

2008

Air Quality Data Summary

October 2009

Working Together for Clean Air

TABLE OF CONTENTS

| | |
|---|-----|
| Table of Contents | i |
| List of Figures..... | ii |
| List of Maps..... | iii |
| List of Tables | iii |
| Appendix – Data Tables | iii |
| Introduction..... | 1 |
| Executive Summary | 3 |
| Air Quality Index | 6 |
| Monitoring Network | 12 |
| Impaired Air Quality – Burn Bans and Smog Watch | 19 |
| Air Quality Standards and Health Goals..... | 23 |
| Particulate Matter..... | 25 |
| Particulate Matter – PM _{2.5} Speciation and Aethalometers | 38 |
| Ozone..... | 42 |
| Nitrogen Dioxide | 47 |
| Carbon Monoxide | 49 |
| Sulfur Dioxide | 51 |
| Lead..... | 54 |
| Visibility | 55 |
| Air Toxics..... | 61 |
| Definitions..... | 74 |

LIST OF FIGURES

| | |
|--|----|
| Figure 1: Number of Days Air Quality Rated As "Good" Per AQI | 7 |
| Figure 2: Air Quality for King County | 8 |
| Figure 3: Air Quality for Kitsap County | 9 |
| Figure 4: Air Quality for Pierce County | 10 |
| Figure 5: Air Quality for Snohomish County | 11 |
| Figure 6: PM_{2.5} during January 23-26 2008 Burn Ban | 20 |
| Figure 7: Impaired Air Quality Resulting in Burn Bans | 21 |
| Figure 8: Smog Forecast Events | 22 |
| Figure 9: Daily PM_{2.5} for King County | 29 |
| Figure 10: Daily PM_{2.5} for Kitsap County | 30 |
| Figure 11: Daily PM_{2.5} for Pierce County | 31 |
| Figure 12: Daily PM_{2.5} for Snohomish County | 32 |
| Figure 13: Days Exceeding the PM_{2.5} Health Goal at One or More Monitoring Sites | 33 |
| Figure 14: Annual PM_{2.5} for King County | 34 |
| Figure 15: Annual PM_{2.5} for Kitsap County | 35 |
| Figure 16: Annual PM_{2.5} for Pierce County | 36 |
| Figure 17: Annual PM_{2.5} for Snohomish County | 37 |
| Figure 18: Seattle Beacon Hill Average Contributions 2008 | 39 |
| Figure 19: Seattle Beacon Hill Contributions on Highest Days 2008 (7 samples over 15 µg/m³) ... 39 | |
| Figure 20: Tacoma South L Average Contributions 2008 | 40 |
| Figure 21: Tacoma South L Contributions on Highest Days 2008 (3 samples over 20 µg/m³) 40 | |
| Figure 22: Ozone for Puget Sound Region | 45 |
| Figure 23: Ozone (O₃) for Puget Sound Region May-September 2008 | 46 |
| Figure 24: Nitrogen Dioxide (NO₂) (1995-2005) and Reactive Nitrogen (2007-2008) | 48 |
| Figure 25: Carbon Monoxide (CO) for Puget Sound Region | 50 |
| Figure 26: Sulfur Dioxide (SO₂) 24-Hour Average for Puget Sound Region | 52 |
| Figure 27: Sulfur Dioxide (SO₂) 1-Hour Average for Puget Sound Region | 53 |
| Figure 28: Puget Sound Visibility | 56 |
| Figure 29: King County Visibility | 57 |
| Figure 30: Kitsap County Visibility | 58 |
| Figure 31: Pierce County Visibility | 59 |
| Figure 32: Snohomish County Visibility | 60 |
| Figure 33: Carbon Tetrachloride Annual Average Concentrations at Beacon Hill, 2000-2008 | 64 |
| Figure 34: Benzene Annual Average Concentrations at Beacon Hill, 2000-2008 | 65 |
| Figure 35: 1,3-Butadiene Annual Average Concentrations at Beacon Hill, 2000-2008 | 66 |
| Figure 36: Formaldehyde Annual Average Concentrations at Beacon Hill, 2000-2008 | 67 |
| Figure 37: Acetaldehyde Annual Average Concentrations at Beacon Hill, 2000-2008 | 68 |
| Figure 38: Chloroform Annual Average Concentrations at Beacon Hill, 2000-2008 | 69 |
| Figure 39: Tetrachloroethylene Annual Average Concentrations at Beacon Hill, 2000-2008 | 70 |

LIST OF MAPS

| | |
|--|-----------|
| Map 1: Active Air Monitoring Network for 2008 | 18 |
| Map 2: The 98th Percentile 3-Year Average Daily PM_{2.5} Concentrations for 2008 | 27 |
| Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2008 | 43 |

LIST OF TABLES

| | |
|---|-----------|
| Table 1: AQI Ratings for 2008 | 4 |
| Table 2: Air Quality Monitoring Network | 14 |
| Table 3: Puget Sound Region Air Quality Standards for Criteria Pollutants for 2008 | 24 |
| Table 4: 2008 Beacon Hill Air Toxics Ranking | 62 |
| Table 5: 2008 Calculation and Breakpoints for the Air Quality Index (AQI) | 74 |

APPENDIX – DATA TABLES

| | |
|--|-------------|
| Air Quality Index King County (1980-2008) | A-1 |
| Air Quality Index Kitsap County (1990-2008) | A-2 |
| Air Quality Index Pierce County (1980-2008) | A-3 |
| Air Quality Index Snohomish County (1980-2008) | A-4 |
| Monitoring Methods Used from 1999 to 2008 in the Puget Sound Airshed | A-5 |
| Burn Bans 1988-2008 | A-6 |
| Particulate Matter (PM_{2.5}) – Reference Sampling Method | A-7 |
| Particulate Matter (PM_{2.5}) – Continuous TEOM Sampling Method | A-8 |
| Particulate Matter (PM_{2.5}) – Continuous Nephelometer Sampling Method | A-9 |
| PM_{2.5} Speciation Analytes Monitored in 2008 | A-11 |
| PM_{2.5} Black Carbon | A-12 |
| Ozone (8-hour concentration) | A-13 |
| Reactive Nitrogen | A-14 |
| Carbon Monoxide | A-15 |
| Sulfur Dioxide | A-16 |
| 2008 Beacon Hill Air Toxics Statistical Summary for Air Toxic Gases | A-17 |
| 2008 Beacon Hill Air Toxics Statistical Summary for PM₁₀ Metals | A-17 |
| 2008 Air Toxics Unit Risk Factors | A-18 |
| 2008 Beacon Hill Potential Cancer Risk Estimates, per 1,000,000, 95th Percentile | A-19 |
| Non-cancer Reference Concentrations (RfC) and Hazard Indices | A-20 |

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

www.pscleanair.org/

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



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

INTRODUCTION

BACKGROUND

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

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

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

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

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

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

REPORT ORGANIZATION

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

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

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

EXECUTIVE SUMMARY

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

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

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

Monitoring sites in Snohomish County are close to the daily fine particle federal standard. Sites in all four counties (King, Kitsap, Pierce, and Snohomish) continue to exceed the agency's local PM_{2.5} health goal, set at 25 µg/m³ to adequately protect health.

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

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

Many of the same sources that produce criteria and toxic air pollutants also generate greenhouse gases. The agency collaborates with public and private partners to reduce greenhouse gases.³ Unlike the criteria pollutants and air toxics included in this summary, we do not monitor their levels in the atmosphere. The agency focuses on local emission inventories and reduction strategies. For more information, refer to <http://www.pscleanair.org/programs/climate/default.aspx>.

²Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

³Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound; <http://www.pscleanair.org/programs/climate/rptfin.pdf>.

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

AIR QUALITY INDEX (AQI)

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

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

Table 1: AQI Ratings for 2008

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

IMPAIRED AIR QUALITY – BURN BANS AND SMOG FORECASTS

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

The agency issued one Stage 1 burn ban in 2008 for Pierce and Snohomish Counties. The burn ban occurred January 23-26.

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

CRITERIA AIR POLLUTANTS AND VISIBILITY

The Puget Sound airshed is currently in attainment for carbon monoxide, ozone, and PM₁₀, and has maintenance plans in place for these pollutants.

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

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

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

AIR TOXICS

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

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

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

AIR QUALITY INDEX

The air quality index (AQI) is reported according to a 500-point scale for five of the six major criteria air pollutants: ozone, particulate matter (both PM_{2.5} and PM₁₀), carbon monoxide, nitrogen dioxide, and sulfur dioxide. The highest pollutant determines the daily ranking. For example, if an area has a carbon monoxide value of 132 on a given day and all other pollutants are below 50, the AQI for that day would be 132. The scale breaks down into 6 categories, listed below. Each category has a corresponding color, shown with pollution concentration breakpoints for each category (see Table 5 in the Definitions section of this document).

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

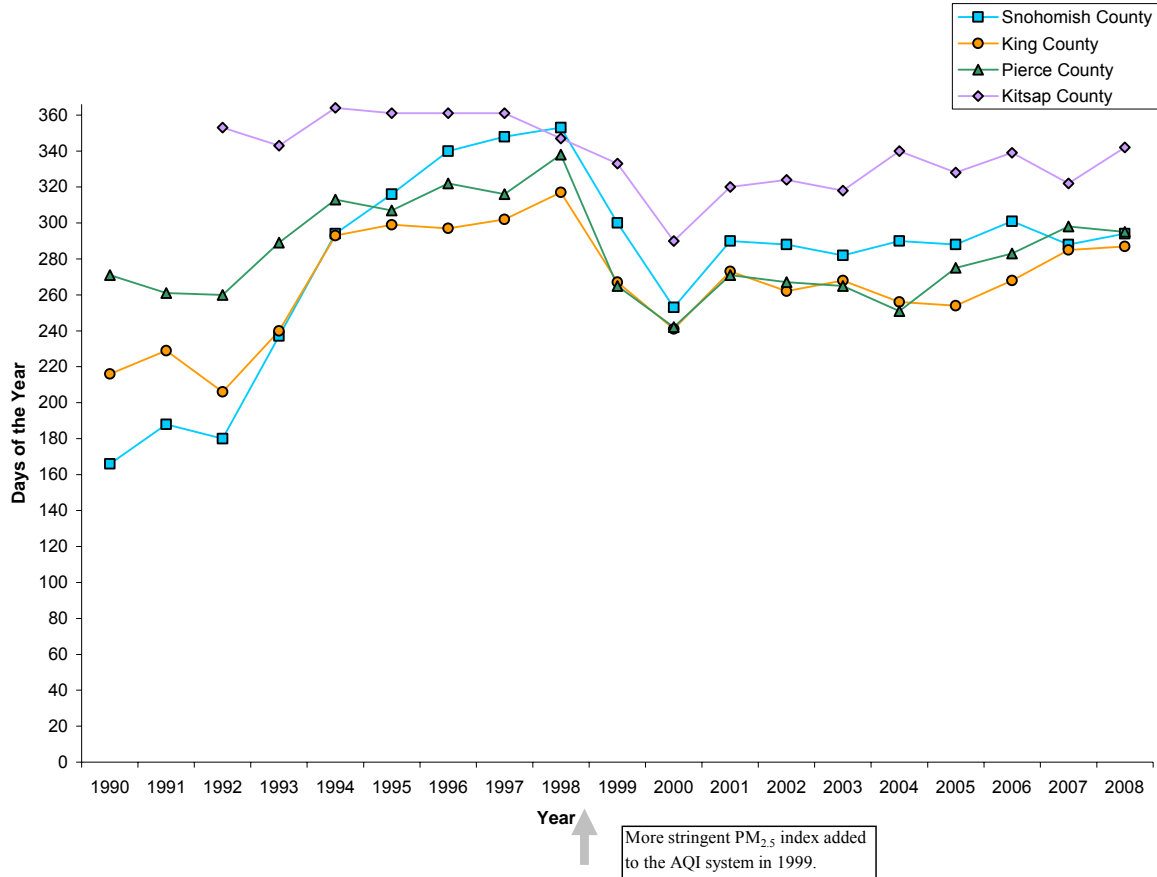
The AQI is a national index, so the reported values and colors used to show local air quality and the associated level of health concern will be the same throughout the United States. Current and archived AQI values for Puget Sound can be found on our website at www.pscleanair.org.

