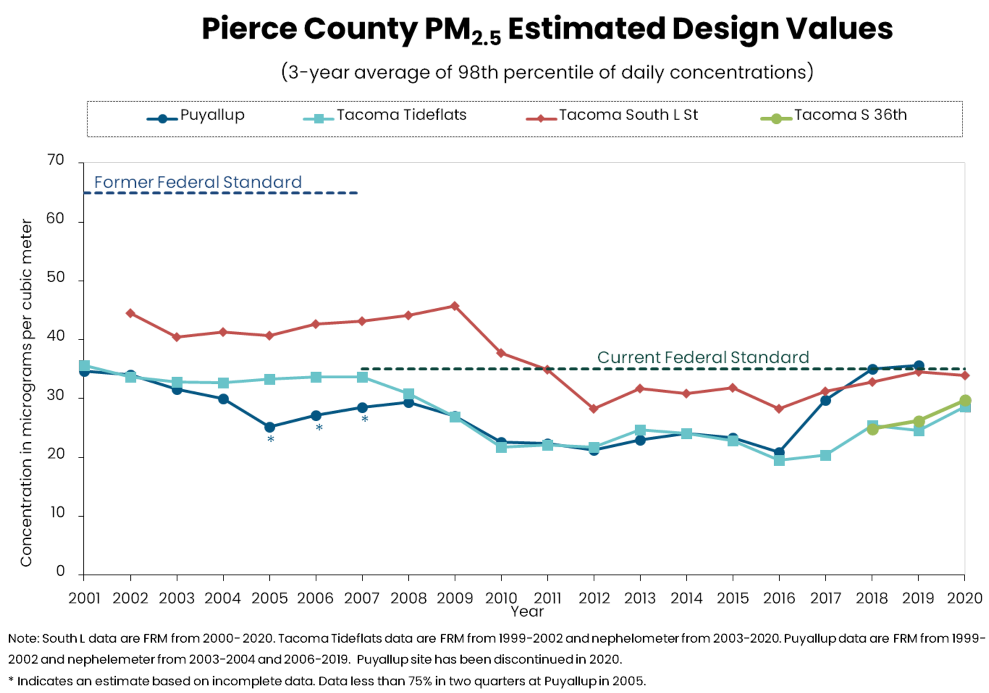


Figure 7: Daily $PM_{2.5}$ Design Values for Pierce County with wildfire-impacted days removed

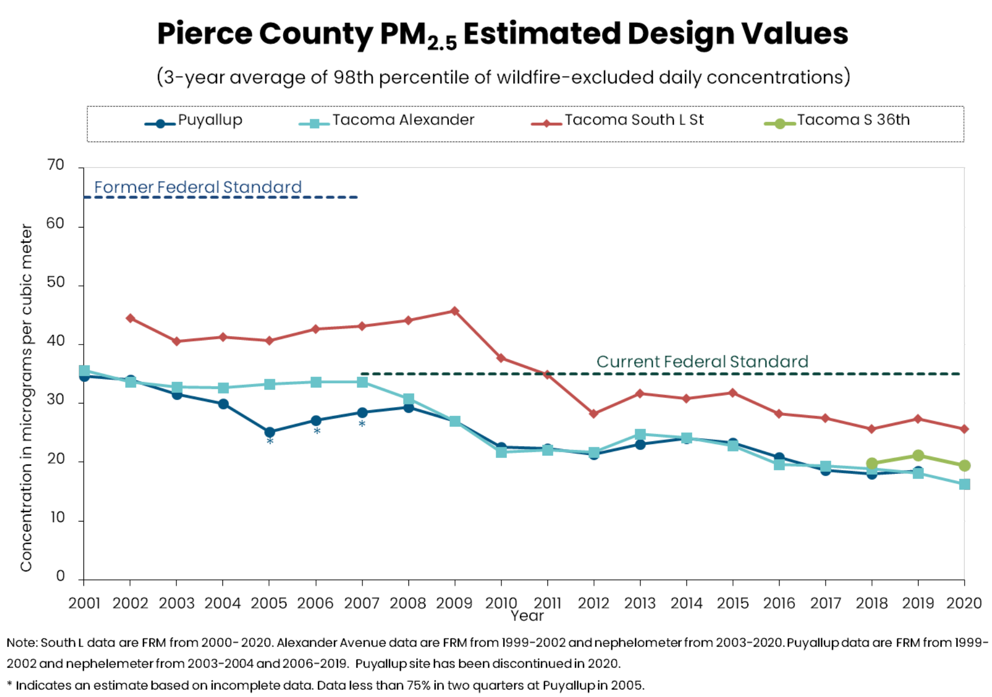
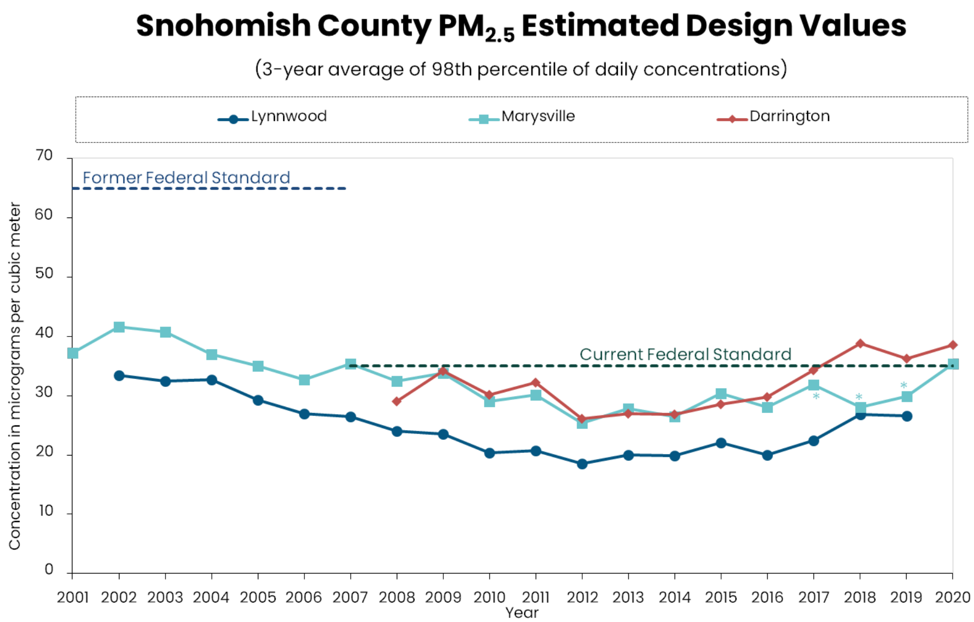


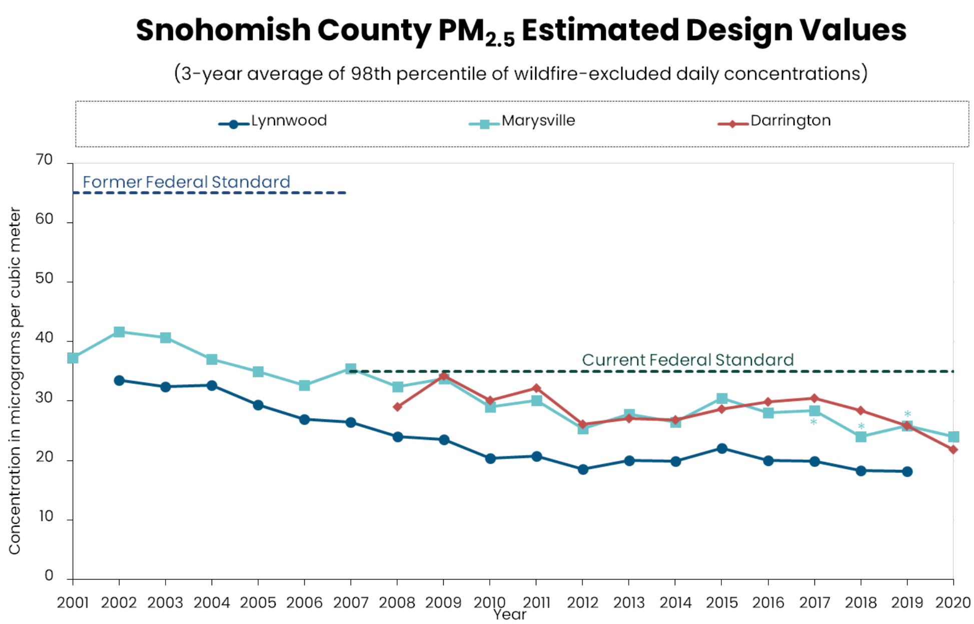
Figure 8: Daily $PM_{2.5}$ Design Values for Snohomish County



Note: Marysville data are FRM 1999-2011, FEM 2012-20. Lynnwood data are FRM 2002-03, 2005-06, Nephelometer 2004, 2007-10, FEM 2011-2016, FEM & Nephelometer combined in 2017, Nephelometer 2018-19. Darrington data are nephelometer in 2006, FRM in 2007-2011, FEM 2012-20. Lynnowood site has been discontinued in 2020.

* Indicates an estimate based on incomplete data. Data less than 75% for a quarter at Marysville in 2017

Figure 9: Daily $PM_{2.5}$ Design Values for Snohomish County with wildfire-impacted days removed



Note: Marysville data are FRM 1999-2011, FEM 2012-20. Lynnwood data are FRM 2002-03, 2005-06, Neph 2004, 2007-10, FEM 2011-2016, FEM & Neph combined in 2017, Neph 2018-19. Darrington data are neph in 2006, FRM in 2007-2011, FEM 2012-20. Lynnwood site has been discontinued in 2020.

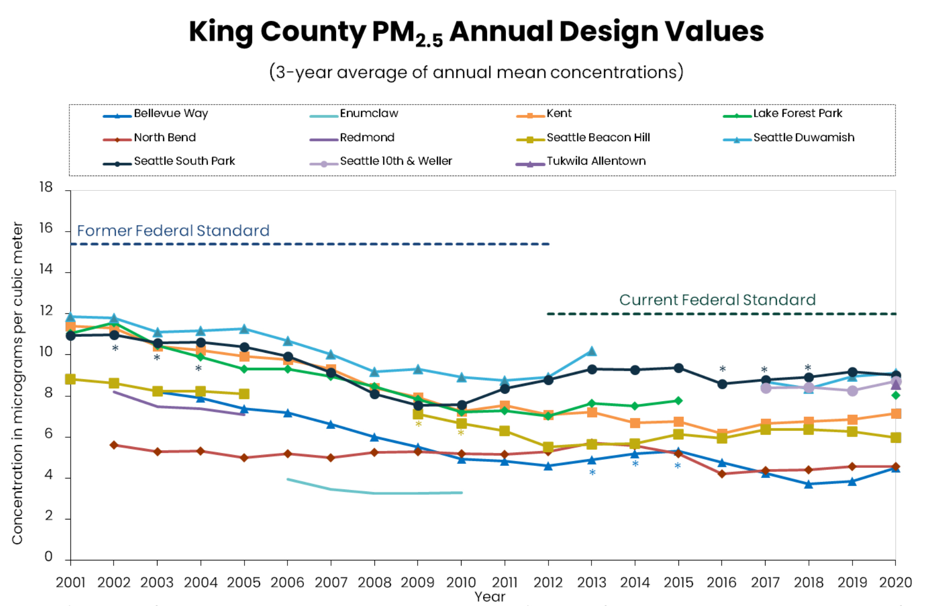
* Indicates an estimate based on incomplete data. Data less than 75% for a quarter at Marysville in 2017.

$PM_{2.5}$ Annual Federal Standard

Figures 10 through 17 present 3-year average of annual concentrations at each monitoring station for King, Kitsap, Pierce, and Snohomish Counties. In 2012, the EPA strengthened the annual standard from 15 $\mu g/m^3$ to 12 $\mu g/m^3$. All counties have levels below the 12 $\mu g/m^3$ annual standard. Figures 12 and 13 do not show any 2012-2014 data for Kitsap County because the Bremerton monitoring site moved to a new location and design values could not be computed until three complete years of data were collected at the new site

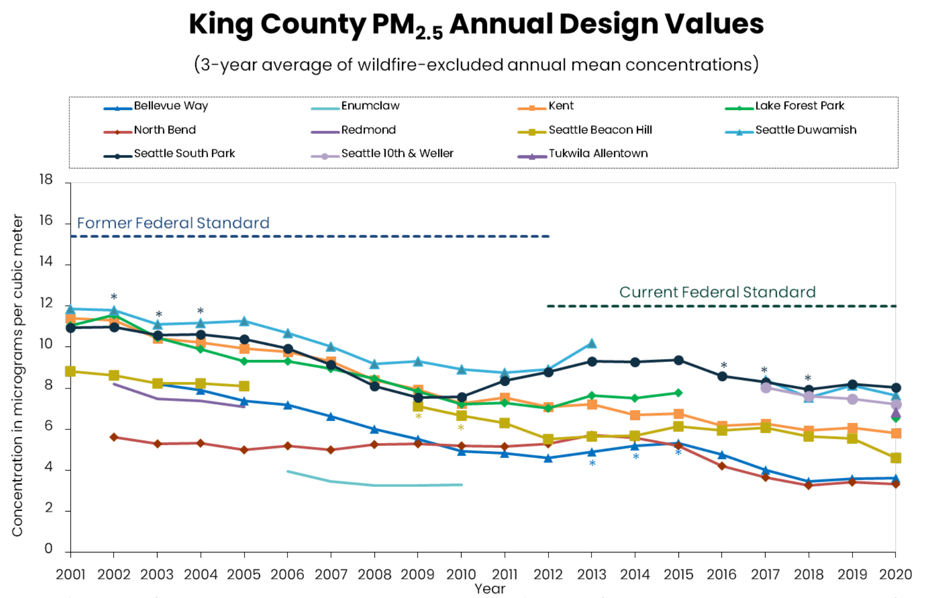
Figures 10 through 17 include data from the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, and each value on the graph is an average of the current year and the two prior years. For example, the value shown for 2020 is the average of the annual averages for 2018, 2019, and 2020. As with the daily standard, for each county we include two figures: the first shows the entire dataset, and the second shows levels with wildfire smoke-impacted days removed in 2017, 2018 and 2020.