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

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

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

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



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

Figure 2: Air Quality for King County

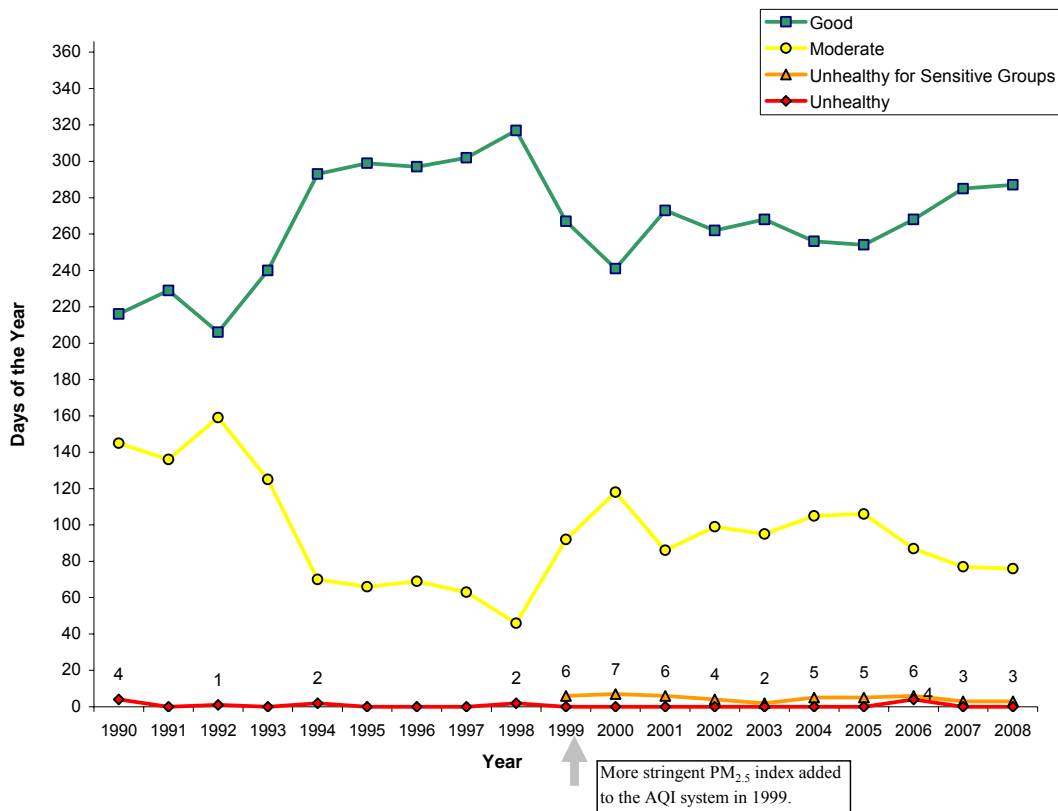


Figure 3: Air Quality for Kitsap County

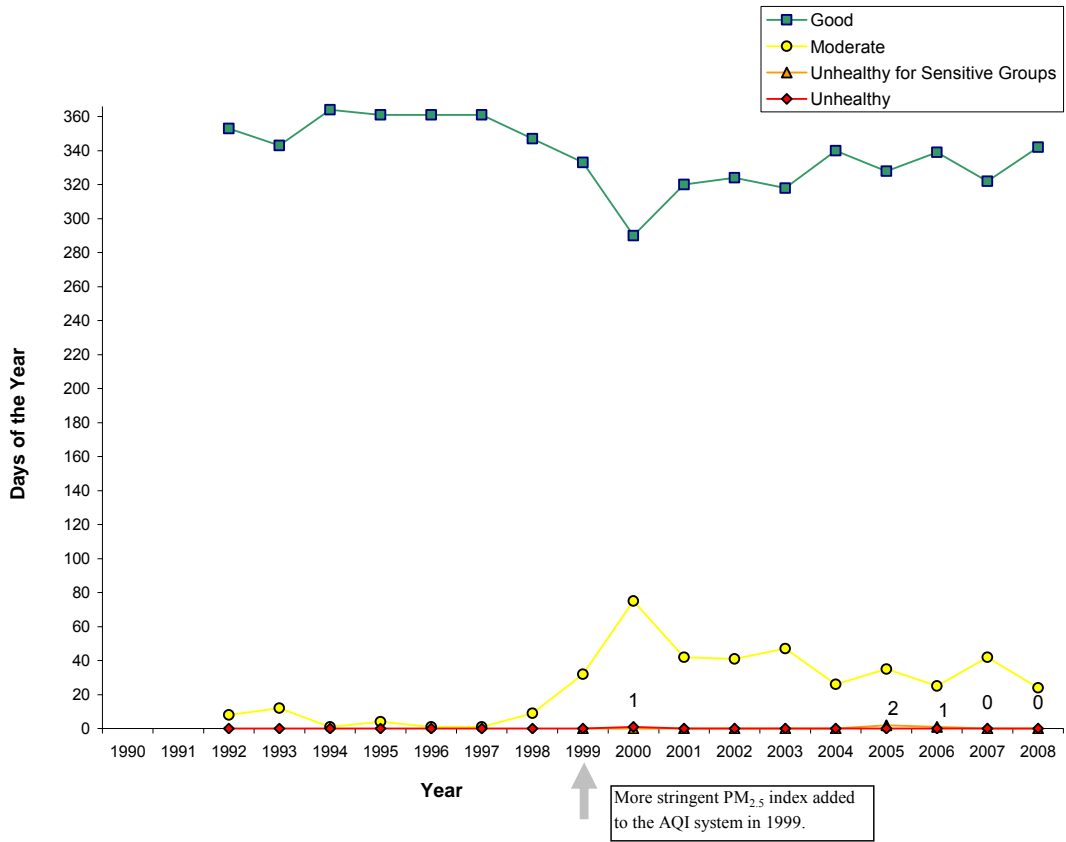


Figure 4: Air Quality for Pierce County

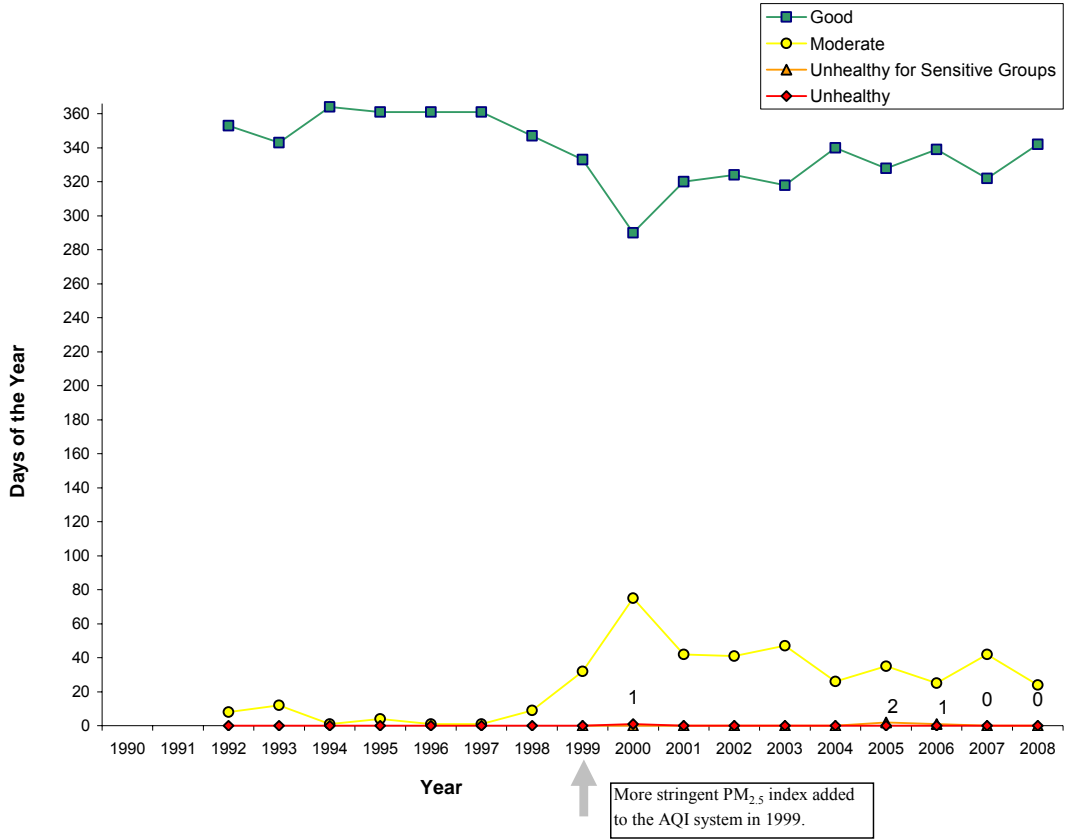
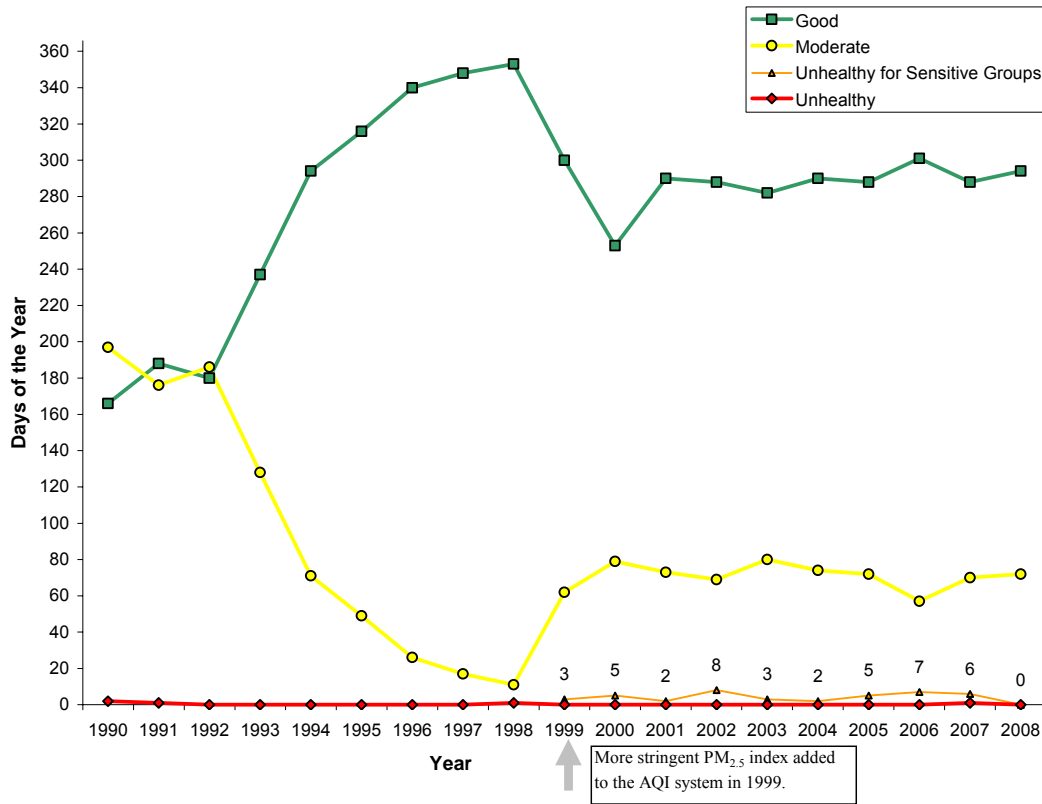


Figure 5: Air Quality for Snohomish County



MONITORING NETWORK

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

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

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

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

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

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

FINE PARTICULATE MONITORING – FEDERAL REFERENCE METHOD AND CONTINUOUS METHODS

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

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

These methods determine fine particulate matter concentration differently:

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

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

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

Table 2: Air Quality Monitoring Network

| Station ID | Location | PM ₁₀ Ref | PM ₁₀ bam | PM ₁₀ Teom | PM _{2.5} ref | PM _{2.5} bam | PM _{2.5} teom | PM _{2.5} ls | PM _{2.5} bc | O ₃ | SO ₂ | NO _y | CO | b _{sp} | Wind | Temp | AT | Vsby | Location |
|------------|--|----------------------|----------------------|-----------------------|-----------------------|-----------------------|------------------------|----------------------|----------------------|----------------|-----------------|-----------------|----|-----------------|------|------|----|------|----------|
| AO | Northgate, 310 NE Northgate Way, Seattle (ended Mar 31, 2003) | | | | | | | | | | | | X | | | | | | b, d, f |
| AQ | Queen Anne Hill, 400 W Garfield St, Seattle (photo/visibility included) | | | | | | | ● | | | | | | ● | ● | ● | | ● | a, d, f |
| AR | 4th Ave & Pike St, 1424 4 th Ave, Seattle (ended Jun 30, 2006) | | | | | | | | | | | | X | | | | | | a, d |
| AS | 5th Ave & James St, Seattle (ended Feb 28, 2001) | | | | | | | | | | | | X | | | | | | a, d |
| AU | 622 Bellevue Way NE, Bellevue (ended Jul 30, 1999) | | | | | | | | | | | | X | | | | | | a, d |
| AZ | Olive Way & Boren Ave, 1624 Boren Ave, Seattle SPECIATION SITE | | | | | | | ● | ● | | | | | ● | ● | ● | | ● | a, d |
| BF | University District, 1307 NE 45th St, Seattle (ended Jun 30, 2006) | | | | | | | | | | | | X | | | | | | b, d |
| BU | Highway 410, 2 miles E of Enumclaw (ended Sep 30, 2000) | | | | | | | | | X | | | | | | | | | c, e |
| BV | Sand Point, 7600 Sand Pt Way NE, Seattle (ended Aug 31, 2006 in the process of restarting) | | | | | | | ● | | | | | | ● | X | X | | | b, d |
| BW | Beacon Hill, 15th S & Charlestown, Seattle SPECIATION SITE | | | | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | b, d, f |
| BZ | | | | | | | | | | | | | | | | | | | |
| CE | Duwamish, 4752 E Marginal Way S, Seattle SPECIATION SITE | X | | X | ● | | ● | ● | ● | | X | | | ● | ● | ● | | ● | a, e |
| CG | Woodinville, 17401 133 rd Av NE, Woodinville | | | | | | | ● | | | | | | ● | | | | | b,d,f |
| CW | James St & Central Ave, Kent | X | | X | X | | ● | ● | | | | | | ● | ● | ● | | ● | b, d |
| CX | 17711 Ballinger Way NE, Lake Forest Park (ended Jun 4, 1999) | X | X | | | | | | | | | | | X | X | | | X | b, d, f |
| CZ | Aquatic Center, 601 143 rd Ave NE, Bellevue (ended May 31, 2006) | | | | | | X | X | | | | | | X | | | | X | b, f |

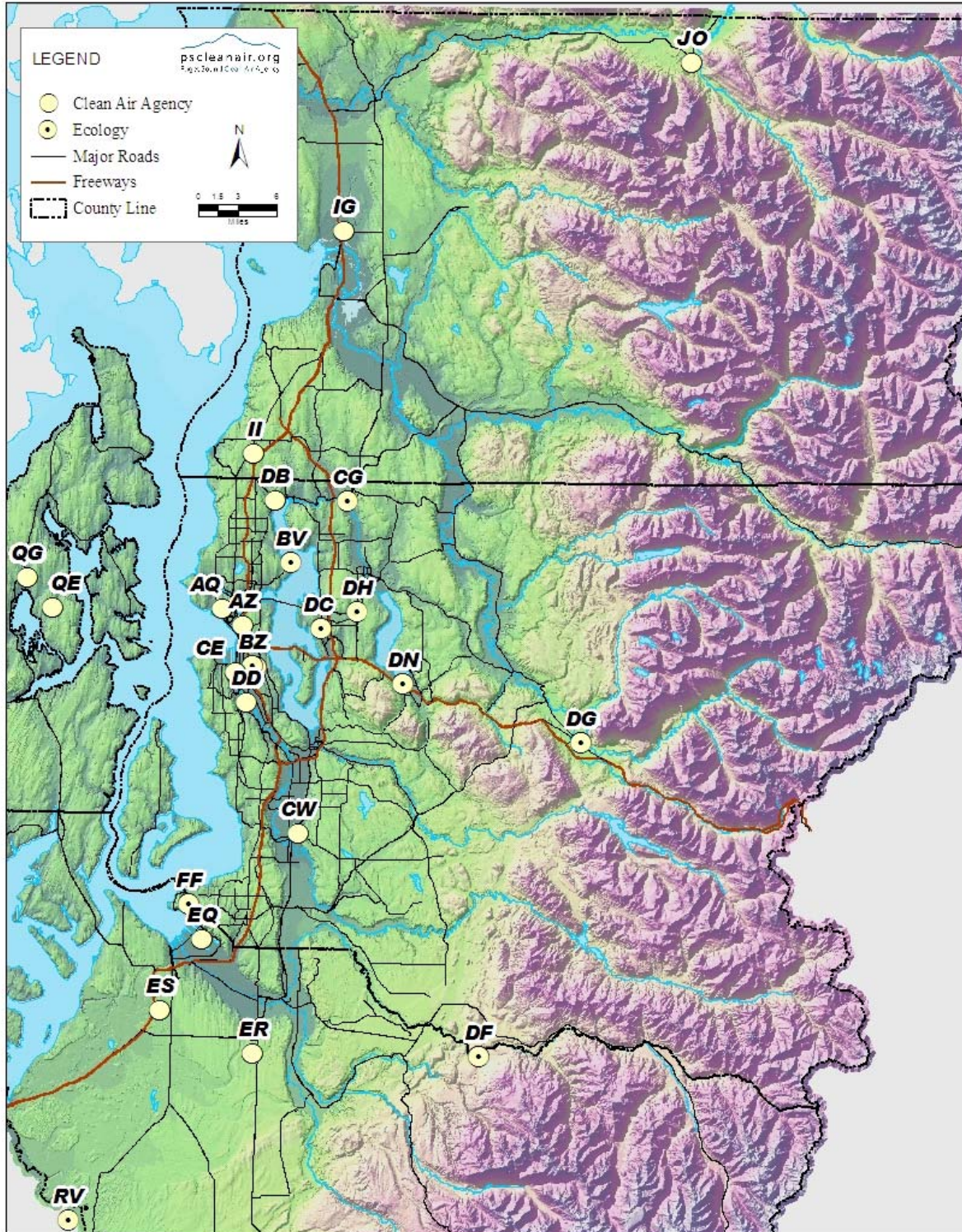
| Station ID | Location | PM ₁₀ Ref | PM ₁₀ bam | PM ₁₀ Teom | PM _{2.5} ref | PM _{2.5} bam | PM _{2.5} teom | PM _{2.5} ls | PM _{2.5} bc | O ₃ | SO ₂ | NO _y | CO | b _{sp} | Wind | Temp | AT | Vsby | Location |
|------------|---|----------------------|----------------------|-----------------------|-----------------------|-----------------------|------------------------|----------------------|----------------------|----------------|-----------------|-----------------|----|-----------------|------|------|----|------|------------|
| DA | South Park, 8025 10 th Ave S, Seattle (ended Dec 31, 2002) | X | | | X | | | X | | | | | | X | X | | | X | b, e, f |
| DB | 17171 Bothell Way NE, Lake Forest Park SPECIATION SITE | X | X | | ● | | ● | ● | ● | | | | | ● | ● | ● | | ● | b, d, f |
| DC⊙ | 305 Bellevue Way NE, Bellevue | | | | X | | | ● | | | | | | ● | | | | ● | a, d |
| DD | South Park, 8201 10 th Ave S, Seattle | | | | | | | ● | | | | | | ● | | | | ● | b, e, f |
| DE⊙ | City Hall, 15670 NE 85 th St, Redmond (ended Dec 14, 2005) | | | | X | | | X | | | | | | X | | | | X | a, d |
| DF⊙ | 30525 SE Mud Mountain Road, Enumclaw | | | | X | | | ● | | ● | | | | ● | ● | ● | | ● | c |
| DG⊙ | 42404 SE North Bend Way, North Bend | | | | X | | X | ● | | ● | | | | ● | ● | ● | | ● | c, d, f |
| DH⊙ | 2421 148 th Ave NE, Bellevue | | | | | | | | | | | | ● | | | | | | b, d |
| DK⊙ | 43407 212 th Ave SE, 2 mi west of Enumclaw (ended Sep 6, 2006) | | | | | | | | | | | | | | X | X | | | c |
| DL⊙ | NE 8th St & 108th Ave NE, Bellevue (ended March 4, 2003) | | | | | | | | | | | | X | | | | | | a, d |
| DN⊙ | 20050 SE 56 th , Lake Sammamish State Park, Issaquah | | | | | | | | | ● | | | | | ● | ● | | | b, d |
| DP⊙ | 504 Bellevue Way NE, Bellevue (ended Sep 30, 1999) | X | | | X | | | | | | | | | | | | | | a, d |
| DZ⊙ | Georgetown, 6431 Corson Ave S, Seattle (ended August 31, 2002) | | | | | | | | | | | X | X | | X | | | | a, d, e, f |
| EA | Fire Station #12, 2316 E 11 th St, Tacoma (ended Dec 31, 2000) | X | X | | | | | | | | | | | | X | | | | a, e |
| EP | 27th St NE & 54th Ave NE, Tacoma (ended Feb 29, 2000) | X | | | | | | | | | X | | | | X | | | | b, e, f |
| EQ | Tacoma Tideflats, 2301 Alexander Ave, Tacoma | X | X | X | X | | X | ● | | | X | | | ● | ● | ● | | ● | a, e |
| ER | South Hill, 9616 128 th St E, Puyallup | X | X | | X | X | | ● | | | | | | ● | ● | ● | | ● | b, f |
| ES | 7802 South L St, Tacoma (began Oct 3, 1999) | | | | ● | | ● | ● | ● | | | | | ● | ● | ● | | ● | b, f |
| FF⊙ | Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma | | | | | | | | | | | | | | ● | ● | | | b, f |