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



Note: Duwamish data are FRM from 1999-2005, 2007-09, nephelometer 2006, 2010, FEM 2011-2020. Beacon Hill data are FRM from 1999-2009, FEM 2010-20. Lake Forest Park data are FRM from 1999-2007, nephelometer 2008-2020. South Park data are FRM from 1999-2004, nephelometer 2005-2020. Bellevue Way data are FRM from 2001-2004, nephelometer 2005-20. Redmond data are FRM from 2000-2002, nephelometer 2003-2005. Queen Anne data are nephelometer from 2002-2015. Olive Way data are nephelometer from 2003-2013. North Bend data are FRM from 2000-2004, nephelometer 2005-2020. Kent data are FRM from 1999-2004, nephelometer 2005-2010, FEM 2011-2020. Enumclaw data are nephelometer from 2000-2009.
*Indicates an estimate based on incomplete data. Data less than 75% complete in one quarter at South Park in 2002 & 2016, Beacon Hill in 2008, Bellevue way in 2013

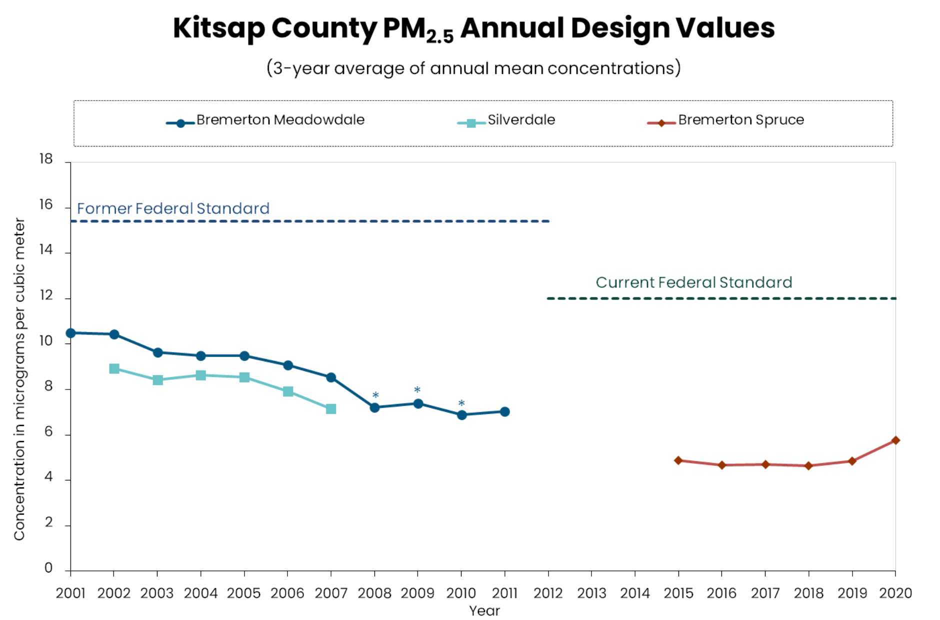
Figure 11: Annual $PM_{2.5}$ Design Values for King County with wildfire-impacted days removed



Note: Duwamish data are FRM from 1999-2005, 2007-09, nephelometer 2006,2010, FEM 2011-2020. Beacon Hill data are FRM from 1999-2009, FEM 2010-20. Lake Forest Park data are FRM from 1999-2007, nephelometer 2008-2020. South Park data are FRM from 1999-2004, nephelometer 2005-2020. Bellevue Way data are FRM from 2001-2004, nephelometer 2005-20. Redmond data are FRM from 2000-2002, nephelometer 2003-2005. Queen Anne data are nephelometer from 2002-2015. Olive Way data are nephelometer from 2003-2013. North Bend data are FRM from 2000-2004, nephelometer 2005-2020. Kent data are FRM from 1999-2004, nephelometer 2005-2010, FEM 2011-2020. Enumclaw data are nephelometer from 2000-2009.

*Indicates an estimate based on incomplete data. Data less than 75% complete in a quarter at South Park in 2002 & 2016, Beacon Hill in 2008, Bellevue way in 2013

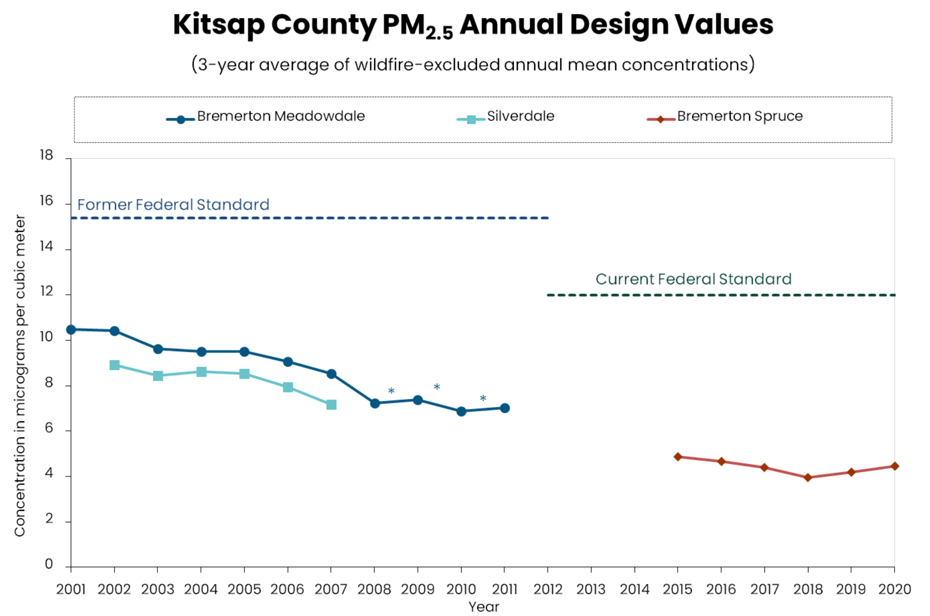
Figure 12: Annual $PM_{2.5}$ Design Values for Kitsap County



Note: Bremerton Meadowdale site ended 4/30/12 and Bremerton Spruce site began 5/1/2012. Bremerton Meadowdale data are nephelometer from 2006-12. Bremerton Spruce data are FEM from 2012-20.

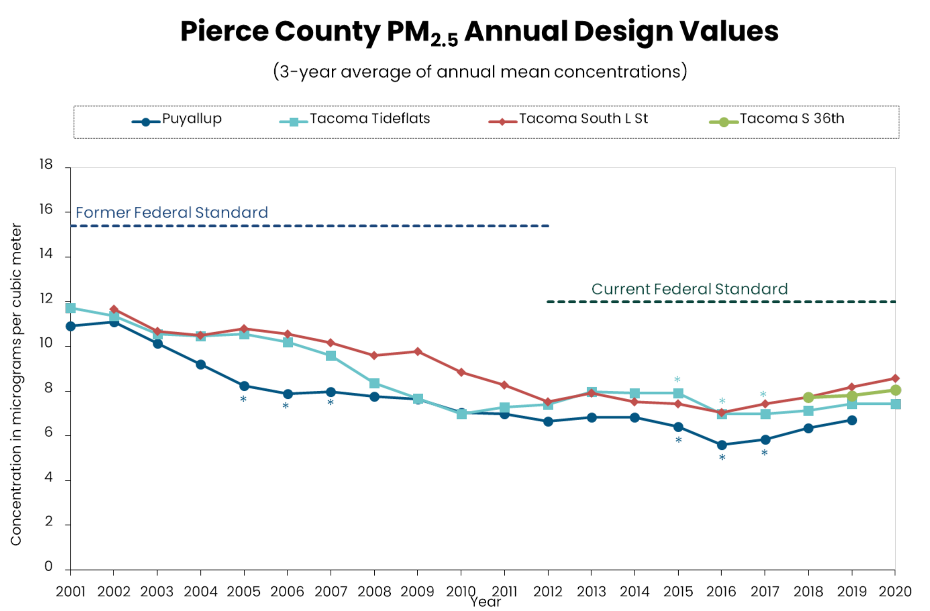
* Indicates an estimate based on incomplete data. Data less than 75% complete in two quarters at Bremerton Meadowdale in 2008.

Figure 13: Annual $PM_{2.5}$ Design Values for Kitsap County with wildfire-impacted days removed



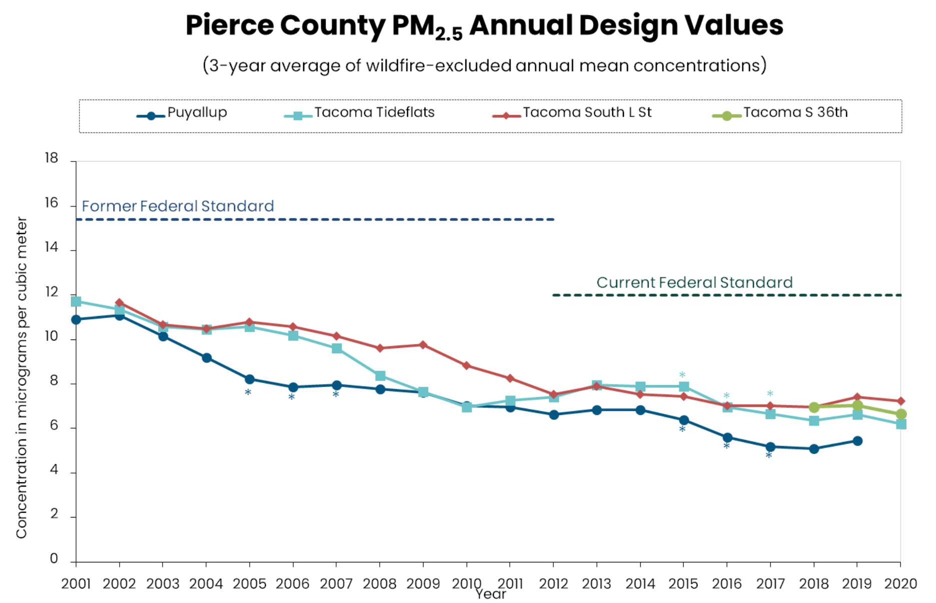
Note: Bremerton Meadowdale site ended 4/30/12 and Bremerton Spruce site began 5/1/2012. Bremerton Meadowdale data are nephelometer from 2006-12. Bremerton Spruce data are FEM from 2012-20.
* Indicates an estimate based on incomplete data. Data less than 75% complete in two quarters at Bremerton Meadowdale in 2008.

Figure 14: Annual $PM_{2.5}$ Design Values for Pierce County



Note: South L data are FRM from 2000-2020. Tacoma Tideflats data are FRM from 1999-2002 and nephelometer from 2003-2020. Puyallup data are FRM from 1999-2002 and nephelometer from 2003-2004 and 2006-2019. Puyallup site has been discontinued in 2020.
* Indicates an estimate based on incomplete data. Data less than 75% complete at Puyallup in two quarters in 2005 & one quarter in 2015, one quarter at Tacoma Tideflats in 2015.

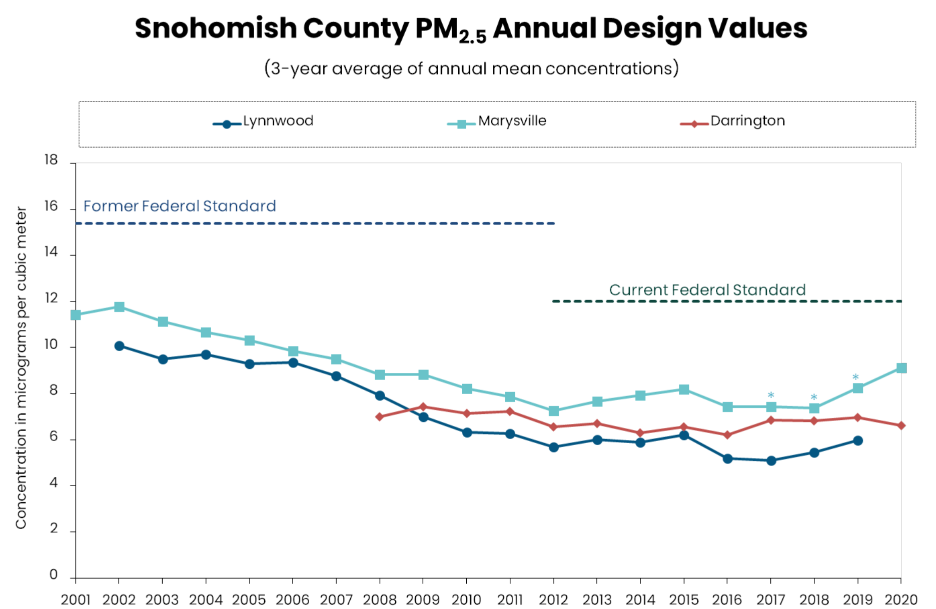
Figure 15: Annual $PM_{2.5}$ Design Values for Pierce County with wildfire-impacted days removed



Note: South L data are FRM from 2000- 2020. Tacoma Tideflats data are FRM from 1999-2002 and nephelometer from 2003-2020. Puyallup data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-2019. Puyallup site has been discontinued in 2020.

* Indicates an estimate based on incomplete data. Data less than 75% complete at Puyallup in two quarters in 2005 & one quarter in 2015, one quarter at Tacoma Tideflats in 2015.

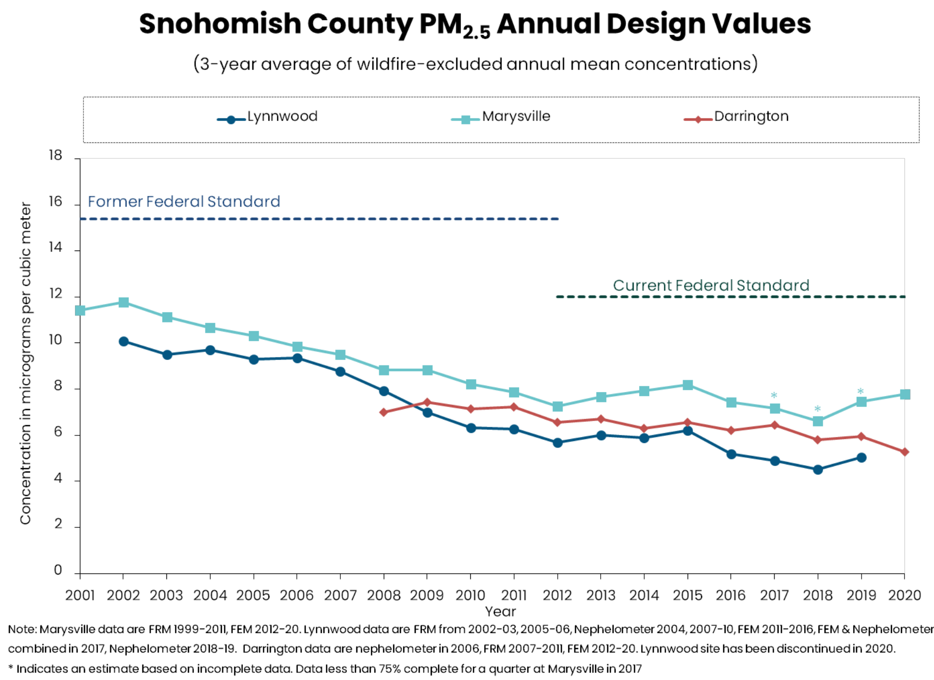
Figure 16: Annual $PM_{2.5}$ Design Values for Snohomish County



Note: Marysville data are FRM 1999-2011, FEM 2012-20. Lynnwood data are FRM 2002-03, 2005-06, Nephelometer 2004, 2007-10, FEM 2011-2016, FEM & Nephelometer combined in 2017, Nephelometer 2018-19. Darrington data are neph in 2006, FRM in 2007-2011, FEM 2012-20. Lynnwood site has been discontinued in 2020.

* Indicates an estimate based on incomplete data. Data less than 75% complete for a quarter at Marysville in 2017

Figure 17: Annual $PM_{2.5}$ Design Values for Snohomish County with wildfire-impacted days removed



$PM_{2.5}$ Continuous Data and Seasonal Variability

Continuous monitoring data provide information on how $PM_{2.5}$ levels vary throughout the year. For example, many sites have elevated $PM_{2.5}$ levels during the winter when residential wood burning and air stagnations are at their peak but have low levels of $PM_{2.5}$ during the summer. A summary of the continuous data for $PM_{2.5}$, black carbon and ozone for the year 2019 is available at https://pscleanair.gov/615/Data-Summary. For more detailed information on continuous data, please see the Air Graphing tool at https://secure.pscleanair.org/airgraphing to plot the sites and timeframes of interest.