| Station ID | Location | PM ₁₀ Ref | PM ₁₀ bam | PM ₁₀ Teom | PM _{2.5} ref | PM _{2.5} bam | PM _{2.5} teom | PM _{2.5} Is | PM _{2.5} bc | O ₃ | SO ₂ | NO _y | CO | b _{sp} | Wind | Temp | AT | Vsby | Location |
|------------|--|----------------------|----------------------|-----------------------|-----------------------|-----------------------|------------------------|----------------------|----------------------|----------------|-----------------|-----------------|----|-----------------|------|------|----|------|----------|
| FG☉ | Mt Rainier National Park, Jackson Visitor Center | | | | | | | | | ● | | | | | | | | | c |
| FH☉ | Charles L Pack Forest, La Grande | | | | | | | | | ● | | | | | | | | | c, f |
| FL☉ | 1101 Pacific Ave, Tacoma (ended Jun 30, 2006) | | | | | | | | | | | | X | | | | | | a, d |
| ID | Hoyt Ave & 26th St, Everett (ended Feb 29, 2000) | | | | | | | | | | x | | | | X | | | | a, e, d |
| IG | Marysville JHS, 1605 7 th St, Marysville | X | X | | ● | | ● | ● | ● | | | | | ● | ● | ● | | ● | b, d |
| IH | 20935 59 th Place West, Lynnwood (ended Jun 8, 1999) | X | | X | | | | | | | | | | X | X | | | X | a, d |
| II | 6120 212 th St SW, Lynnwood | | | | X | X | ● | ● | | | | | | ● | ● | ● | | ● | b, d |
| JN☉ | 5810 196 th Street, Lynnwood (ended Jun 30, 2006) | | | | | | | | | | | | X | | | | | | a, d |
| JO | Darrington High School, Darrington 1085 Fir St | | | | ● | | | ● | ● | | | | | ● | ● | ● | | ● | d, f |
| JP☉ | 2939 Broadway Ave, Everett (ended March 31, 2003) | | | | | | | | | | | | X | | | | | | a, d |
| JQ☉ | 44th Ave W & 196 th St SW, Lynnwood (ended May 3, 2004) | | | | | | | | | | | | X | | | | | | a, d |
| JS☉ | Broadway & Hewitt Ave, Everett (ended May 21, 2000) | | | | | | | | | | | | X | | | | | | a, d |
| QE | Meadowdale, 7252 Blackbird Dr NE, Bremerton | X | | | | X | | ● | | | | | | ● | ● | ● | | ● | b, f |
| QF | Lions Park, 6th Ave NE & Fjord Dr, Poulsbo (ended Feb 29, 2000) | | | | | | | | | | | | | | X | | | | b, f |
| QG | Fire Station #51, 10955 Silverdale Way, Silverdale (began Jun 2, 2000) | | | | | X | | ● | | | | | | ● | ● | ● | | ● | a, d |
| RV☉ | Yelm N Pacific Road, 931 Northern Pacific Rd SE, Yelm (began May 2005) | | | | | | | | | ● | | | | | | | | | c, f |
| UB☉ | 71 E Campus Dr, Belfair (ended Sep 30, 2004) | | | | | | | | | X | | | | | | | | | c |

| Station ID | Location | PM ₁₀ Ref | PM ₁₀ bam | PM ₁₀ Teom | PM _{2.5} ref | PM _{2.5} bam | PM _{2.5} teom | PM _{2.5} ls | PM _{2.5} bc | O ₃ | SO ₂ | NO _y | CO | b _{sp} | Wind | Temp | AT | Vsby | Location |
|------------|---|----------------------|----------------------|-----------------------|-----------------------|-----------------------|------------------------|----------------------|----------------------|----------------|-----------------|-----------------|----|-----------------|------|------|----|------|----------|
| VK⊙ | Fire Station, 709 Mill Road SE, Yelm (began May 1, 2000, ended in Oct 2005) | | | | | | | | | X | | | | | | | | | c,f |

- ⊙ Station operated by Ecology
- RV⊙ Shading indicates station currently functioning
- Indicates parameter currently monitored
- X Indicates parameter previously monitored
- PM₁₀ ref Particulate matter 10 micrometers (reference)
- PM₁₀ bam Particulate matter 10 micrometers (beta attenuation continuous)
- PM₁₀ teom Particulate matter 10 micrometers (teom continuous)
- PM_{2.5} ref Particulate matter 2.5 micrometers (reference)
- PM_{2.5} bam Particulate matter 2.5 micrometers (beta attenuation continuous)
- PM_{2.5} teom Particulate matter 2.5 micrometers (teom continuous)
- PM_{2.5} ls Particulate matter 2.5 micrometers (light scattering nephelometer continuous)
- PM_{2.5} bc Particulate matter 2.5 micrometers black carbon (light absorption aethalometer)
- Location
 - a Urban Center
 - b Suburban
 - c Rural
 - d Commercial
 - e Industrial
 - f Residential
- SO₂ Sulfur Dioxide
- NO_x Nitrogen Oxide
- CO Carbon Monoxide
- b_{sp} Light scattering by atmospheric particles (nephelometer)
- Wind Wind direction and speed
- Temp Air temperature (relative humidity also measured at BW)
- AT Air Toxics
- VSBY Visual range (light scattering by atmospheric particles)
- PHOTO Visibility (camera)
- O₃ Ozone (May through September)

Map 1: Active Air Monitoring Network for 2008



IMPAIRED AIR QUALITY – BURN BANS AND SMOG WATCH

BURN BANS

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

There are two stages of the indoor burn bans. For a Stage 1 burn ban, residential burning in fireplaces or uncertified wood stoves is prohibited (unless a wood-burning device is the only adequate source of heat).⁵ For a Stage 2 burn ban, the use of any kind of wood-burning device (including certified wood stoves and pellet stoves) is prohibited unless a wood-burning device is the only adequate source of heat.

Before 2008 a Stage 1 burn ban could be declared by the agency when $PM_{2.5}$ levels reached $35 \mu\text{g}/\text{m}^3$ (24-hour average). A Stage 2 burn ban could be declared when $PM_{2.5}$ levels reached $60 \mu\text{g}/\text{m}^3$ (24-hour average). In 2008, the Washington State Legislature revised the burn ban triggers to be consistent with the new, stricter $PM_{2.5}$ standard. Under the revised statute, a Stage 1 burn ban is triggered when meteorological conditions are predicted to cause fine particulate levels to exceed $35 \mu\text{g}/\text{m}^3$ (based on a 24-hour average) within 48 hours. A Stage 2 burn ban is generally triggered when the following three things have happened:

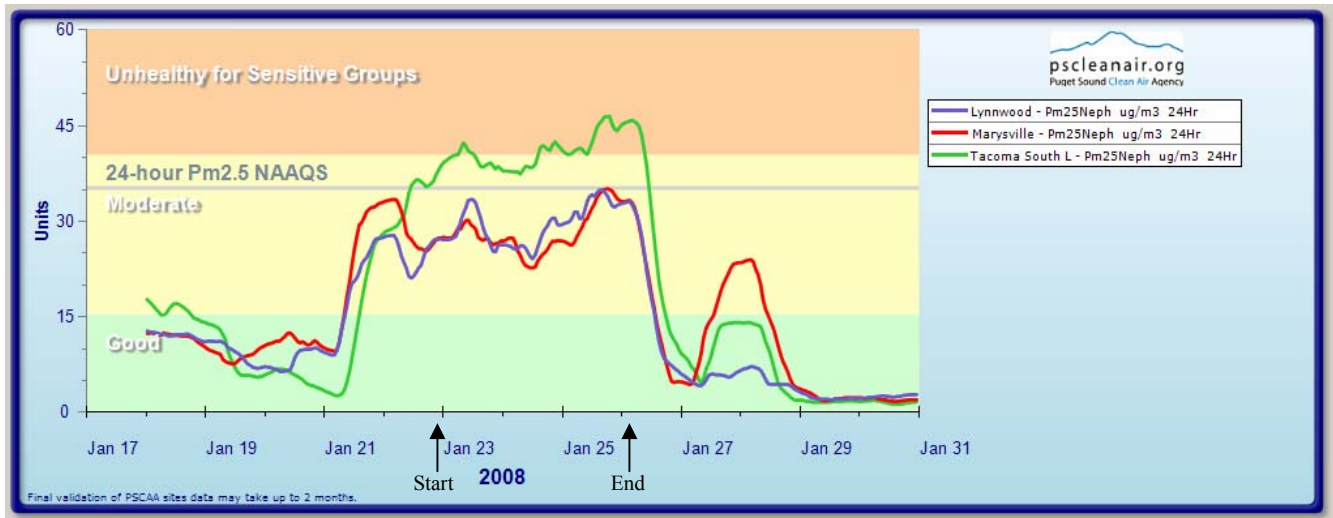
- 1) a Stage 1 burn ban has been enforced and has not been sufficient to reduce the increasing fine particulate pollution trend,
- 2) $PM_{2.5}$ levels are recorded at or above $25 \mu\text{g}/\text{m}^3$ (based on a 24-hour average), and
- 3) forecasted meteorological conditions are not expected to allow $PM_{2.5}$ concentrations to decline.

In the past, Stage 2 burn bans have been very rare; however, with the new burn ban thresholds, it is likely that there will be more Stage 2 burn bans in the future. The agency called one Stage 1 burn ban in 2008 for Snohomish and Pierce counties. The burn ban occurred January 23-26.

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

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

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

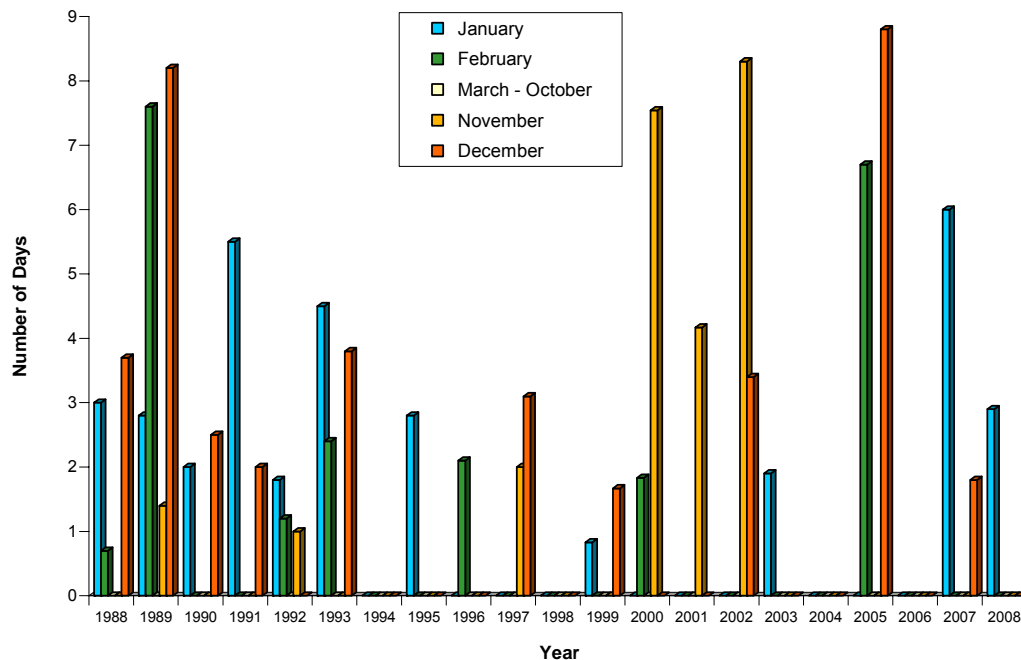


Even with the burn ban, air quality reached the “unhealthy for sensitive groups” designation at the Tacoma South L monitoring site, and exceeded the federal daily standard of 35 $\mu\text{g}/\text{m}^3$. This is not necessarily a violation of the federal standard, because the daily standard is based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

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

Figure 7: Impaired Air Quality Resulting in Burn Bans

Number of Days with Indoor Burning Bans in Puget Sound Region



SMOG FORECASTS

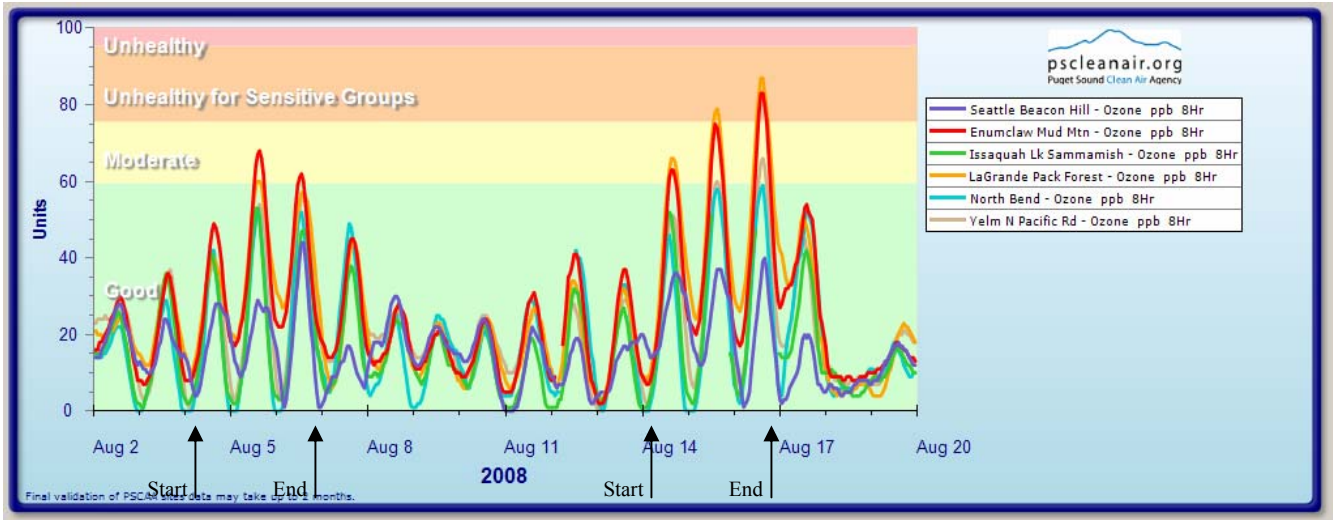
The agency maintains a voluntary air quality smog forecast program. During the summer, the agency notifies residents of potential unhealthy ozone levels. Summer ozone typically becomes a problem on hot stagnant summer days. Thus, advisories are driven more by meteorology than by monitored air quality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

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

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

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

Figure 8: Smog Forecast Events



AIR QUALITY STANDARDS AND HEALTH GOALS

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

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

In addition to air quality standards, the agency has developed an air quality health goal for daily PM_{2.5} concentrations. The agency convened a Particulate Matter Health Committee, comprised of local health professionals, who examined the fine particulate health research.⁷ The Health Committee did not consider the federal standard at the time to be protective of human health. In 1999, the agency adopted a health goal of 25 µg/m³ for a daily average, more protective than the current federal standard of 35 µg/m³. This level is consistent with the American Lung Association's goal and the EPA Clean Air Science Advisory Committee's recommended lower range for the EPA's 2006 ambient air quality standard revision.^{8,9} The form of the agency's health goal is "never-to-be-exceeded." The agency did not adopt a separate health goal for the annual PM_{2.5} average.

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

Similarly, EPA revised the quarterly lead standard on October 15, 2008 from 1.5 µg/m³ to 0.15 µg/m³.¹¹

⁶Washington Administrative Code chapters 173-470, 173-474, and 173-475.

⁷Puget Sound Clean Air Agency. Final Report of the Puget Sound Clean Air Agency PM_{2.5} Stakeholder Group; http://www.pscleanair.org/news/library/reports/pm2_5_report.pdf.

⁸American Lung Association; http://lungaction.org/reports/sota06exec_summ.html.

⁹EPA Clean Air Science Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; <http://www.epa.gov/sab/panels/casacpmpanel.html>.

¹⁰2008 Revised Ground-Level Ozone Standards; <http://www.epa.gov/air/ozonepollution/actions.html>.

¹¹EPA. National Ambient Air Quality Standards – Lead Standards; <http://www.epa.gov/air/lead/actions.html>.

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

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

^aDaily concentration is the 24-hour average, measured from midnight to midnight.

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

^cEPA changed the 8-hour ozone standard from 0.08 to 0.075 in March of 2008.

^dWashington's Ambient Air Standards for SO₂ are more stringent than EPA's standards. These standards can be found at <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-474-100>.

^eEPA changed the quarterly standard for lead from 1.5 µg/m³ to 0.15 µg/m³ in October 2008.

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

PARTICULATE MATTER

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

PM₁₀

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

PM_{2.5} HEALTH AND ENVIRONMENTAL EFFECTS

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

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

PM_{2.5} DAILY FEDERAL STANDARD AND HEALTH GOAL

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

¹²U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; <http://www.epa.gov/particles/actions.html>.

¹³Pope et al. Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association*. 287: pp 1132-1141, March 6, 2002.

¹⁴Gauderman et al. The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. *The New England Journal of Medicine*. Volume 351: pp 1057–1067, Number 11, September 9, 2004.

¹⁵Kunzli et al. Ambient Air Pollution and Atherosclerosis in Los Angeles. *Environmental Health Perspectives*. Volume 113, 2: pp 201-206, February 2005; <http://ehp.niehs.nih.gov/members/2004/7523/7523.pdf>.

¹⁶U.S. Environmental Protection Agency. Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information. EPA-452/R-05-005, June 2005; http://www.epa.gov/ttn/naaqs/standards/pm/data/pmstaffpaper_20050630.pdf.

¹⁷Park et al. Effects of Air Pollution on Heart Rate Variability: The VA Normative Aging Study. *Environmental Health Perspectives*. Volume 113, 3. pp 304-309, March 2005; <http://ehp.niehs.nih.gov/members/2004/7447/7447.pdf>.

¹⁸Goss et al. Effect of Ambient Air Pollution on Pulmonary Exacerbations and Lung Function in Cystic Fibrosis. *American Journal of Respiratory Critical Care Medicine*. Volume 169: pp 816-821. January 12, 2004.