PM_{10}: Annual Standard and Modeled Concentrations

Our region was nonattainment for PM_{10} in 1987 in the three industrial areas of Puget Sound: Seattle Duwamish Valley, Tacoma Tideflats, and Kent. The streets were paved, and the area saw significant reductions thereafter and levels were far below the standard since. While the direct monitoring of PM_{10} concentrations ended in 2007, we can still model recent concentration levels of PM_{10} using the observed $PM_{2.5}$ concentrations and two site-dependent linear relationships (one for summer (Apr-Sep) and one for winter (Oct-Mar)). These relationships were established for the 1999-2007 time-period when PM_{10} and $PM_{2.5}$ were recorded simultaneously at our sites. The main assumption with that method is that the linear relationships remained constant over time.[4]

In Table 3, we present the design values (DVs) that have been calculated using both a table-look-up method and a statistical-fit method, described in the EPA PM_{10} State Implementation Plan (SIP) Development Guideline[5]. We did these calculations for the following sites: Kent (AQS Site ID: 53 033 2004), Seattle-Duwamish (53 033 0057), and Tacoma Tideflats (53 053 0031) PM_{10} Maintenance Areas and for the last four years (2017, 2018, 2019 & 2020).

Table 3: Five-year DVs for PM_{10} concentrations for 2017-2020

	5-yr PM_{10} DVs -Scenario 1				5-yr PM_{10} DVs - Scenario 2			
Sites:	2017	2018	2019	2020	2017	2018	2019	2020
Kent	89±25 (82)	115±35 (118)	115±37 (118)	226±98 (214)	54±6 (53)	62±12 (65)	60±13 (64)	54±13 (44)
Seattle	72±11 (80)	119±45 (110)	117±46 (101)	216±104 (192)	53±3 (56)	52±3 (53)	48±4 (48)	46±3 (46)
Tacoma	93±39 (94)	163±69 (165)	163±70 (165)	234±92 (240)	60±16 (55)	60±12 (58)	59±13 (58)	59±14 (57)

Values appear as DV ± an uncertainty interval from a lognormal fit to the data and its 95% prediction interval. Parenthetical values are the DVs obtained using the table-look-up method.[5]

The DVs presented in Table 3 are calculated following two scenarios:

- **Scenario 1**: All daily modeled PM_{10} concentrations are included in the DV calculation.

[4] The $PM_{2.5}$ concentrations come from several instruments at each site. At all sites, we prioritize instruments measuring $PM_{2.5}$ concentrations with missing values in the following way: FEM BAM > 1400ab/8500 FEM TEOM > 1405 FEM TEOM > nephelometer. While Kent and Seattle-Duwamish have the majority of their data coming from TEOM (2013-2018) and BAM (2018-2020), only a nephelometer has been in operation at Tacoma-Tideflats for 2013-2020.

[5] PM_{10} SIP Development Guideline - United States Environmental Protection Agency. June 1987. EPA-450/2-86-001

- **Scenario 2**: Daily modeled PM_{10} concentrations are excluded from the DV calculation during 2017, 2018 & 2020 wildfire-smoke days (I-Flags[6,7,8]).

As part of being in maintenance at these sites, five-year DVs less than 98 µg/m³ are required to continue to qualify for the Limited Maintenance Plan (LMP)[9]. Over the last three years, scenario 1 (with wildfire smoke days included) does not meet this qualification. Scenario 2 does meet the qualification and is a more appropriate estimate for the Puget Sound region's three Maintenance Areas, given the unprecedented wildfire smoke levels witnessed in summers of 2017, 2018 and 2020.

[6] Informational Flag request for 2017 Wildfire Affected Exceedances – WA Dept. of Ecology. Flagging Memo. Feb 2018.
[7] Informational Flag request for 2018 Wildfire Affected Exceedances – WA Dept. of Ecology. Flagging Memo. Feb 2019.
[8] Informational Flag request for 2020 Wildfire Affected Exceedances – WA Dept. of Ecology. Flagging Memo. May 2021.

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 beneficial to know its chemical makeup in addition to its mass. Knowledge about the composition of fine particulate can help guide emissions reduction strategies, such as the Agency's commitment to reducing wood smoke and diesel particulate emissions,[8,9,10] and is useful to scientific and health researchers investigating questions about the effects of fine particulate matter on human health and the environment.

Speciation Monitoring and Source Apportionment

Speciation monitoring involves determining the chemical composition of fine particulate matter collected on different types of filters. Speciation filters are analyzed to determine what metals and organic molecules make up the fine particulate at a site. Over 40 chemical 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 and PSCAA conducted speciation monitoring at five sites in the Puget Sound region in 2020:

- Seattle Beacon Hill – typical urban impacts, mixture of sources (speciation samples collected every third day, operated by Ecology)
- Seattle 10th & Weller – Near-road micro-scale monitoring site (speciation samples collected every sixth day, operated by Ecology)
- Seattle Duwamish – urban site with industrial sources (speciation samples collected every sixth day, operated by PSCAA)
- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day, operated by Ecology)
- Tacoma Tideflats - urban site with industrial sources (speciation samples collected every sixth day, operated by Ecology)

---

[8] Puget Sound Air Toxics Evaluation, October 2003. www.pscleanair.org/DocumentCenter/View/2355/Puget-Sound-Air-Toxics-Evaluation-Final-ReportPDF?bidId=

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

[10] Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley $PM_{2.5}$ Nonattainment Area". Publication Number 10-02-009. https://fortress.wa.gov/ecy/publications/documents/1002009.pdf

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 page A-13 of the Appendix.

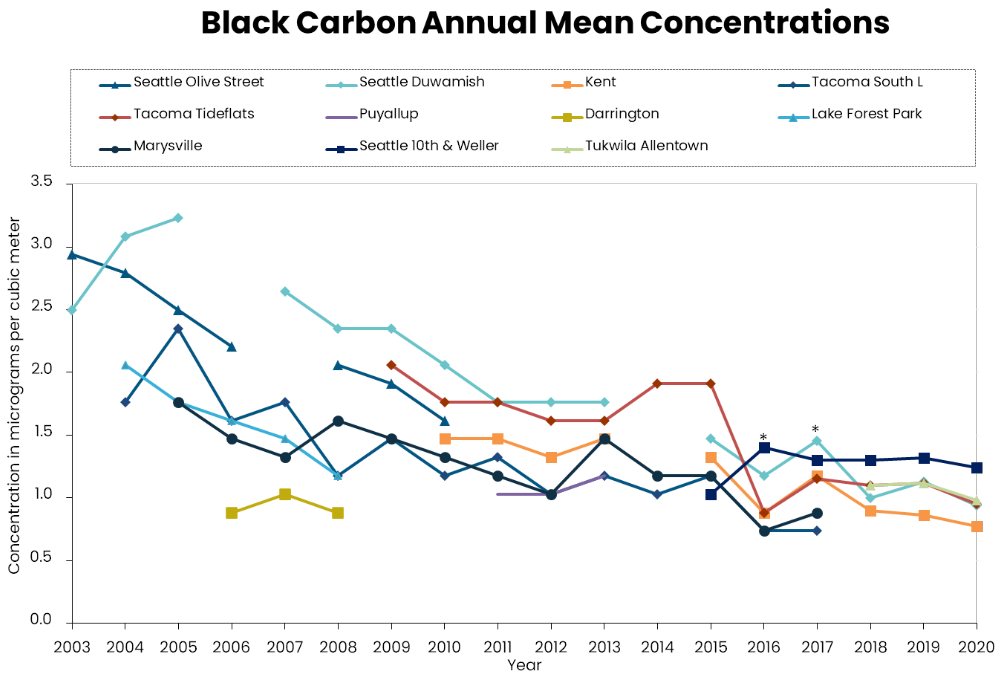
Aethalometer Data

Aethalometers provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption at seven different optical wavelengths to estimate carbon concentrations. Two of these wavelengths are important in our evaluation: black carbon (BC) and ultraviolet (UV). Measurements from the black carbon channel correlate well with elemental carbon (EC) concentrations derived from speciation data. Measurements from the UV channel help produce a qualitative estimate of organic carbon (OC), which is correlated with the difference between the UV and BC channel measurements (UV-BC). Elemental and organic carbon are related to diesel particulate, wood smoke particulate, and particulate from other combustion sources.[11] Unfortunately, neither is uniquely attributed to a particular combustion type, so the information gained from aethalometer data is qualitative.

The Agency maintains aethalometers at monitoring sites with high particulate matter concentrations, as well as sites with speciation data, so that data from the different methods to measure carbon may be compared. Figure 18 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-14 of the Appendix.

[11] Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer Carbon Measurements for the Seattle Metropolitan Area. https://www3.epa.gov/ttnamti1/archive/files/ambient/samwg/spring2004/awmaurb.pdf

Figure 18: Annual $PM_{2.5}$ Black Carbon



*Data less than 75% in a quarter at Seattle 10th & Weller in 2016, and Seattle Duwamish in 2017.

Ozone

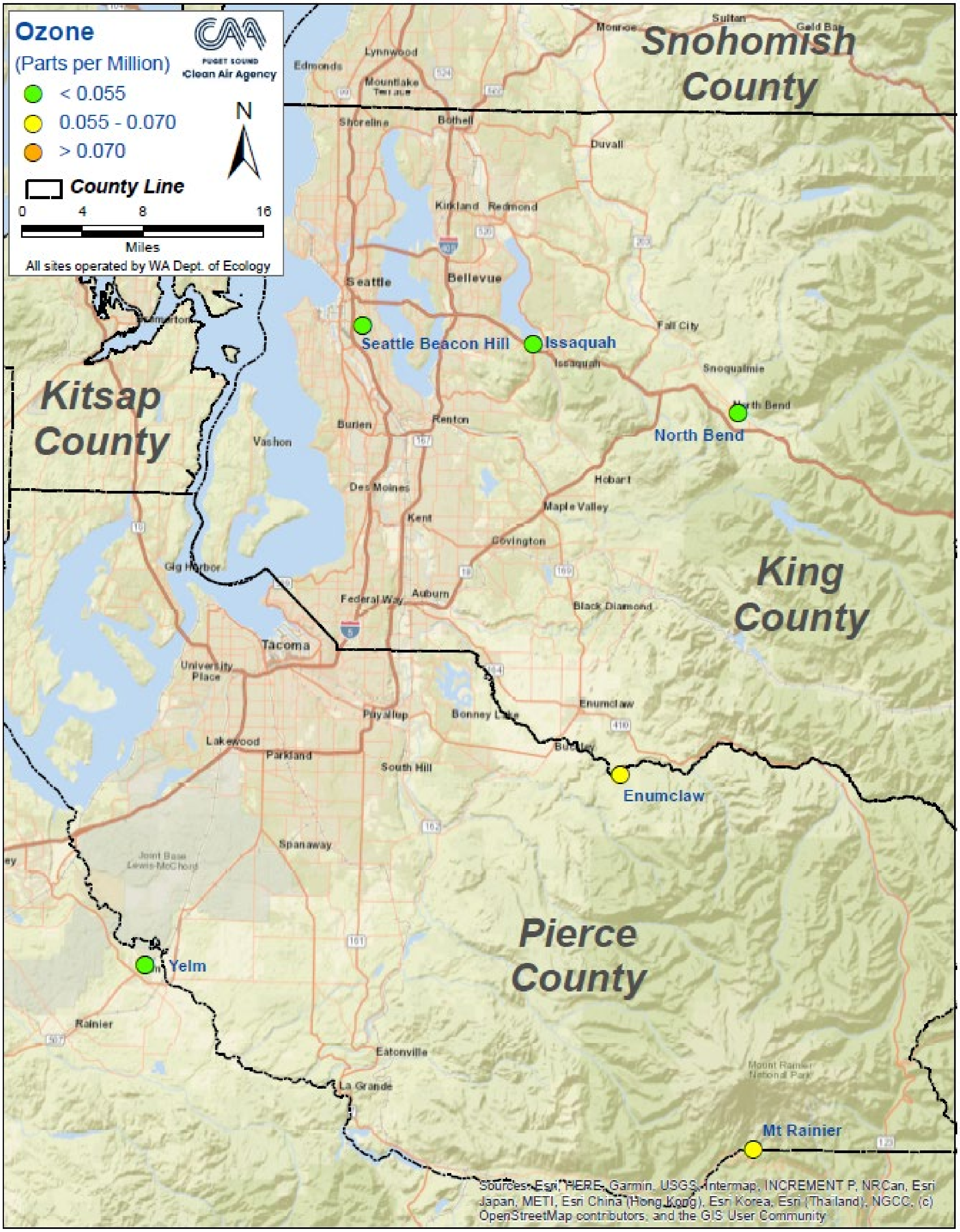
Ozone is a summertime air pollution problem in our region and is not directly emitted by pollutant sources. Ozone forms when photochemical pollutants react with sunlight. These pollutants are called ozone precursors and include volatile organic compounds (VOC) and nitrogen oxides (NO_x), with some influence by carbon monoxide (CO). These precursors come from human activities such as transportation and solvent use, as well as natural sources. 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 ozone monitoring in our four counties.

People sometimes confuse upper atmosphere ozone with ground-level ozone. Upper atmosphere, or 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.[12] Ozone has also been linked to immune system impairment. 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.[13]

Most ozone monitoring stations are located in rural areas of the Puget Sound region in the western foothills of the Cascade Mountains, while 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, and 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. Map 3 shows the ozone monitoring network and the highest concentrations measured in 2020.

[12] EPA, Air Quality Index: A Guide to Air Quality and Your Health; epa.gov/airnow/aqi_brochure_02-14.pdf.
[13] 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 2020



Figures 19 and 20 present data for each monitoring station and the 8-hour federal standard. Figure 19 shows levels with the entire dataset, and Figure 20 shows ozone levels with wildfire smoke impacted days removed in 2017, 2018 and 2020. The federal standard is based on the 3-year average of the annual 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 2020 are an average of 2018, 2019, and 2020 4th highest concentrations.

The EPA's 2015 8-hour standard is 0.070 ppm. The highest 2020 site design value (for the entire dataset, including wildfire smoke impacted days) is 0.063 ppm at the Enumclaw site. All the monitoring sites are below the standard value of 0.070 ppm.

Statistical summaries for 8-hour average ozone data are provided on page A-15 of the Appendix.

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

Figure 19: Ozone for Puget Sound Region

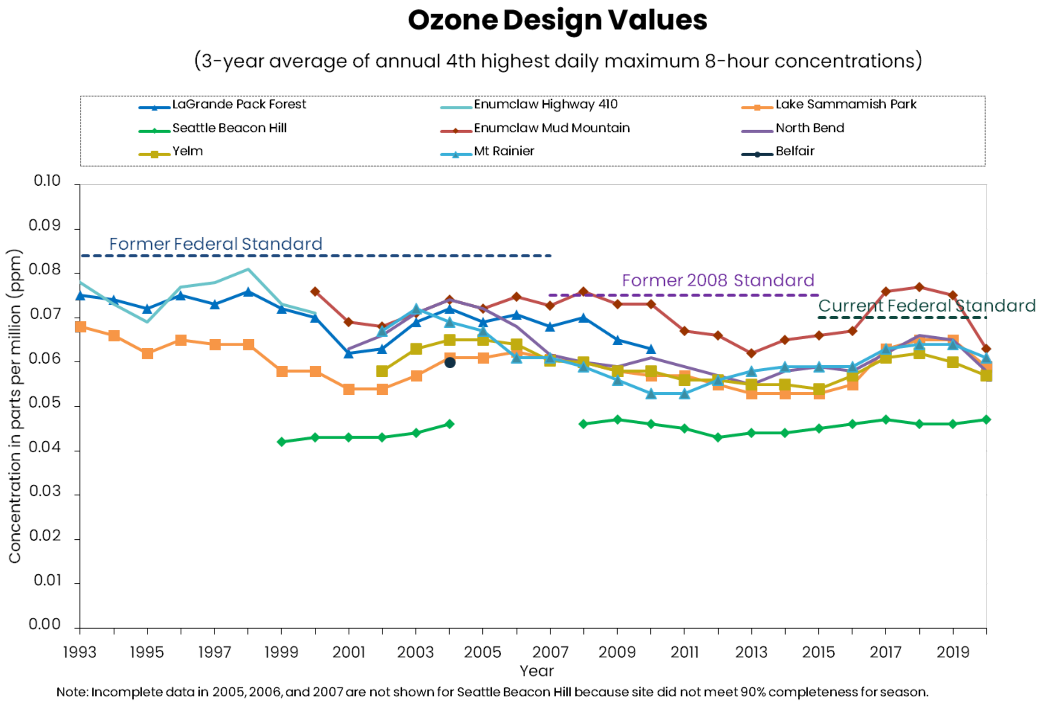
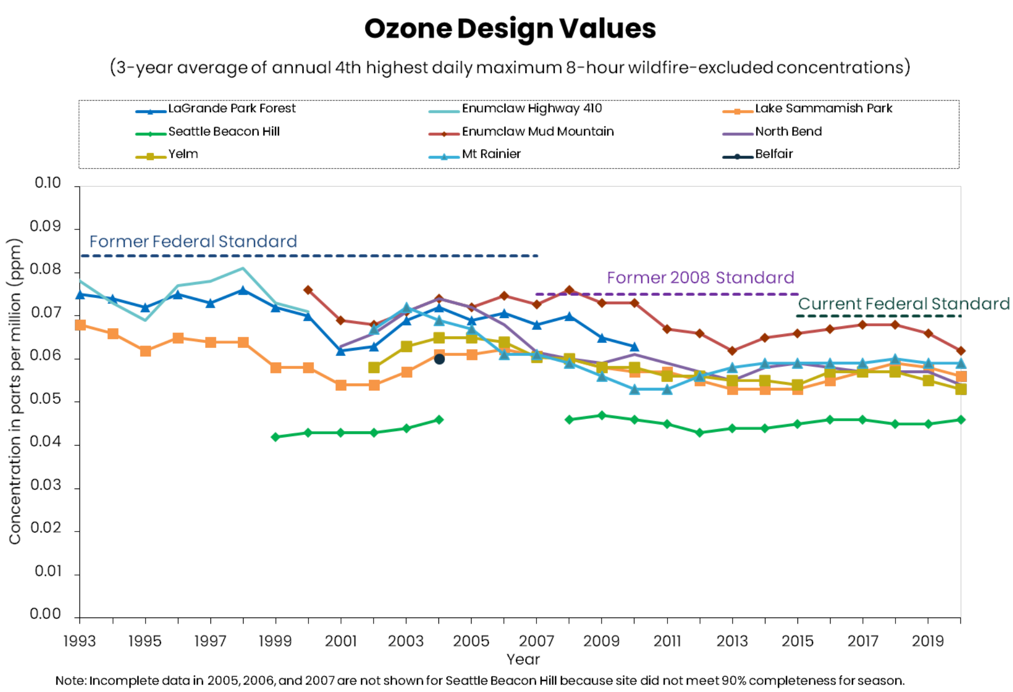


Figure 20: Ozone for Puget Sound Region with wildfire impacted days removed



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.[14] 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 in our region. 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 declined dramatically since the 1970s.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010.[15] Since then, Department of Ecology added two "near-road" monitoring sites very close to Interstate 5: one in Seattle (10th & Weller), and one in Tacoma (South 36th St.). To learn more about the monitoring method visit https://www3.epa.gov/ttn/amtic/nearroad.html

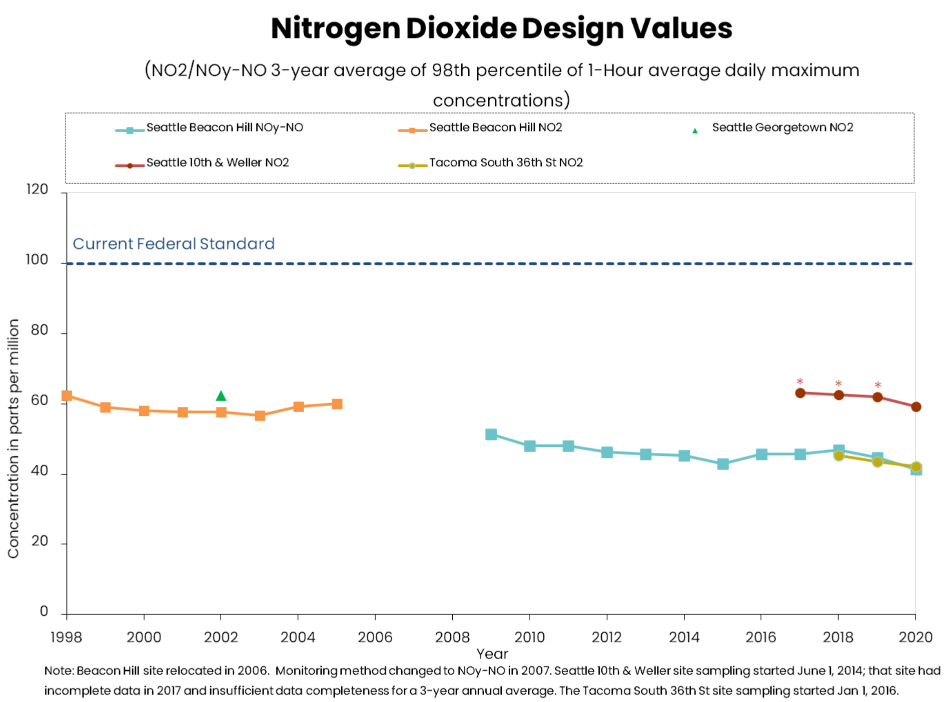
In addition to the near-road sites, the Department Ecology measures nitrogen dioxide at the Seattle Beacon Hill site. The monitoring method now records NO_y instead of NO_x, in order to observe all reactive nitrogen compounds. NO_y is NO_x plus all other reactive nitrogen oxides present in the atmosphere. 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.

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

Figure 21 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.

The 2010 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 21 with historical data since 1998. The years prior to 2010 have been included on the graphs for historical comparison.
Visit epa.gov/airquality/nitrogenoxides/ for additional information on NO_2.

Figure 21: Nitrogen Dioxide (NO_2) (1998-2005) and Reactive Nitrogen (NO_y – NO) (2007-2020) for the Puget Sound Region



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. Most of the 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 have 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. There currently are no CO monitoring stations in Kitsap, Pierce, or Snohomish Counties.

The CO national ambient air quality standard is based on the 2nd highest 8-hour average using the procedures published in the federal register. The EPA also has 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 typically much lower than the 35 ppm standard.

For a historic look at the Puget Sound region's carbon monoxide levels, please see the 2015 Air Quality Data Summary which is available on our website at www.pscleanair.gov/DocumentCenter/View/2294/Air-Quality-Data-Summary-2015PDF.

For additional information on CO, visit epa.gov/airquality/carbonmonoxide.

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, the symptoms of which 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.

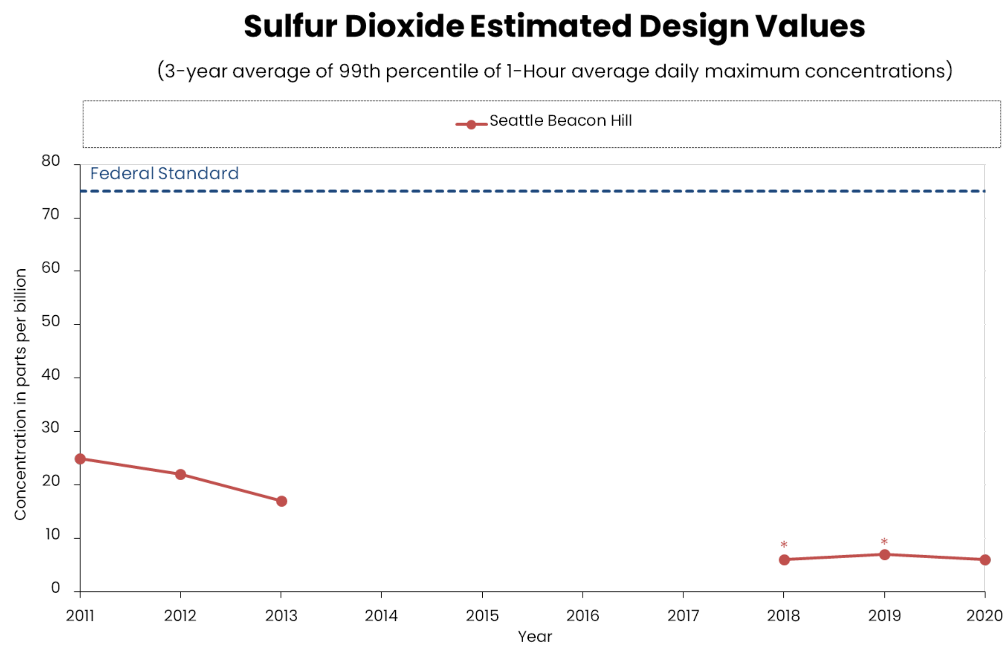
In 1971, the EPA set an annual SO2 standard of 0.03 ppm and a 24-hour standard of 0.14 ppm that could not be exceeded more than once a year. EPA changed the SO_2 standard in June of 2010 to a shorter-term (1-hour) standard of 0.075 ppm (75 ppb) and revoked the former annual and daily average standards. 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 99th percentile of the daily 1-hour maximum concentrations. Levels must be below 75 ppb. Sulfur dioxide levels at the Seattle Beacon Hill site have been below the 2010 standard from 2011-2020.

Figure 22 shows the maximum 3-year average of the 99th percentile of 1-hour maximum concentrations at Beacon Hill which have stayed within the standard.

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

Figure 22: 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.
* Indicates an estimate based on incomplete data. Data less than 75% for a quarter at Beacon Hill in 2016 & 2017.

Lead

Lead is a highly toxic metal that was used for many years in household products such as paints, transportation fuel, and industrial chemicals. Now that lead has been banned from paint and most fuels, the greatest sources of lead emissions, nationally, are industrial processes (particularly primary and secondary lead smelters) and battery manufacturers. And while lead has been removed from fuel for large aircraft, lead found in aviation gasoline (avgas), used by small aircraft, remains a concern nationally.

People and animals are mainly exposed to lead by breathing it in 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.

Since the phase-out of lead in most fuels and the closure of the Harbor Island secondary lead smelter in Seattle in 1984, 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 on request.

In October 2008, EPA strengthened the lead standard from 1.5 µg/m^3 to 0.15 µg/m^3 (rolling three-month average).[16] 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. Results are available here: https://fortress.wa.gov/ecy/publications/SummaryPages/1302040.html. EPA maintained this level in its 2016 review of the lead standard.

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

[16] 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 in miles or kilometers, at which a black object is visible 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 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 and can be transported aloft and may remain suspended for a week or longer. Figures 23 and 24 show visibility for the overall Puget Sound area, as well as 12-month moving average for 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-12 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 2020, the 12-month moving average increased from 47 miles to 90 miles.

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

Figure 23: Puget Sound Visibility

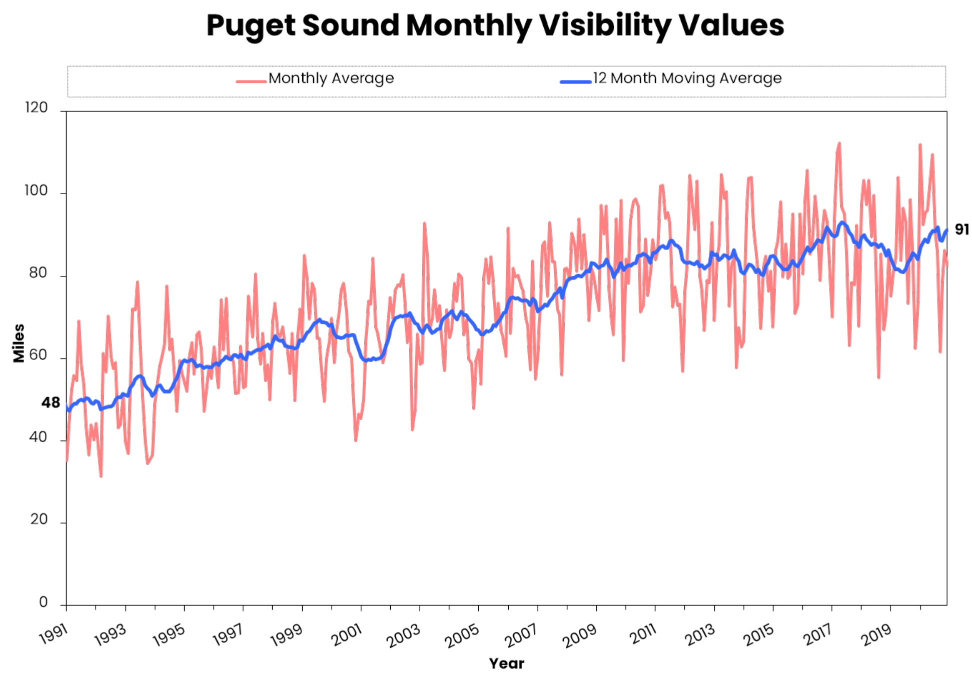
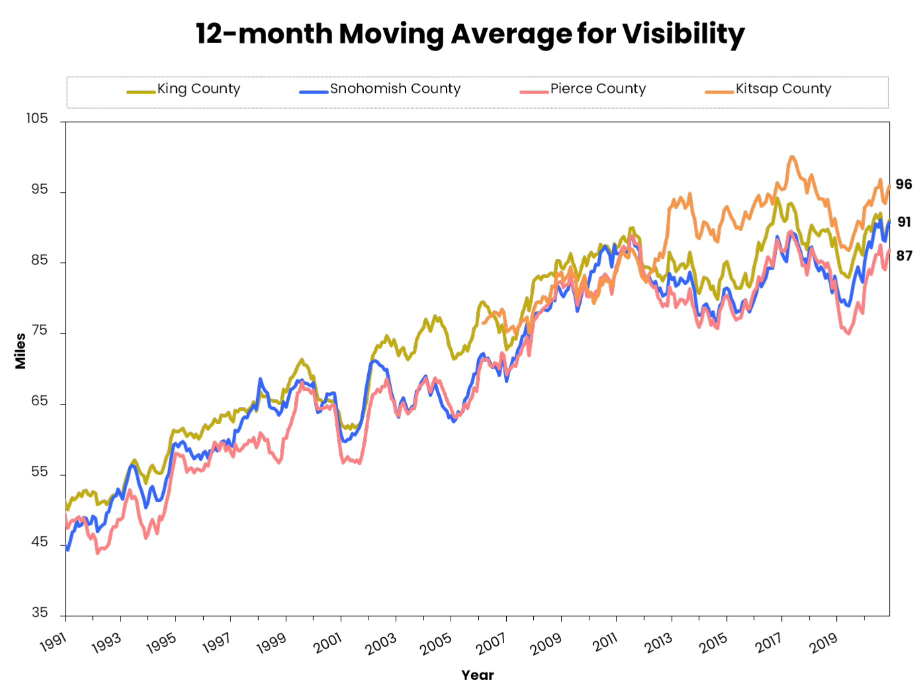


Figure 24: County-wise Visibility



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.[17,18] The Agency considers over 400 different air pollutants air toxics.

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

Ecology monitors for air toxics at the Seattle Beacon Hill site. The Beacon Hill site is one of 27 EPA-sponsored National Air Toxic Trends Sites across the country.[19] 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 www.pscleanair.gov/162/Air-Toxics. Air toxics statistical summaries are provided starting on page A-16 of the Appendix.