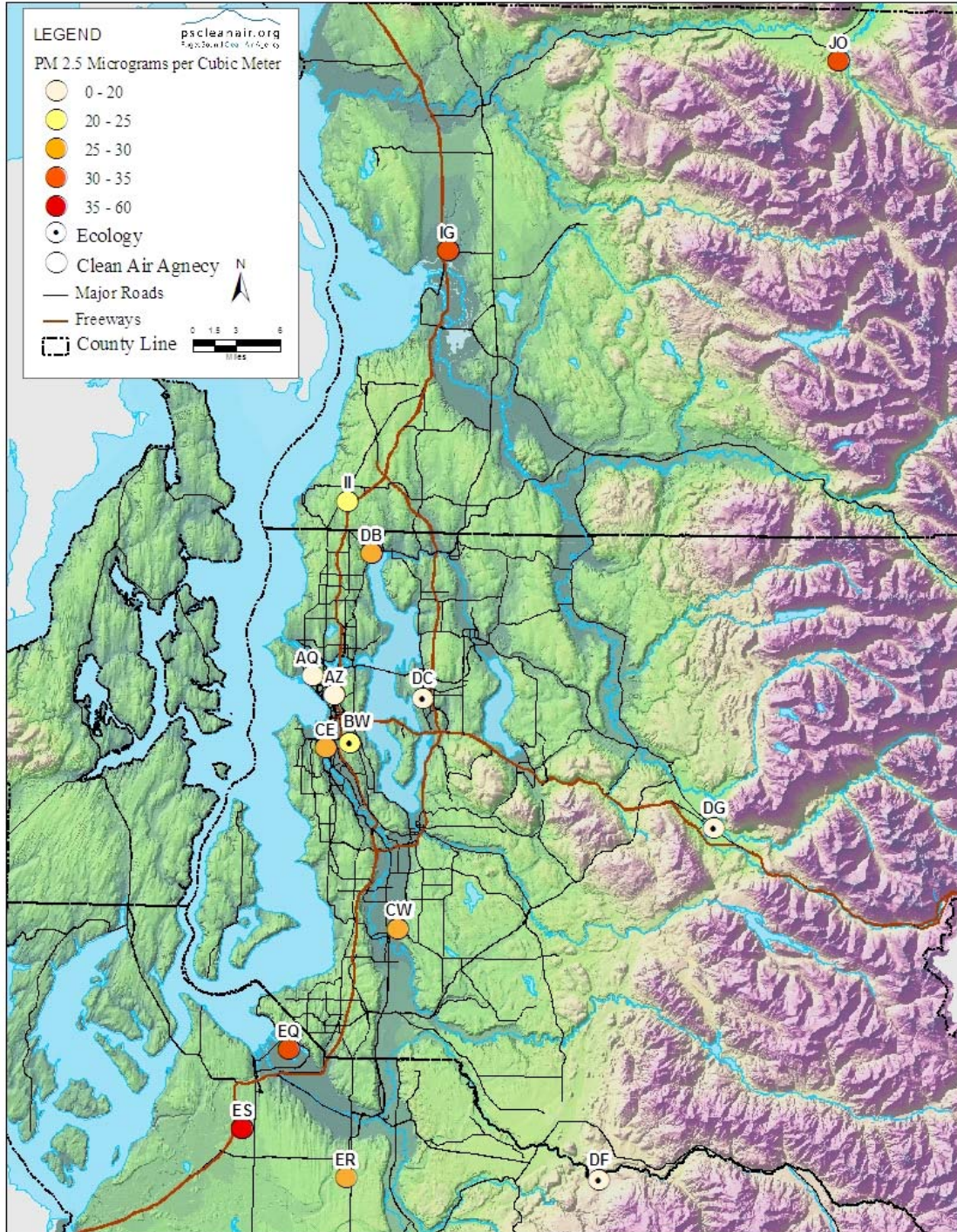
¹⁹U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; <http://www.epa.gov/particles/actions.html>.

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

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

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

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



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

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

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

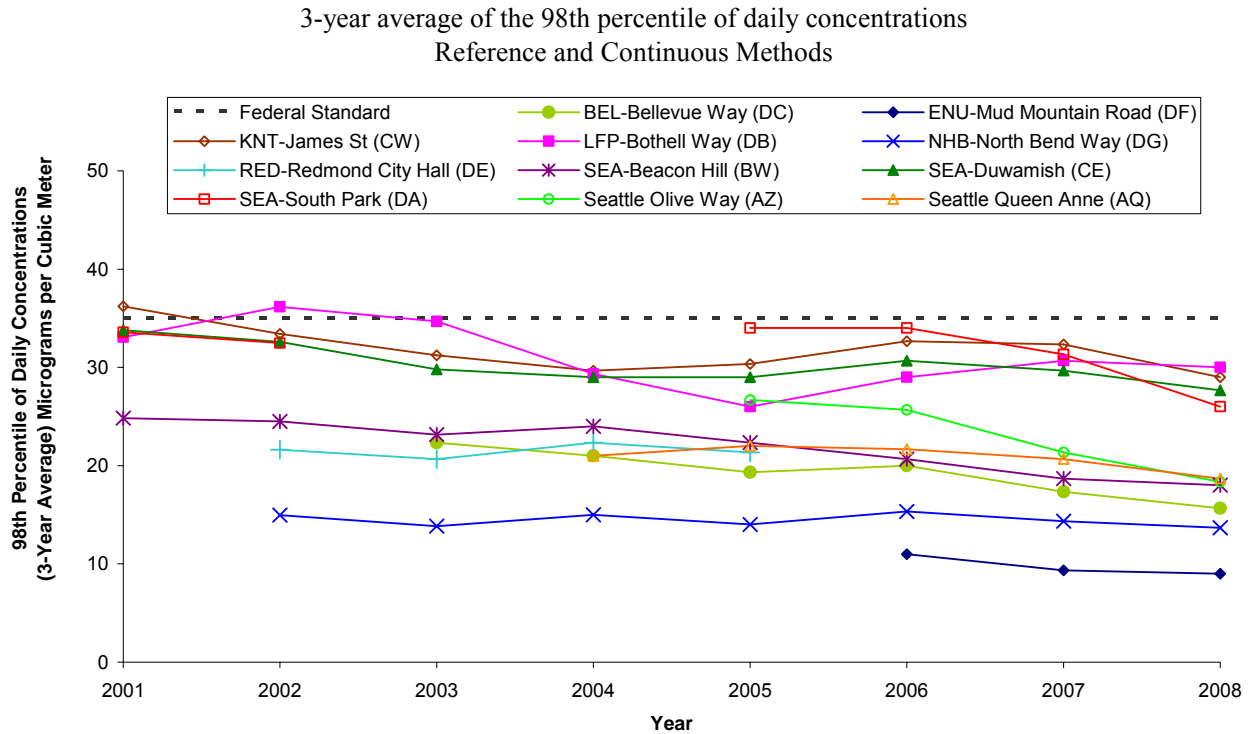
Figure 11 shows that the Tacoma South L Site, located at the south end of Tacoma, violates the new federal standard of 35 $\mu\text{g}/\text{m}^3$. Concentrations at the Darrington and Marysville monitors in Snohomish County, and the Tacoma Tideflats monitor in Pierce County and are the next highest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

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

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

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

Figure 9: Daily PM_{2.5} for King County



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

Figure 10: Daily PM_{2.5} for Kitsap County

3-year average of the 98th percentile of daily concentrations
Continuous Method (BAM/neph)

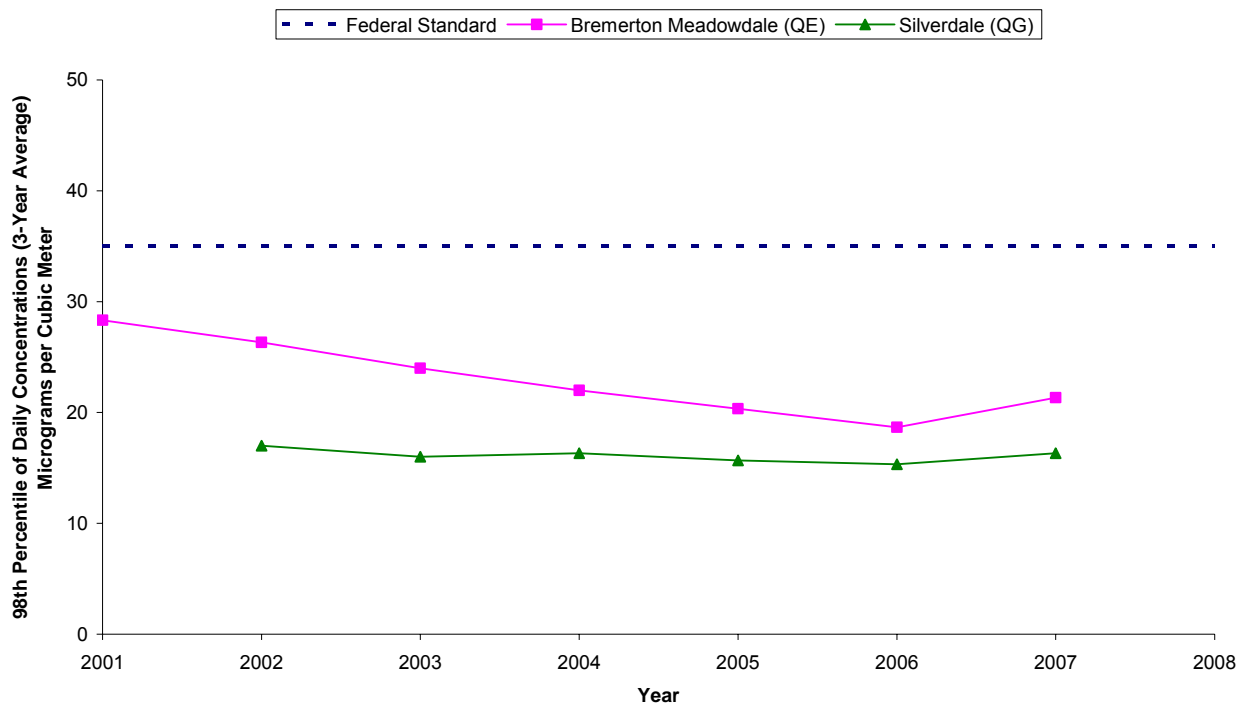
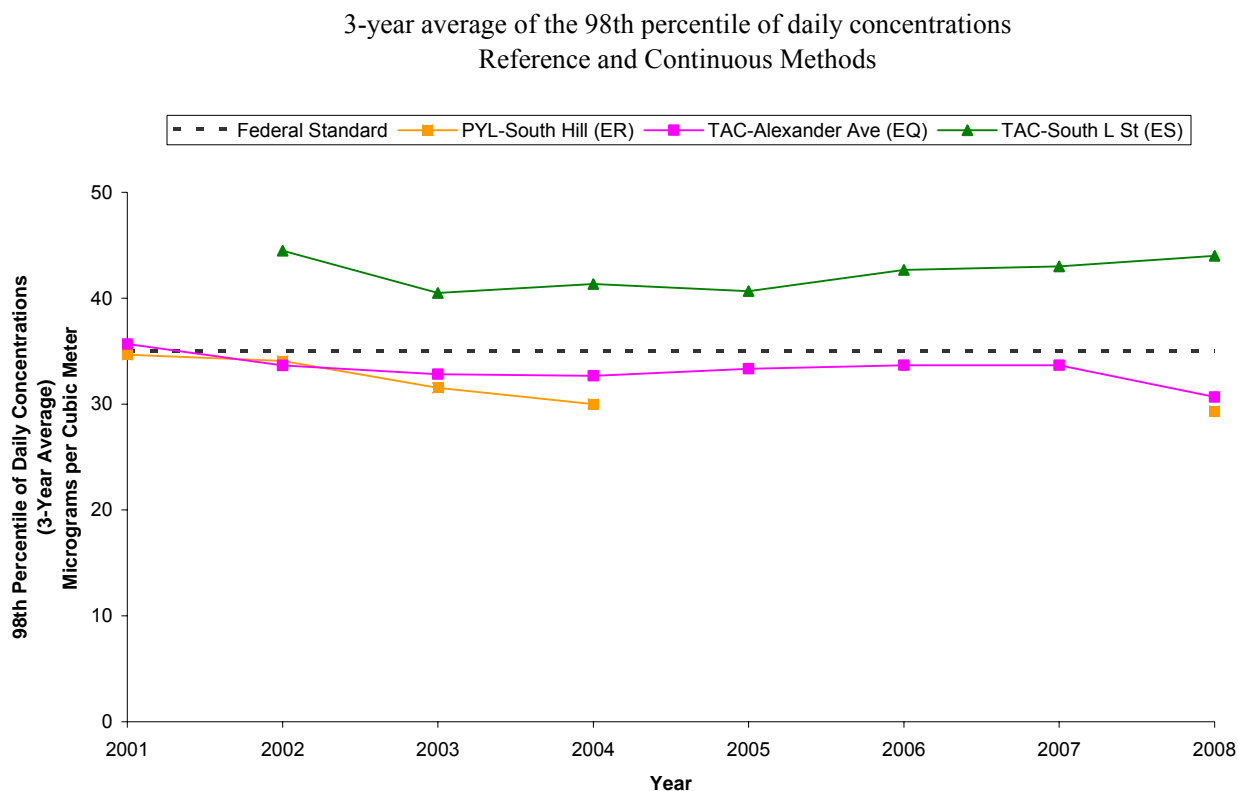