Relative ranking based on cancer risk & unit risk factors

Table 4 below ranks 2020 air toxics from the Seattle Beacon Hill monitoring site according to mean potential cancer risk per million people. 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 or carcinogenic a pollutant is. Cancer risk estimates are shown here to provide a meaningful basis of comparison between pollutants and are not intended to represent any one community's or individual's exposure.

Since the release of the 2018 Air Quality Data Summary, Ecology released an updated list of cancer risk factors, known as the Ambient Source Impact Level (ASIL) table.[20] The main reason for this update was to align the ASIL table with the latest scientific data. Ecology does not determine the unit risk factors that are the basis of the table, but rather uses values from three authoritative sources:

[17] US EPA, Hazardous Air Pollutants: https://www.epa.gov/haps.
[18] US EPA, Risk Assessment for Toxic Air Pollutants: A Citizen's Guide: https://www3.epa.gov/airtoxics/3_90_024.html.
[19] https://www3.epa.gov/ttnamti1/natts.html
[20] Washington Administrative Code Section 173-460-150; https://apps.leg.wa.gov/wAc/default.aspx?cite=173-460-150

the EPA's Integrated Risk Information System (IRIS); the California Office of Environmental Health Hazard Assessment (OEHHA), and the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). Many unit risk factors were updated by these agencies between the last ASIL update, in 2009, and 2019, leading to sometimes significant changes in the predicted risk. In some cases, the predicted risks have increased, such as with ethylene oxide, while in others, they have decreased, such as with carbon tetrachloride. These changes do not mean that the inherent risk of these pollutants has changed, but rather that our scientific understanding of the risk has improved, and we now have better estimates of their carcinogenicity.

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 threshold of one in one million is commonly used as a screening value and is used here.[21]

For details on how air toxics were ranked, please see page A-17 in the Appendix.

In 2020, the air toxics sampling could not be conducted from mid-March to July due to COVID-19. Hence, the annual average data for 2020 is the average of only seven months and doesn't include some summer samples. Risks presented in this table are based on annual average ambient (outside) concentrations. Risks based on 95th percentile concentrations (a more conservative statistic than presented in Table 4) are presented on page A-18 of the Appendix. Page A-18 also lists the frequency (percentage) of samples that were over the cancer screening level of one in a million risk.

[21]US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, Version 2, October 2010; https://www.epa.gov/sites/production/files/2020-01/documents/air_1_-preliminary_risk-based_screening_approach_p1009a7c.pdf

Table 4: 2020 Beacon Hill Air Toxics Ranking

(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk[a]
Ethylene oxide	1	502
Formaldehyde	2	7
Benzene	3	5
Hexavalent Chromium	3	5[b]
Arsenic (PM_{10})	4	2
1,3-Butadiene	5	2
Acetaldehyde	6	2
Carbon tetrachloride	7	3
Chloroform	8	2
Naphthalene	9	1
Ethylene dichloride	10	2
Acrolein	11	1
Tetrachloroethylene	12	< 1
Ethylbenzene	13	< 1
Cadmium (PM_{10})	14	<1
Nickel (PM_{10})	15	<1

[a]Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level Table, 2019 update (WAC 173-460-150)[22]

[b]Sampling for hexavalent chromium was discontinued in 2013 and the included estimate is based on 2013 data using 2019 ASILs.

PM_{10} = fine particles less than 10 micrometers in diameter

Two of the air toxics that present the greatest 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

[22]Washington State Administrative Code WAC 173-460-150, apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150

report, however, the Agency has estimated the cancer risk for these parameters in recent studies.[23,24] Diesel Exhaust risk estimates can range from 400-600 per million in near-road and industrial areas.

---

[23] Puget Sound Clean Air Agency. 2010. Tacoma and Seattle Area Air Toxics Evaluation. https://www.pscleanair.gov/DocumentCenter/View/2361

[24] Puget Sound Clean Air Agency. 2018. Near-road air toxics study in the Chinatown-International District. https://www.pscleanair.gov/DocumentCenter/View/3398/Air-Toxics-Study-in-the-Chinatown-International-District-Full-Report

Health effects other than cancer

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

To determine non-cancer health risks, we compared each air toxic to its chronic reference exposure level, as established by California EPA (the most comprehensive dataset available)[25]. A chronic reference exposure level (chREL) is considered a safe level of continuous exposure to an individual air toxic for non-cancer health effects.

Only one air toxic, acrolein, failed the screen for non-cancer chronic health effects, with measured concentrations consistently exceeding the chREL. Acrolein irritates the lungs, eyes, and nose, and is a combustion by-product.[26] A table of reference concentrations and hazard indices for each air toxic measured in the last year with a hazard index greater than zero is on page A-19 of the Appendix. A hazard index is the concentration of a pollutant (either mean or other statistic) divided by the reference concentration. Typically, no adverse non-cancer health effects for that pollutant are associated with a hazard index less than 1, although it is important to consider that people are exposed to many pollutants at the same time. We did not explore acute non-cancer health effects, which are based on 1-hour measurements, because the Beacon Hill air toxics measurements are made on 24-hour samples.

Air toxics trends

Trends in annual average cancer risks are shown on the following pages for the highest-ranked air toxics measured at Seattle Beacon Hill from 2000 to 2020. For many air toxics, our analysis of the trends shows a statistically significant decrease in annual average concentrations. We do not show a trend analysis for acrolein and ethylene oxide because they have significant measurement uncertainty, and any potential trend is likely within the margin of error of the measurement. [27]

In 2020, the air toxics sampling could not be conducted from mid-March to July due to COVID-19. Hence, the annual average data for 2020 is the average of only seven months and doesn't include some summer samples.

[25] https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary
[26] EPA, Acrolein Hazard Summary; https://www.epa.gov/sites/production/files/2016-08/documents/acrolein.pdf.
[27] EPA, Schools Monitoring Acrolein Update, https://www3.epa.gov/air/sat/pdfs/acroleinupdate.pdf.

EPA has not set ambient air standards for air toxics, so graphs do not include reference lines for federal standards. A statistical summary of the trends shown on the following pages can be found on page A-20 of the Appendix.

Ethylene Oxide

The EPA lists ethylene oxide as a known human carcinogen. Ethylene oxide inhalation is associated with increased risk of blood cancers and of breast cancer in women.[28] Its main use is as a chemical intermediate in the production of ethylene glycol (antifreeze), but it is also used as a fumigating agent for spices and cosmetics, and a sterilizing agent for medical supplies. Ethylene oxide's 2020 average potential cancer risk estimate at Seattle Beacon Hill was 770 in one million.

This is the second year that ethylene oxide has appeared on the Agency's list of highest-ranked air toxics. There are two reasons for this change. First, it was added to the suite of air toxics measured at Beacon Hill mid-year in 2018. Second, its ASIL value became more stringent by a factor of 57 (from 0.0114 to 0.0002). The change in the ASIL value resulted from a 2016 update to the EPA's unit risk factor for ethylene oxide, the first update to this value since 1985. The large magnitude of the increase reflects the fact that scientific understanding of the cancer risks of ethylene oxide advanced significantly in 30 years.

In 2019, ethylene oxide sampling (October 2018-March 2019) across the country showed that the Seattle Beacon Hill monitor was one of the lowest across the country.[29] In 2020, the values have reduced further at Seattle Beacon Hill site. As the ASIL is well below the detection limit, and most samples are near detection (including 62% below detection) the annual average value has a significant degree of uncertainty (well over 100 per million potential cancer risk).

The Agency is working alongside the EPA to determine key sources of ethylene oxide and reduction strategies.[30] We do not show a trend analysis for ethylene oxide both because there is only two years of data and there is significant measurement uncertainty.

---

[28] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/ethylene-oxide.pdf

[29] EPA 2019. Map of NATTS/UTAMP Sites. https://www.epa.gov/sites/production/files/2019-11/documents/map_of_natts_uatmp.pdf

[30] EPA 2020. EPA's Work to Understand Background Levels of Ethylene Oxide. https://www.epa.gov/sites/production/files/2020-09/documents/background_eto_monitoring.september_2020.pdf

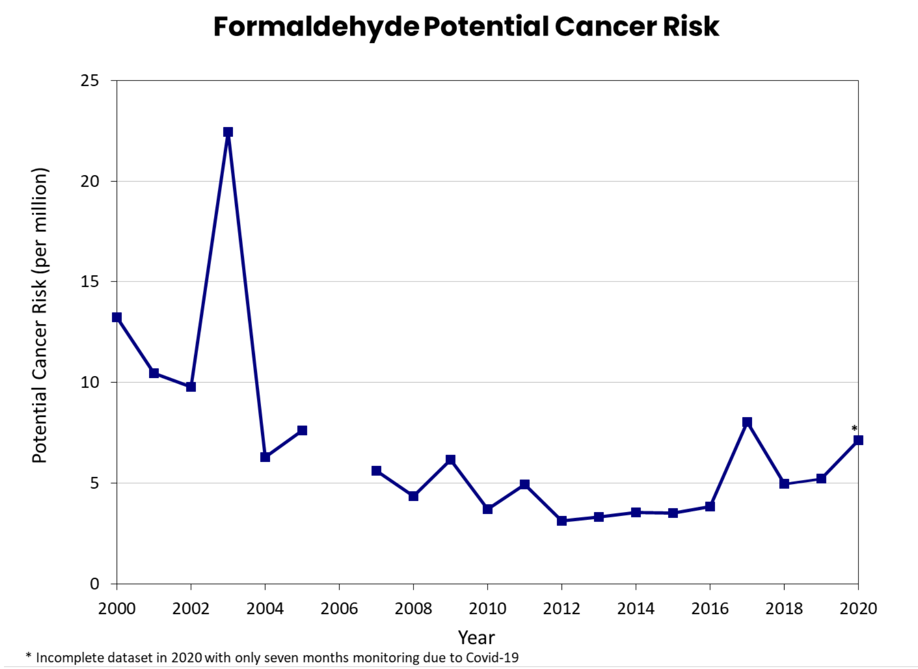
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat, and lung irritation.[31] Sources of ambient formaldehyde include automobiles, trucks, wood burning and other combustion. Formaldehyde's 2020 average potential cancer risk estimate at Beacon Hill was 7 in one million.

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

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce formaldehyde emissions. Since 2000, we have found a statistically significant drop in risk from formaldehyde at an average rate of about 0.5 per million per year; however, the risk has been increasing in the recent years.

Figure 25: Formaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020



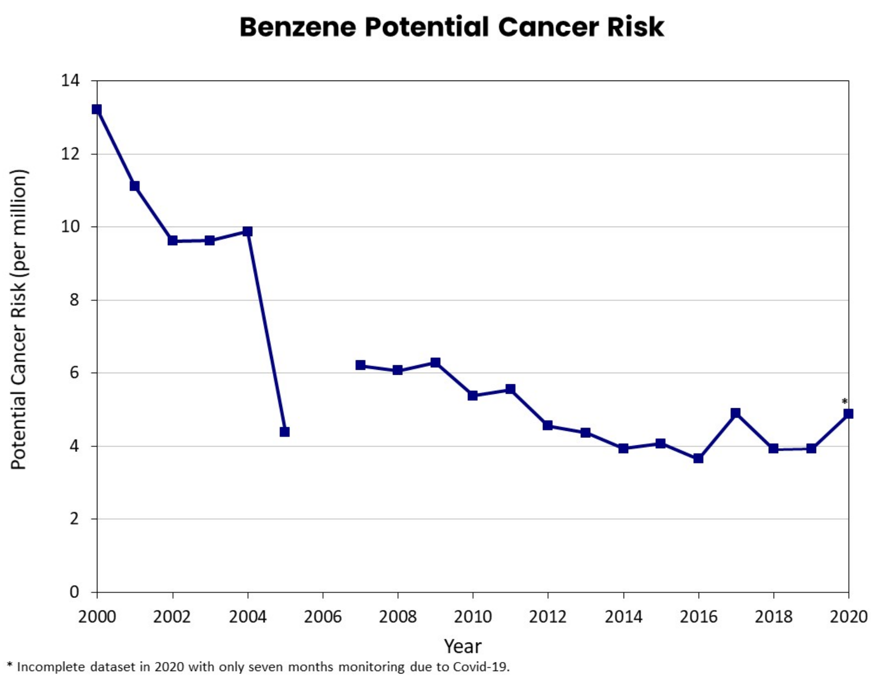
[31]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/formaldehyde.pdf.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune and nervous system disorders.[32] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvent and other combustion. Benzene's 2020 average potential cancer risk estimate at Beacon Hill was 5 in one 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 have found a statistically significant drop in risk from benzene at an average rate of about 0.4 per million per year since 2000.

Figure 26: Benzene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020



[32]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/benzene.pdf.

Hexavalent Chromium

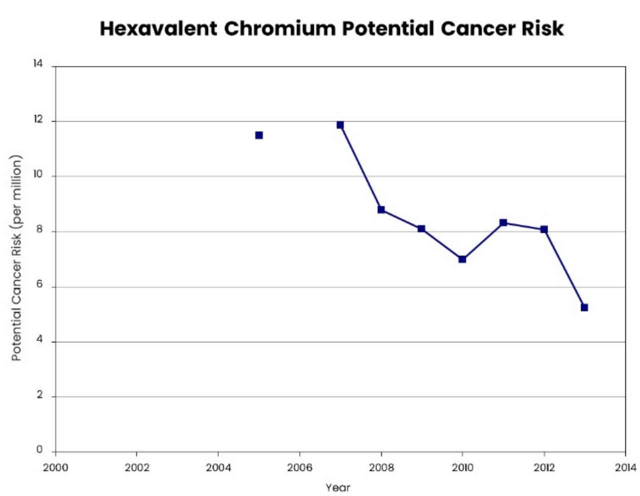
Chromium is present in two chemical states (trivalent and hexavalent) in our air. Trivalent chromium occurs naturally, while hexavalent comes from human activities and is much more toxic. EPA lists hexavalent chromium as a known carcinogen, associated primarily with lung cancer. Hexavalent chromium is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

Exposure to hexavalent chromium is also associated with adverse respiratory, liver, and kidney effects.[33] Sources of hexavalent chromium include industrial processes such as chrome electroplating, as well as combustion of distillate oil, green glass production, 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 June 2013. The 2013 estimated average potential cancer risk for hexavalent chromium at Beacon Hill was 3 in one million based on the first half of the year.

In some years, up to 20% of the samples were below method detection limits. For the trend below, we used Kaplan-Meier analysis to estimate the annual means, as this method is designed to overcome bias from samples below the detection limit and other forms of censored data. Since 2000, we found a statistically significant drop in risk from hexavalent chromium at an average 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 27: Hexavalent Chromium Annual Average Potential Cancer Risk at Beacon Hill, 2005-2013



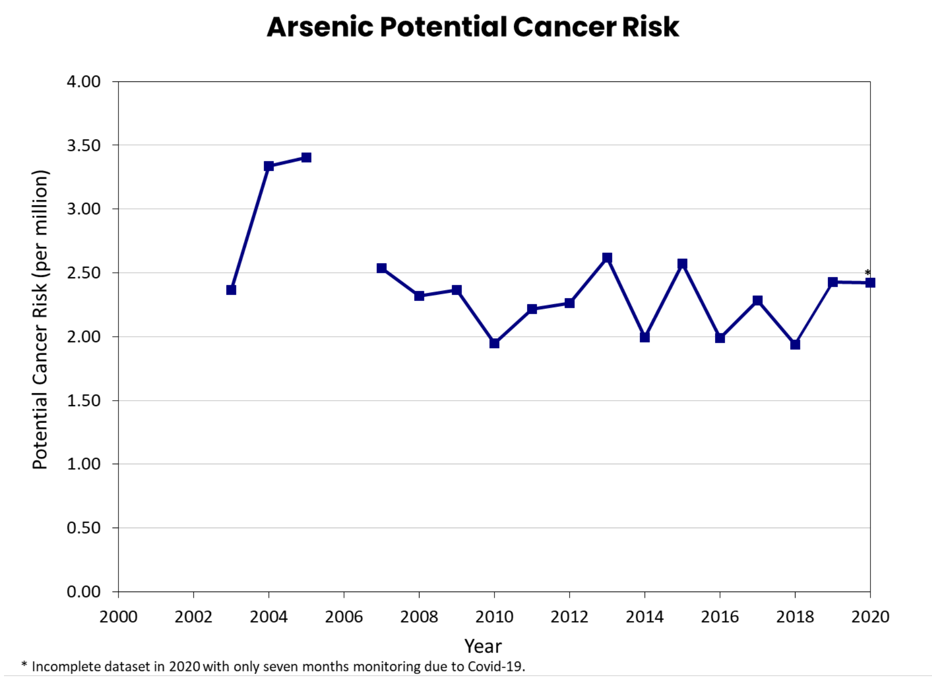
[33]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/chromium-compounds.pdf.

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation and liver and kidney damage.[34] Arsenic is used to treat wood and in colored glass. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2020 average potential cancer risk estimate at Beacon Hill was 2 in one million. Since 2000, we found a statistically significant drop in risk from arsenic at an average rate of about 0.05 per million per year.

The Agency's permitting program works with and regulates industrial users of arsenic to reduce emissions. Illegal burning, especially of treated wood, can also contribute to arsenic emissions in our area.

Figure 28: Arsenic Annual Average Potential Cancer Risk at Beacon Hill, 2003-2020



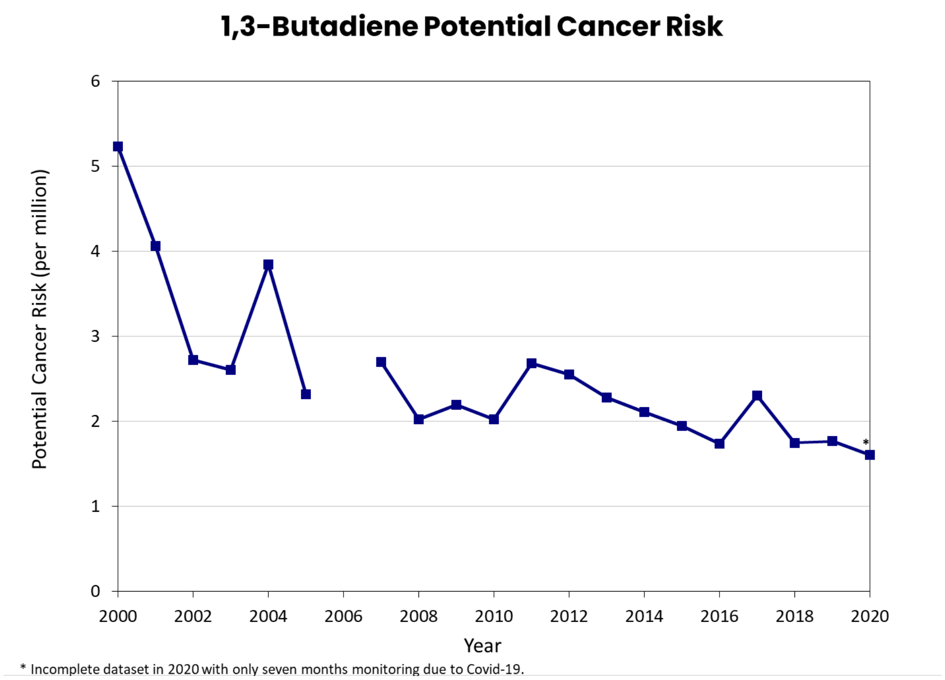
[34] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/arsenic-compounds.pdf.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.[35] Primary sources of 1,3-butadiene include cars, trucks, buses, and wood burning. 1,3-butadiene's 2020 average potential cancer risk estimate at Beacon Hill was 2 in one million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce 1,3-butadiene emissions. Since 2000, we have found a statistically significant drop in risk from 1,3-butadiene at an average rate of about 0.1 per million per year.

Figure 29: 1,3-Butadiene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020



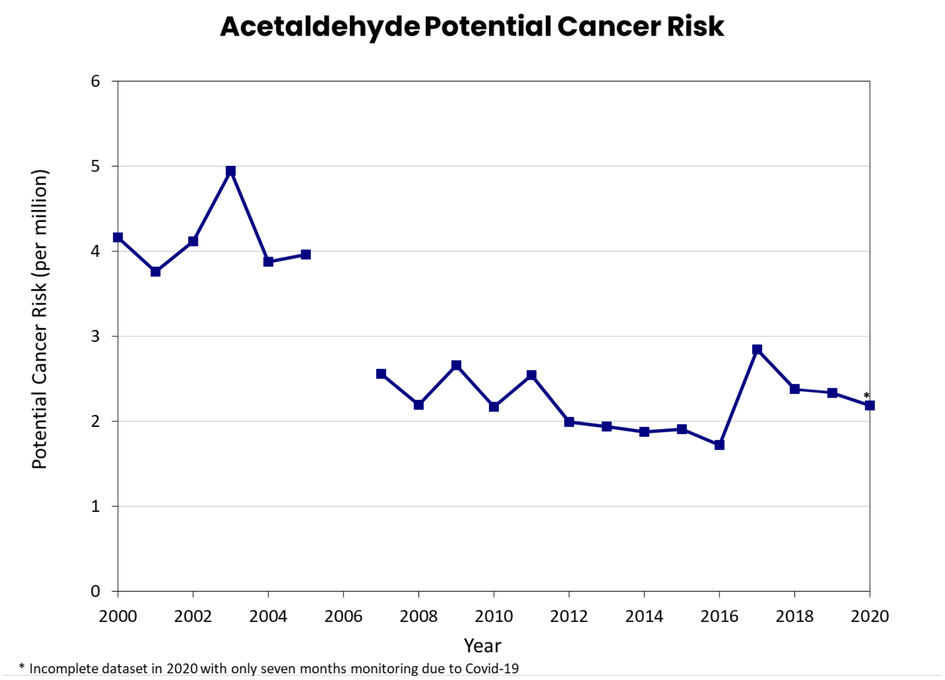
[35]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-08/documents/13-butadiene.pdf.

Acetaldehyde

The EPA lists acetaldehyde as a probable human carcinogen. Acetaldehyde inhalation is also associated with irritation of eyes, throat and lungs, and long-term effects similar to those of alcoholism.[36] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2020 average potential cancer risk estimate at Beacon Hill was 2 in one million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce acetaldehyde emissions. Since 2000, we have found a statistically significant drop in risk from acetaldehyde at an average rate of about 0.1 per million per year.

Figure 30: Acetaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020



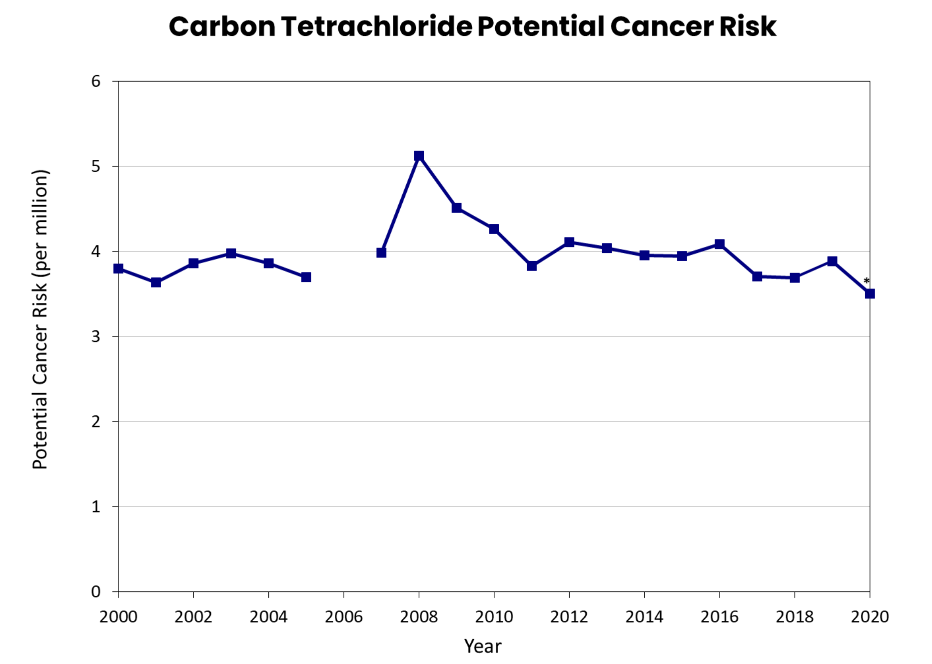
[36]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/acetaldehyde.pdf.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[37] It was widely used as a solvent in both industry and consumer applications and was banned from consumer use in 1995. Trace amounts are still emitted by wastewater treatment plants. Carbon tetrachloride is relatively ubiquitous, has a long half-life, and occurs in similar concentrations in urban and rural areas. Carbon tetrachloride's 2020 average potential cancer risk estimate at Beacon Hill was 3 in one 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 31: Carbon Tetrachloride Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020



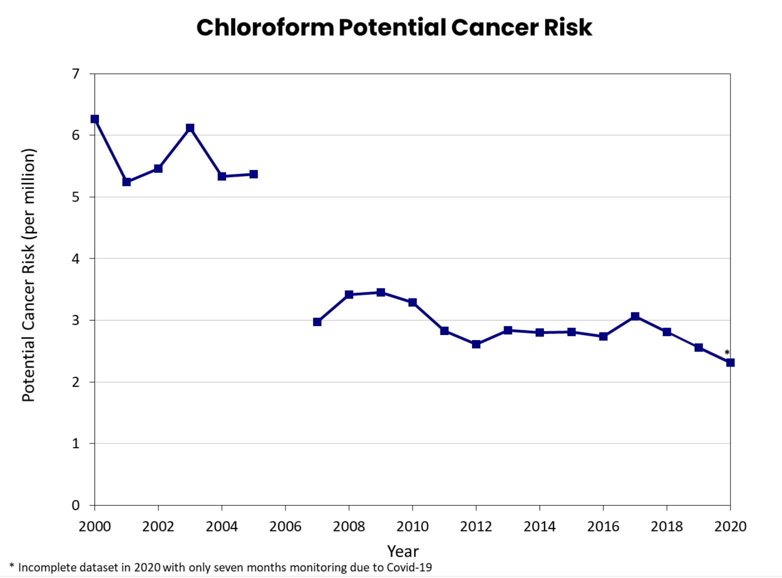
[37] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/carbon-tetrachloride.pdf.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.[38] Main sources of chloroform are water treatment plants and reservoirs.[39] Because the Beacon Hill monitoring site is located at the Beacon Hill reservoir, which was uncovered prior to 2009, the chloroform measurements from 2000 through 2008 may be higher than expected for most of our region. However, the reservoir underwent a major renovation in 2008 and 2009 and is now completely enclosed, possibly at least partially explaining the drop in chloroform levels around that time. Chloroform's 2020 average potential cancer risk estimate at Beacon Hill was 2 in one 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, the majority of which have been covered in accordance with a 2006 federal regulation on drinking water protection.[40] Since 2000, we have found a statistically significant drop in risk from chloroform at an average rate of about 0.2 per million per year.

Figure 32: Chloroform Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020



[38]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/chloroform.pdf.

[39]Seattle Public Utilities. 2018 Water Quality Analysis shows detectable levels of trihalomethanes in treated drinking water, which is stored in reservoirs (trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform); https://www.seattle.gov/Documents/Departments/SPU/Services/Water/Water_Quality_Report_2018.pdf.

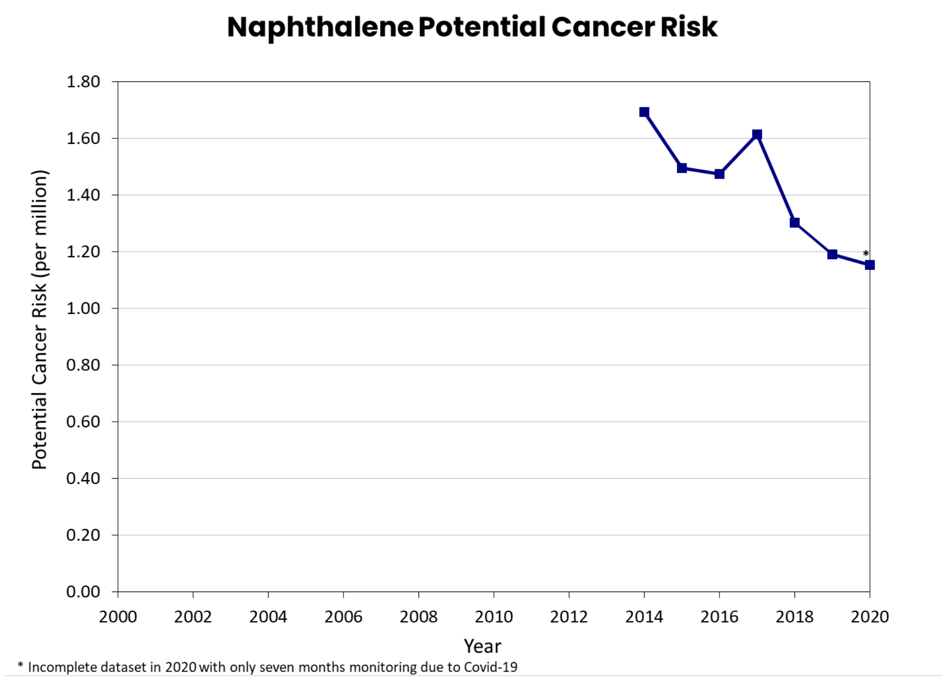
[40]Long Term 2 Enhanced Surface Water Treatment Rule; https://www.epa.gov/dwreginfo/long-term-2-enhanced-surface-water-treatment-rule-documents

Naphthalene

EPA lists naphthalene as a possible human carcinogen. Naphthalene is also associated with respiratory effects and retina damage.[41] Local sources of naphthalene include combustion of wood and heavy fuels. Naphthalene's 2020 average potential cancer risk estimate at Beacon Hill was at 1 in one million.

The Agency works with and regulates wood burning through burn bans and wood stove replacement programs to reduce naphthalene emissions. Since 2014, we have found a statistically significant drop in risk from naphthalene at an average rate of about 0.08 per million per year. Monitoring for naphthalene and other polycyclic aromatic hydrocarbons started in 2008.

Figure 33: Naphthalene Annual Average Potential Cancer Risk at Beacon Hill, 2008-2020



[41] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/naphthalene.pdf.