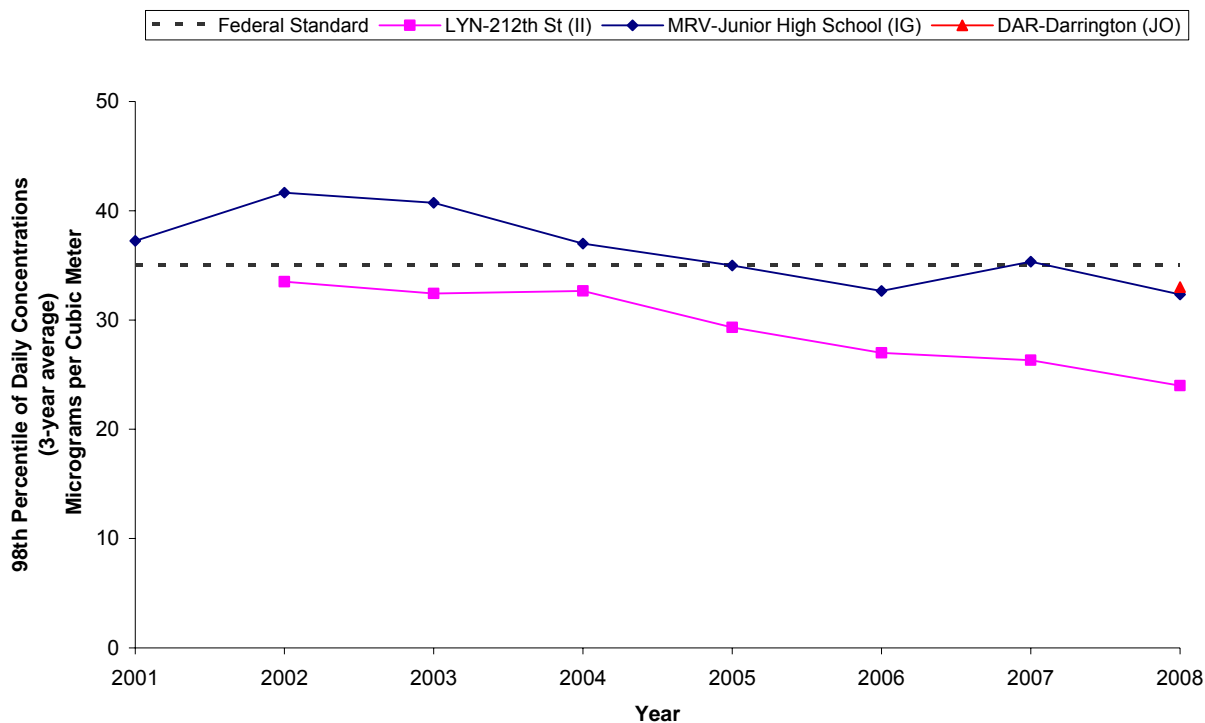
Figure 11: Daily PM_{2.5} for Pierce County



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

Figure 12: Daily PM_{2.5} for Snohomish County

3-year average of the 98th percentile of daily concentrations
Reference and Continuous Methods

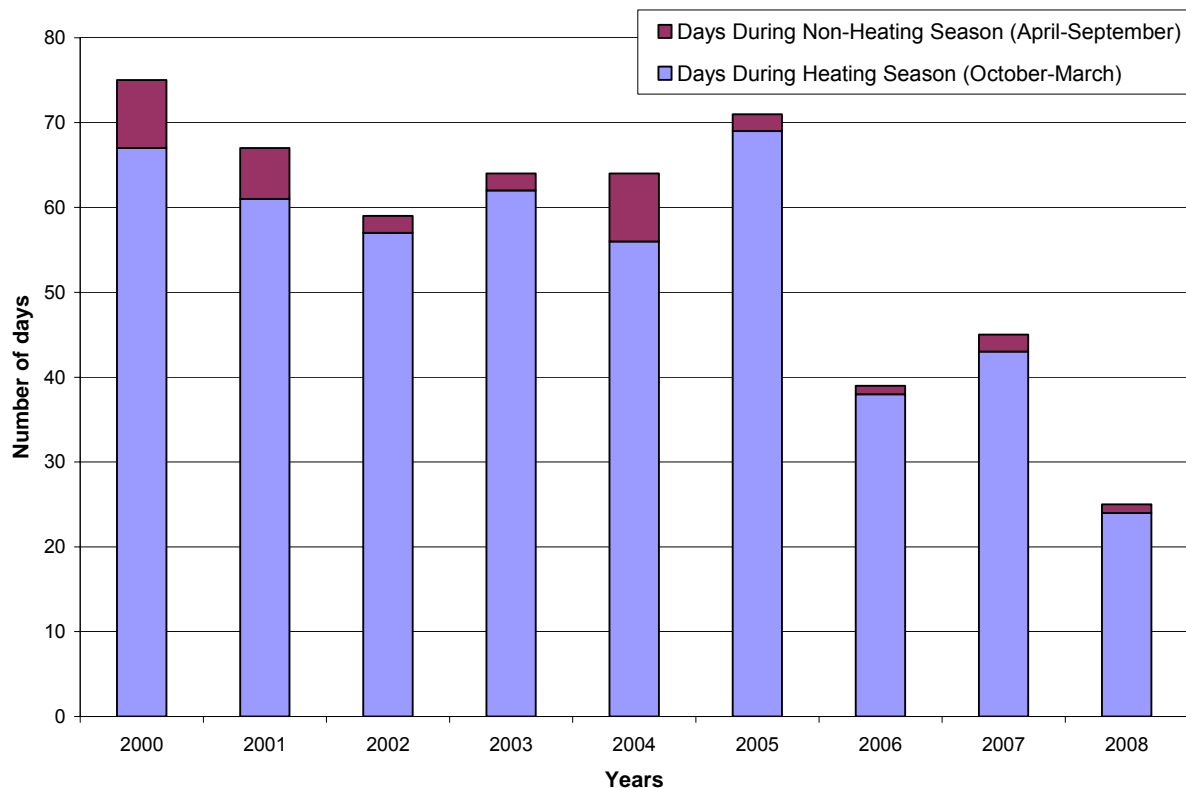


Note: Marysville data are FRM from 1999-2008. Lynnwood (II) data are FRM except 2004, 2007, and 2008 which were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2008.

As described in the Air Quality Standards and Health Goals section, the agency also has a daily fine particulate health goal. Many of the monitoring sites in King, Pierce, and Snohomish Counties exceed the agency’s daily fine particulate health goal of 25 µg/m³ for a 24-hour average. This health goal is intended to never be exceeded (unlike the federal standard that is based on the 98th percentile of a 3-year average).

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

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



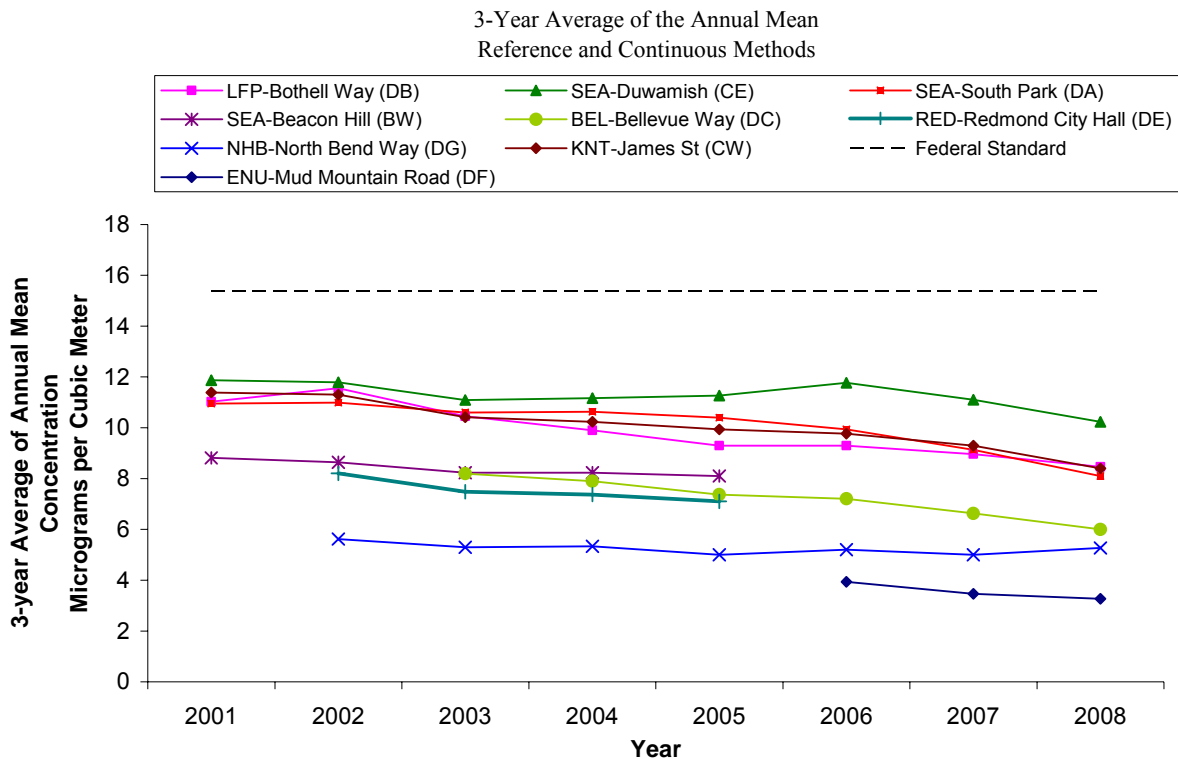
Includes data from all sites in King, Kitsap, Pierce, and Snohomish counties, both daily and continuous methods. The Darrington monitor was added in 2004.