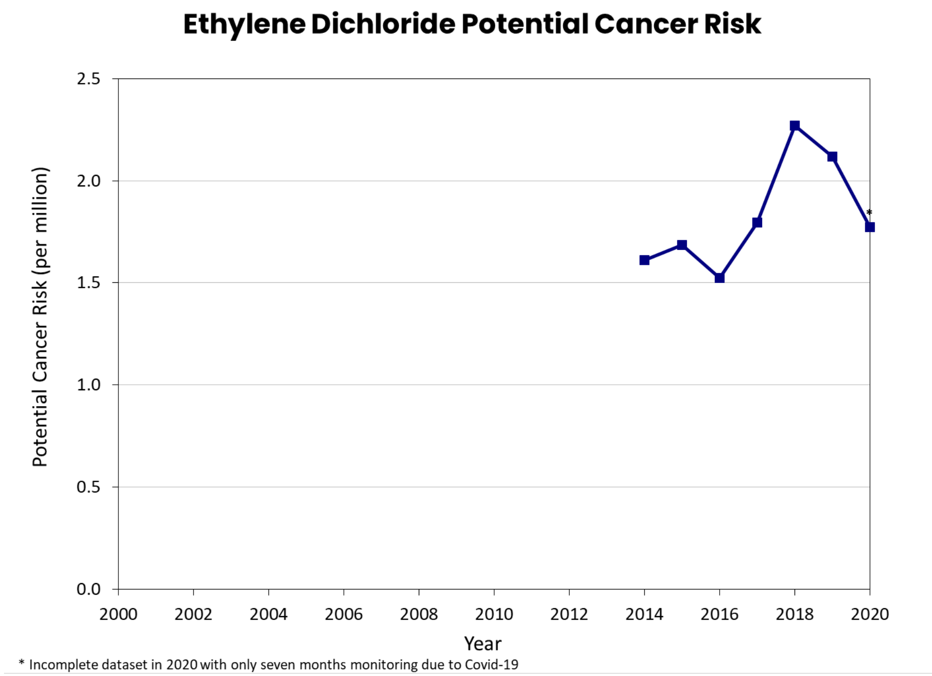
Ethylene Dichloride

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 gasoline, but this is expected to be a very minor source, as leaded gas for on-road vehicle use was phased out in 1996.[42,43] We estimated ethylene dichloride's 2020 average potential cancer risk estimate at Beacon Hill at 2 in one million.

There is no useful trend information for this air toxic since most of the measurements are near the practical quantitation limit of the analytical method. That is, most of the samples in 2020 were within twice the method detection limit. Additionally, in prior years, most of the samples were also below the quantitation limits. In the years for which we have ethylene dichloride data, the detection limit for this air toxic is typically 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.

Figure 34: Ethylene Dichloride Annual Average Potential Cancer Risk at Beacon Hill, 2014-2020



[42] EPA Hazard Summary, https://www.epa.gov/sites/production/files/2016-09/documents/ethylene-dichloride.pdf.

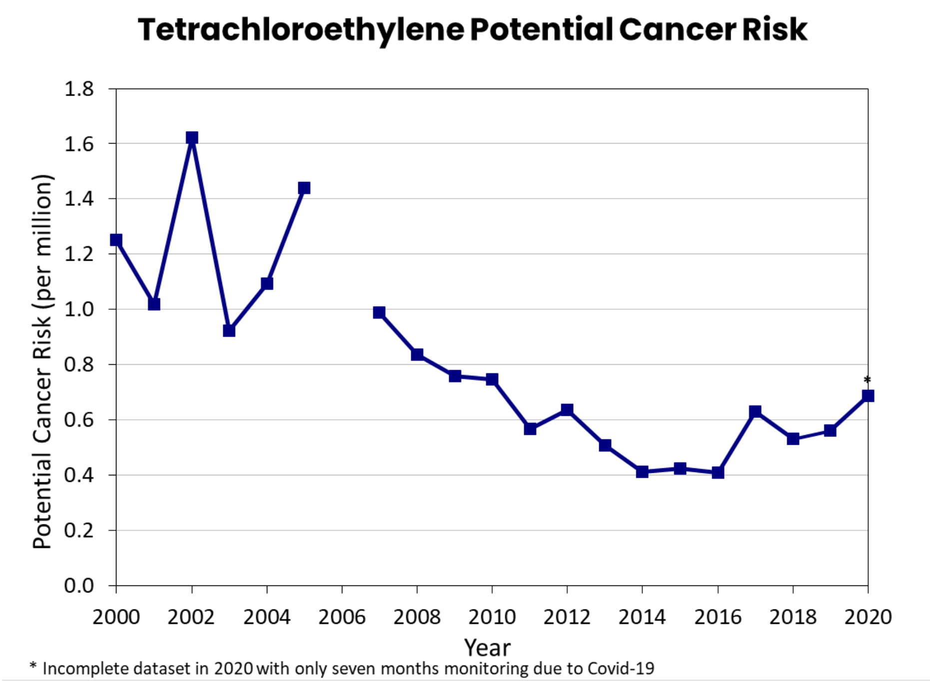
[43] US Energy Information Administration: Gasoline and the Environment; https://www.eia.gov/energyexplained/index.php?page=gasoline_environment

Tetrachloroethylene

EPA lists tetrachloroethylene as a probable human carcinogen. It is widely used for dry-cleaning fabrics and textile processing. It is also used for vapor degreasing in metal cleaning process. Chronic exposure to tetrachloroethylene may affect kidney, liver, immune system and neurological behavior. We estimated ethylene dichloride's 2020 average potential cancer risk estimate at Beacon Hill at less than one in one million.

Since 2007, we have found a statistically significant drop in risk from tetrachlorethylene, but recent years have seen a slight increase. The Agency's compliance program works with and regulates dry cleaners and other producers of ethylene dichloride to reduce emissions.

Figure 35: Tetrachloroethylene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2020

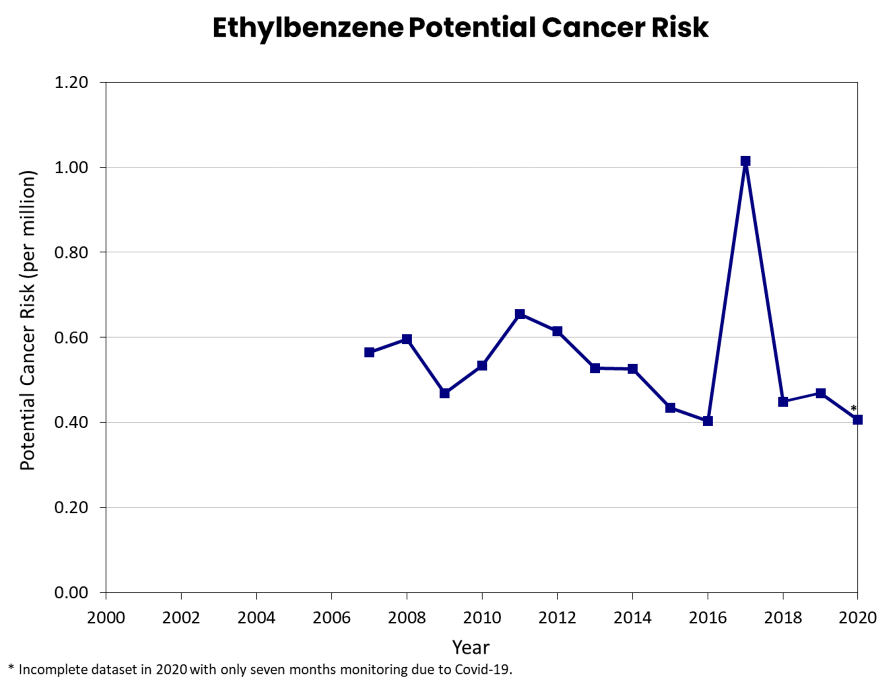


Ethylbenzene

EPA lists ethylbenzene as a Group D pollutant, which is not classifiable as to human carcinogenicity due to limited information available.[44] 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 2020 average potential cancer risk estimate at Beacon Hill was less than one in one million.

We did not find a statistically significant trend in ethylbenzene levels over the 2007-2020 timeframe for which we have data. The Agency works with and regulates solvent-using businesses to reduce ethylbenzene emissions.

Figure 36: Ethylbenzene Annual Average Potential Cancer Risk at Beacon Hill, 2007-2020



[44] EPA Hazard Summary: https://www.epa.gov/sites/production/files/2016-09/documents/ethylbenzene.pdf.

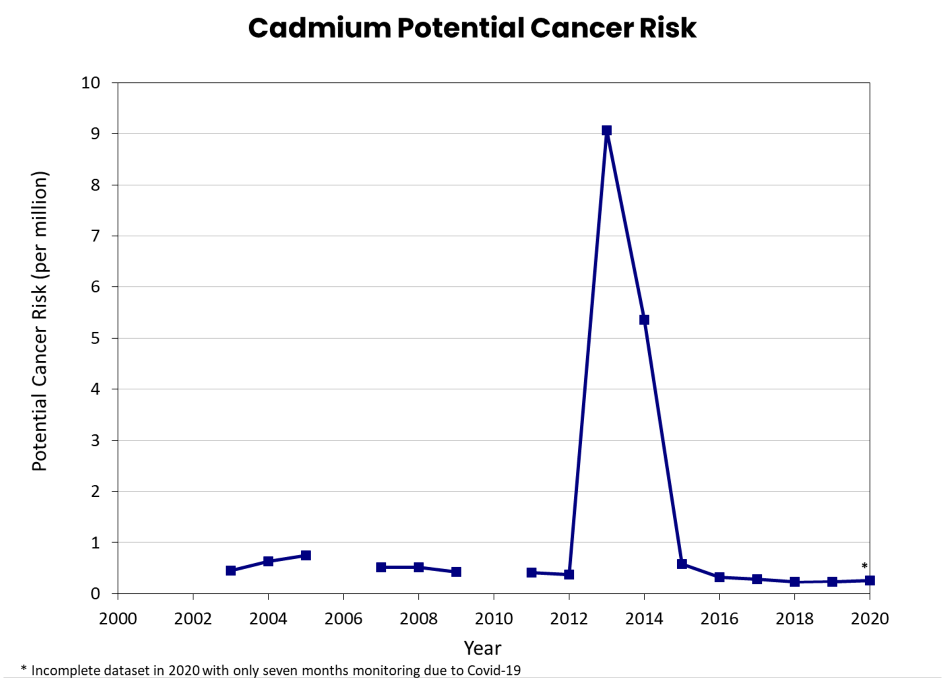
Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[45] Combustion of distillate oil is a main source of cadmium in the Puget Sound area.

Cadmium's 2020 average potential cancer risk estimate at Beacon Hill was less than 1 in one million. Our trend is affected by a number of factors, including the fact that over half the samples in 2010 were below the detection limits and thus we did not have sufficient data to make a comparable average. Extremely high outlier results on 11/18/13 and 9/8/14 resulted in high average concentrations in each of those respective years. On those days, no other metal concentrations were statistical outliers compared to their respective annual variability. With the outliers excluded for 2013 and 2014, the estimated annual potential cancer risks for those years 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 37: Cadmium Annual Average Potential Cancer Risk at Beacon Hill, 2003-2020



[45]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/cadmium-compounds.pdf.

Definitions

General Definitions

Air Quality Index

Table 5: 2020 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[(a)]	$PM_{2.5}$ (µg/m³) 24 hour	PM_{10} (µg/m³) 24 hour	CO (ppm) 8 hour	SO_2[(c)] (ppb) 1 hour	NO_2 (ppb) 1 hour	AQI value	Category
0.000–0.054	—	0.0–12.0	0–54	0.0–4.4	0–35	0–53	0–50	Good
0.055–0.070	—	12.1–35.4	55–154	4.5–9.4	36–75	54–100	51–100	Moderate
0.071–0.085	0.125–0.164	35.5–55.4	155–254	9.5–12.4	76–185	101–360	101–150	Unhealthy for sensitive groups
0.086–0.105	0.165–0.204	55.5–150.4	255–354	12.5–15.4	(186–304)[(d)]	361–649	151–200	Unhealthy
0.106–0.200	0.205–0.404	150.5–250.4	355–424	15.5–30.4	(305–604)[(d)]	650–1249	201–300	Very unhealthy
(b)	0.405–0.504	250.5–350.4	425–504	30.5–40.4	(604–804)[(d)]	1250–1649	301–400	Hazardous
(b)	0.505–0.604	350.5–500.4	505–604	40.5–50.4	(805–1004)[(d)]	1650–2049	401–500	Hazardous

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

[(b)] 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)] 1-hour SO_2 values do not define higher AQI values (≥ 200). AQI values of 200 or greater are calculated with 24-hour SO_2 concentrations.

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-21 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 187 pollutants as HAPs at https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications.

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 4,000 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 process 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.

PUGET SOUND
Clean Air Agency

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

2020

Air Quality Data Summary Appendix

October 2021

Monitoring Methods Used from 1999 to 2020 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) (ended 3/18/2015)							X						X	X	X		X	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 (ended 8/6/2014)							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
BL	11675 44th Ave S, Tukwila Allentown						●	●	●					●	●	●		●	b, e, f
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, 4700/4752 E Marginal Way S, Seattle SPECIATION SITE	X		X	X	●	X	●	●		X			X	●	●	X	●	a, e
CG⦿	Woodinville, 17401 133rd Av NE, Woodinville (ended April 2010)							X						X					b ,d ,f

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
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
DB	17171 Bothell Way NE, Lake Forest Park	X	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 (ended 1/21/2010)												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

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
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			●	●	●	X	●	a, e
ER	South Hill, 9616 128th St E, Puyallup (ended December 2, 2020)	X	X		X	X		X	**X**					X	X	X		X	b, f
ES	7802 South L St, Tacoma SPECIATION SITE				●	●	X	●	●					●	●	●	X	●	b, f
FF⦿	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma														●	●			b, f
FG⦿	Mt Rainier National Park, Jackson Visitor Center									●									c
FH⦿	Charles L Pack Forest, La Grande (ended 9/30/2010)									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		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 (ended April 9, 2020)				X	X	X	X						X	X	X		X	b, d
IK⦿	14310 SE 12th St, Bellevue						●							●				●	a, d
JN⦿	5810 196th Street, Lynwood (ended Jun 30, 2006)												X						a, d
JO	Darrington High School, Darrington 1085 Fir St				X	●	X	●	●					●	●	●		●	d, f
JP⦿	2939 Broadway Ave, Everett (ended March 31, 2003)												X						a, d

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
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
PA⦿	1802 S 36th St, Tacoma					●	●					●			●	●			a, f
QE	Meadowdale, 7252 Blackbird Dr NE, Bremerton (ended 5/1/2012)	X				X	X	X						X	X	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
QK	Spruce, 3250 Spruce Ave, Bremerton						●	●						●	●	●		●	b, f
RV⦿	Yelm N Pacific Road, 931 Northern Pacific Rd SE, Yelm									●									c, f
RZ	Gig Harbor, 9702 Crescent Valley Dr NW, Gig Harbor							X						X	X	X		X	f
TC	M St E, Auburn (ended April 7, 2020)							X						X	X	X		X	b
TR	Eatonville, 560 Center St, Eatonville							X						X	X	X		X	F
TS	1301 Yesler Way, Seattle								X								X		a, f
TT	602 S. Jackson St, Seattle								X								X		a, 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 – 2020

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)
2016	1 Jan (1300) – 4 Jan (0930)
	7 Jan (1300) – 9 Jan (1200)
	10 Jan (1300) – 11 Jan (0900)
	15 Dec (1300) – 18 Dec (0900)
2017	4 Jan (1800) – 7 Jan (1300)
	11 Jan (1200) – 16 Jan (1700)
	24 Jan (1400) – 25 Jan (1200)
	2 Aug (1600) – 5 Aug (1100)
	8 Aug (1400) – 11 Aug (1400)
	8 Dec (1400) – 13 Dec (1400)
	22 Dec (1400) – 24 Dec (1200)
2018	1 Jan (1400) – 2 Jan (1100)
	20 Aug (1700) – 23 Aug (1300)
2019	1 Jan (1400) – 2 Jan (1000)
	13 Jan (1300) – 16 Jan (1200)
2020	None

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

Micrograms per Cubic Meter

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

2020

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
7802 South L St, Tacoma	170	--	--	--	9.8	--	--	81.5
15th S & Charlestown, Beacon Hill, Seattle	69	--	--	--	6.1	--	--	42.0

Notes:

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

(2) Quarterly averages are shown only if 75 percent or more of the data are available. In 2020, monitoring operations had to be discontinued due to COVID-19 from 3/2020 to 8/2020.

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

(4) Data from primary sampler at site

PARTICULATE MATTER ($PM_{2.5}$) – Federal Equivalent Methods

Micrograms per Cubic Meter

Equivalent Sampling Methods: Met One BAM

2020

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Bremerton Spruce	360	4.3	3.9	15.9	6.3	7.6	41.2	170.4
Darrington	338	6.0	2.5	12.2	8.2	7.3	51.2	175.2
Kent	350	4.0	3.1	17.1	9.9	8.7	72.0	188.2
Marysville	352	8.7	6.8	16.4	10.2	10.7	47.2	165.5
Seattle 10th and Weller	353	5.4	4.8	19.3	8.3	9.4	60.5	179.0
Seattle Beacon Hill	358	3.4	1.9	14.6	4.7	6.3	53.0	179.1
Seattle Duwamish	359	7.8	5.6	17.9	9.0	10.2	46.3	179.2
Tukwila Allentown	355	5.7	4.2	16.2	8.7	8.8	40.3	172.8
Tacoma South L St	361	6.7	4.7	16.1	9.7	9.4	37.7	180.8
Tacoma South 36th S	359	5.4	4.7	18.4	8.6	9.2	40.5	179.6

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.

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

Micrograms per Cubic Meter

Sampling Method: Ecotech Nephelometer

2020

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Bellevue	361	3.0	2.8	14.7	4.0	6.2	49.7	159.5
Bremerton Spruce*	365	3.8	3.4	15.9	5.3	7.2	48.9	185.9
Darrington	364	6.0	2.5	12.6	7.5	7.2	46.8	174.1
Kent	364	5.2	4.6	18.3	7.7	9.0	46.7	204.2
Lake Forest Park	348	5.2	4.0	14.7	8.6	8.3	52.7	156.1
Marysville	365	5.3	3.8	17.2	7.8	8.6	60.6	203.5
North Bend	365	2.4	2.3	14.1	3.0	5.5	45.9	175.1
Puyallup	324	3.9	3.3	14.5	--	--	--	169.5
Seattle Duwamish	364	8.2	6.7	21.3	10.8	11.8	54.0	252.5
Seattle South Park*	350	7.2	6.7	10.8	9.3	8.5	19.1	350.0
Tukwila Allentown	361	5.8	4.8	19.8	8.2	9.8	56.5	224.7
Tacoma Tideflats	364	4.6	4.0	13.3	6.9	7.3	35.4	134.2
Tacoma South L St	365	6.8	4.7	16.1	9.8	9.4	36.8	180.8

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.

$PM_{2.5}$ Speciation Analytes Monitored in 2020

in Micrograms per Cubic Meter

Acceptable Pm2.5 Aqi & Speciation Mass	Oc Csn_Rev Unadjusted Pm2.5 Lc Tot
Aluminum Pm2.5 Lc	Oc Pm2.5 Lc Tor
Ammonium Ion Pm2.5 Lc	Oc Pm2.5 Lc Tot
Ammonium Nitrate Pm2.5 Lc	Oc1 Csn_Rev Unadjusted Pm2.5 Lc
Ammonium Sulfate Pm2.5 Lc	Oc1 Pm2.5 Lc
Antimony Pm2.5 Lc	Oc2 Csn_Rev Unadjusted Pm2.5 Lc
Arsenic Pm2.5 Lc	Oc2 Pm2.5 Lc
Barium Pm2.5 Lc	Oc3 Csn_Rev Unadjusted Pm2.5 Lc
Bromine Pm2.5 Lc	Oc3 Pm2.5 Lc
Cadmium Pm2.5 Lc	Oc4 Csn_Rev Unadjusted Pm2.5 Lc
Calcium Pm2.5 Lc	Oc4 Pm2.5 Lc
Cerium Pm2.5 Lc	Op Csn_Rev Unadjusted Pm2.5 Lc Tor
Cesium Pm2.5 Lc	Op Csn_Rev Unadjusted Pm2.5 Lc Tot
Chloride Pm2.5 Lc	Op Pm2.5 Lc Tor
Chlorine Pm2.5 Lc	Op Pm2.5 Lc Tot
Chromium Pm2.5 Lc	Organic Carbon Mass Pm2.5 Lc
Cobalt Pm2.5 Lc	Phosphorus Pm2.5 Lc
Copper Pm2.5 Lc	Pm2.5 - Local Conditions
Ec Csn_Rev Pm2.5 Lc Tor	Potassium Ion Pm2.5 Lc
Ec Csn_Rev Pm2.5 Lc Tot	Potassium Pm2.5 Lc
Ec Pm2.5 Lc Tor	Rubidium Pm2.5 Lc
Ec Pm2.5 Lc Tot	Selenium Pm2.5 Lc
EC1 CSN_Rev Unadjusted PM2.5 LC	Silicon Pm2.5 Lc
Ec1 Pm2.5 Lc	Silver Pm2.5 Lc
EC2 CSN_Rev Unadjusted PM2.5 LC	Sodium Ion Pm2.5 Lc
Ec2 Pm2.5 Lc	Sodium Pm2.5 Lc
EC3 CSN_Rev Unadjusted PM2.5 LC	Soil Pm2.5 Lc
Ec3 Pm2.5 Lc	Strontium Pm2.5 Lc
Indium Pm2.5 Lc	Sulfate Pm2.5 Lc
Iron Pm2.5 Lc	Sulfur Pm2.5 Lc
Lead Pm2.5 Lc	Tin Pm2.5 Lc
Magnesium Pm2.5 Lc	Titanium Pm2.5 Lc
Manganese Pm2.5 Lc	Total Nitrate Pm2.5 Lc
Nickel Pm2.5 Lc	Vanadium Pm2.5 Lc
Nitrite Pm2.5 Lc	Zinc Pm2.5 Lc
Oc Csn_Rev Unadjusted Pm2.5 Lc Tor	Zirconium Pm2.5 Lc

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

2020

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Seattle Duwamish	366	0.9	0.5	1.1	0.8	0.9	7.2
Tukwila Allentown	362	1.0	0.5	1.1	0.9	1.0	6.7
Kent	365	0.7	0.3	0.9	0.6	0.8	3.9
Tacoma Tideflats	360	0.9	0.5	0.9	0.8	1.0	6.1
Seattle 10th & Weller	366	1.0	0.8	1.6	1.2	1.2	7.4

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.

OZONE

Parts per Million

Sampling Method: Ultraviolet Photometric Detection Method

2020

Location / Continuous Sampling Period(s)	2020 4th Highest Daily 8-Hour Concentration		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2018	2019	2020	2018-2020
Seattle Beacon Hill (1 Jan- 31Dec)	0.052	15 Aug	0.045	0.046	0.052	0.047
Lake Sammamish Park (1 May – 30 Sep)	0.060	10 Sep	0.067	0.052	0.060	0.059
North Bend (1 May – 30 Sep)	0.051	28 May	0.071	0.053	0.051	0.058
Enumclaw Mud Mountain (1 May – 30 Sep)	0.059	29 Jul	0.077	0.055	0.059	0.063
Yelm (1 May – 30 Sep)	0.057	27 Jul	0.063	0.052	0.057	0.057
Mt Rainier National Park (1 Jan – 31 Dec)	0.060	10 Sep	0.067	0.056	0.060	0.061

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.

2020 Beacon Hill Air Toxics Statistical Summary for Air Toxics (*units in parts per billion*)

	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Carbon Tetrachloride	Chloroform	Ethylbenzene	Ethylene Dichloride	Ethylene Oxide	Formaldehyde	Tetrachloro ethylene
2020 Count	36	36	36	36	36	36	36	36	36	36	36
ND's (reported as 0)	0	0	0	0	0	0	0	0	6	0	0
Median (ppb)	0.0151	0.599	0.108	0.163	0.0932	0.0188	0.0342	0.017	0.0456	0.7375	0.0089
Mean (ppb)	0.0239*	0.8073	0.1876*	0.1959	0.0946	0.0204	0.0422	0.0166	0.0766*	1.2103	0.0162*
95th Percentile (ppb)	0.0787	1.7075	0.273	0.3635	0.1103	0.0272	0.1035	0.0222	0.148	3.1	0.0319
Max (ppb)	0.0867	4.97	0.426	1.03	0.119	0.0406	0.165	0.0252	0.156	8.04	0.0324
# Below MDL	14	0	24	0	0	1	1	3	24	0	28
% Below MDL	39%	0%	67%	0%	0%	3%	3%	8%	67%	0%	78%

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

ND = Non-Detects (values reported as zero)

MDL = Method Detection Limit

* = Kaplan-Meier method used to estimate these means due to a large proportion of results being below the MDL.

2020 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})
2020 Count	50	50	34	50
ND's (reported as 0)	0	0	0	0
Median (ng/m^3)	0.4685	0.0363	27.7	0.5245
Mean (ng/m^3)	0.7268	0.0625	33.4353	0.9516
95th Percentile (ng/m^3)	2.0525	0.1601	85.32	2.22
Max ng/m^3)	4.24	0.434	127	2.92
# Below MDL	0	5	0	32
% Below MDL	0%	10%	0%	64%

Estimates of Air Toxics Risk
2020 Air Toxics Unit Risk Factors

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

*Potential cancer risk = ambient concentration (µg/m^3) * unit risk factor (risk/µg/m^3)*

Unit risk factors are often based on epidemiological studies (studies of diseases occurring in human populations) and are also extrapolated from laboratory animal studies. Unit risk factors are typically based on an assumed 70-year (lifetime) exposure interval and are available from multiple sources. In this data summary, cancer risk was estimated using unit risk factors from the Washington State Acceptable Source Impact Levels (ASIL) table.[1] The ASIL values relevant to this summary are in the table below. The two sources from which values in the ASIL table are derived are the U.S. EPA's Integrated Risk Information System[2] (IRIS) and California EPA's Office of Environmental Health and Hazard Assessment[3] (OEHHA). Unit risk factors from both of these sources are derived from extensive reviews of peer-reviewed literature and other datasets. The cancer rating, based on IARC definitions, refers to its "weight of evidence" ranking: 1 = carcinogenic to humans, 2A = probably carcinogenic to humans, 2B = possibly carcinogenic to humans, and 3 = not classifiable as to its carcinogenicity to humans.[4]

2020 Air Toxics Unit Risk Factors

AIR TOXIC	WA ASIL 460 UNIT RISK FACTOR RISK/µg/m^3	CANCER RATING[5]
1,3-Butadiene	3.0×10^{-5}	1
Acetaldehyde	2.7×10^{-6}	2B
Acrolein	2.9×10^{-6}	3
Arsenic	3.3×10^{-3}	1
Benzene	7.7×10^{-6}	1
Cadmium	4.2×10^{-3}	1
Carbon Tetrachloride	5.9×10^{-6}	2B
Chloroform	2.3×10^{-5}	2B
Chromium (Hexavalent)	2.5×10^{-1}	1
Ethylbenzene	2.5×10^{-6}	2B
Ethylene Dichloride	2.6×10^{-5}	2B
Ethylene Oxide	5.0×10^{-3}	1
Formaldehyde	5.9×10^{-6}	1
Naphthalene	3.4×10^{-5}	2B
Tetrachloroethylene	6.3×10^{-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, May 8, 2018; arb.ca.gov/toxics/healthval/healthval.htm.

[4]International Agency for Research on Cancer; http://monographs.iarc.fr/.

[5]Ratings per International Agency for Research on Cancer, updated July 2019; http://monographs.iarc.fr/ENG/Classification/

2020 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
Ethylene oxide	1	1333	83%
Formaldehyde	2	18	100%
Benzene	3	9	100%
Arsenic (PM_{10})	4	7	70%
1,3-Butadiene	5	5	53%
Acetaldehyde	6	5	75%
Carbon tetrachloride	7	4	100%
Chloroform	8	3	100%
Naphthalene	9	3	44%
Ethylene dichloride	10	2	97%
Acrolein	11	2	36%
Tetrachloroethylene	12	1	6%
Ethylbenzene	13	1	6%
Cadmium (PM_{10})	14	1	4%
Nickel (PM_{10})	15	1	0%

2020 Non-cancer Reference Concentrations (RfC) and Hazard Indices >1

Air toxic	Non-cancer RfC (ug/m^3)	Mean Hazard Index
Acrolein	**0.35**	**1.229**
Benzene	3	0.209
Formaldehyde	9	0.134
Nickel (PM_{10})	0.014	0.068
Manganese (PM_{10})	0.09	0.056
Arsenic (PM_{10})	0.015	0.048
1,3-Butadiene	2	0.024
Carbon tetrachloride	40	0.015
Acetaldehyde	140	0.006
Toluene	300	0.004
Naphthalene	9	0.004
Cadmium (PM_{10})	0.02	0.003
Chloroform	300	< 0.001
Mercury (PM_{10})	0.03	< 0.001
Ethylene dichloride	400	< 0.001
Propylene	3000	< 0.001
Ethylbenzene	2000	< 0.001
Beryllium (PM_{10})	0.007	< 0.001
Styrene	900	< 0.001
Trichloroethylene	600	< 0.001
Nickel ($PM_{2.5}$)	0.014	< 0.001
Carbon disulfide	800	< 0.001
Manganese ($PM_{2.5}$)	0.09	< 0.001
Cadmium (PM2.5)	0.02	< 0.001
Methyl chloroform	1000	< 0.001
Arsenic ($PM_{2.5}$)	0.015	< 0.001
Chlorobenzene	1000	< 0.001

Reference concentrations are based on chronic Reference Exposure Levels (chRELs) from the California Office of Environmental Health Hazard Assessment (OEHHA)[6].

Mean hazard index, HI = mean concentration/reference concentration.

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

[6] https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary

2000-2020 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 at the 95% confidence level.

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)	-0.110	3.751	0.588	20
Acetaldehyde	True (0)	-0.120	4.151	0.621	20
Arsenic PM_{10}	True (0.038)	-0.040	2.924	0.256	17
Benzene	True (0)	-0.378	10.508	0.713	20
Cadmium PM_{10}	False (0.854)	0.022	0.990	0.002	16
Carbon Tetrachloride	False (0.691)	-0.005	4.031	0.009	20
Chloroform	True (0)	-0.187	5.810	0.779	20
Chromium VI TSP	True (0.005)	-0.713	16.005	0.754	8
Ethylbenzene	False (0.676)	-0.005	0.614	0.015	14
Ethylene Dichloride	False (0.16)	0.075	0.481	0.353	7
Formaldehyde	True (0.01)	-0.407	11.427	0.318	20
Naphthalene	True (0.007)	-0.086	2.957	0.797	7
Nickel PM_{10}	True (0)	-0.030	0.858	0.659	16
Tetrachloroethylene	True (0)	-0.044	1.298	0.653	20

Air Quality Standards and Health Goals

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 μg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 μg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 μg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 μg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 μg/m^3 as a calendar quarter average) also remain in effect.
(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.
(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.
(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2)any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

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 https://ecology.wa.gov/Regulations-Permits?topics=27.[7] The air quality standards that apply to the Puget Sound air shed are summarized below.

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/naaqs-table

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.

---

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

[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; https://yosemite.epa.gov/sab/SABPEOPLE.NSF/PeopleSearch/60BA5C6D6F54A288852568A900645FE4?OpenDocument.