PM_{2.5} ANNUAL FEDERAL STANDARD

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

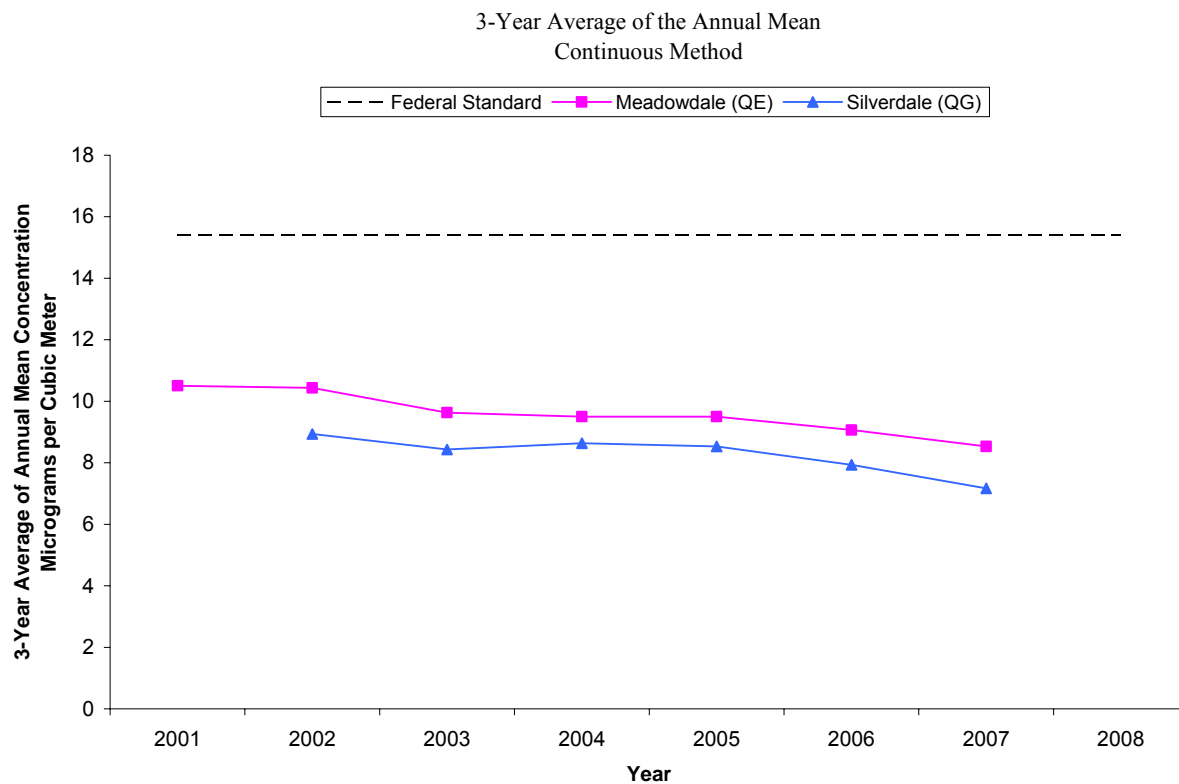
The agency's Particulate Matter Health Committee did not recommend an annual PM_{2.5} health goal lower than the federal annual standard (15 µg/m³).

Figure 14: Annual PM_{2.5} for King County



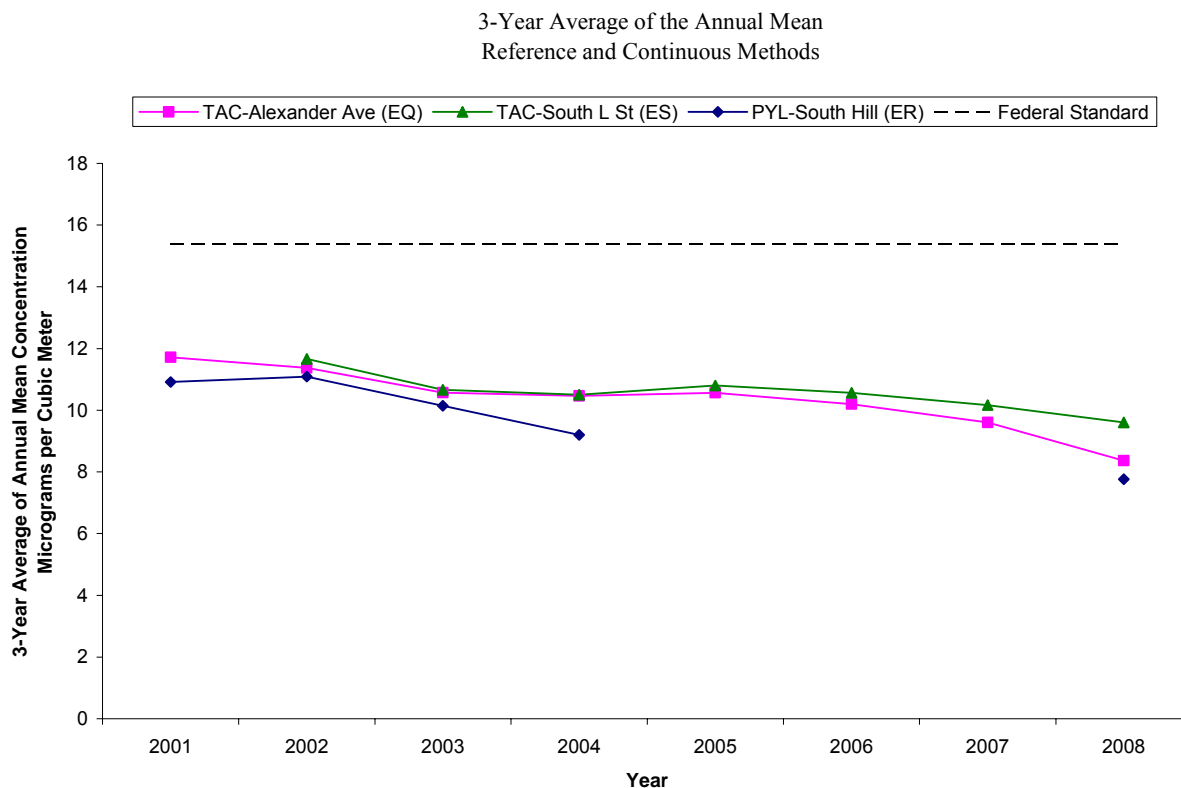
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008. Beacon Hill (BW), and Duwamish (CE) data are FRM from 1999-2008. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2008. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way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

Figure 15: Annual PM_{2.5} for Kitsap County



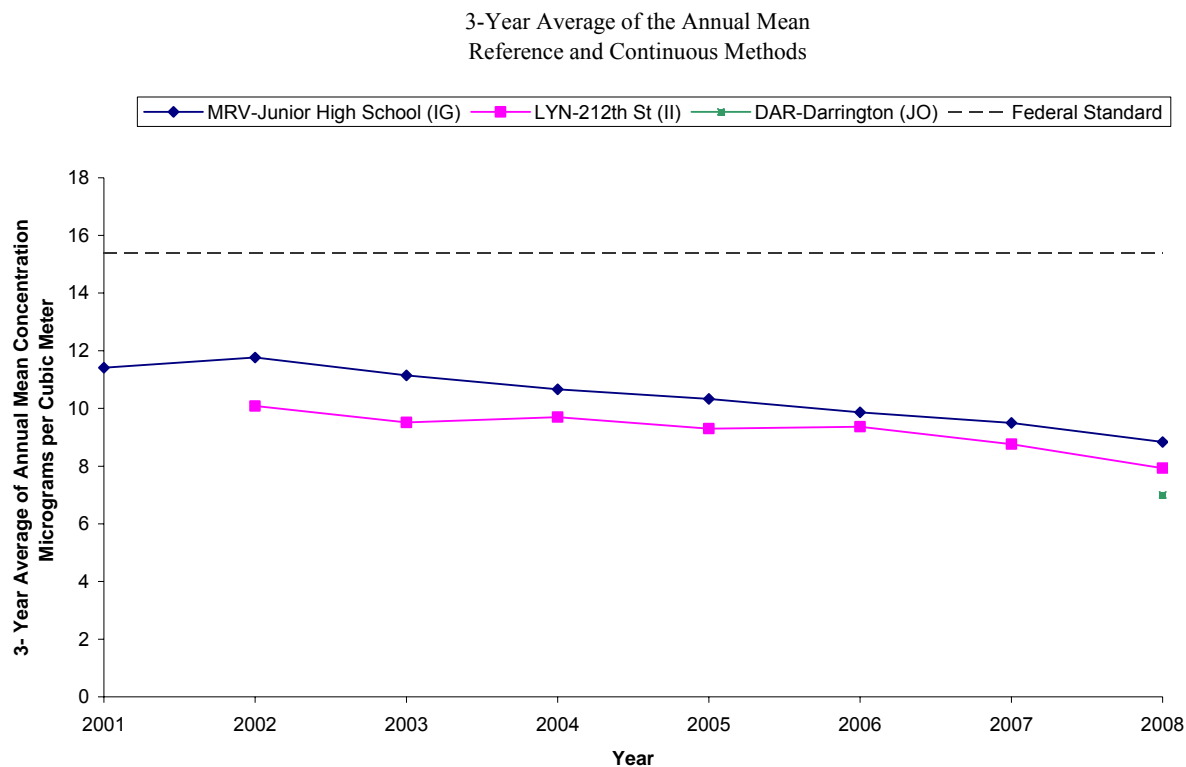
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2008.

Figure 16: Annual PM_{2.5} for Pierce County



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

Figure 17: Annual PM_{2.5} for Snohomish County



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

PM_{2.5} CONTINUOUS DATA AND SEASONAL VARIABILITY

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

PARTICULATE MATTER – PM_{2.5} SPECIATION AND AETHALOMETERS

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

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

SPECIATION MONITORING AND SOURCE APPORTIONMENT

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

Ecology conducted speciation monitoring at two monitoring sites in the Puget Sound region in 2008:

- Seattle Beacon Hill – typical urban impacts, mixture of sources (speciation samples collected every third day)
- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day)

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

- Organic and Elemental Carbon – These are largely from combustion sources.
- Sulfate and Nitrates – These are formed in the atmosphere from sulfur and nitrogen oxides, SO_x and NO_x. The largest sources of SO_x and NO_x in our area are on-road and non-road mobile

²²Puget Sound Air Toxics Evaluation, October 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

²³Brook, Dann, and Burnett. The Relationship Among TSP, PM₁₀, PM_{2.5}, and Inorganic Constituents of Atmospheric Particulate Matter at Multiple Canadian Locations. *Journal of Air & Waste Management*. Volume 47: pp 2-19. January 1997. Page 6 includes a mass reconstruction equation for soil components.

²⁴Jeffrey Brook and Tom Dann. Contribution of Nitrate and Carbonaceous Species to PM_{2.5} Observed in Canadian Cities. *Journal of Air & Waste Management*. Volume 49: pp 193-199. February 1999. Results demonstrate that organic carbon concentrations should be multiplied by a factor of roughly 1.4 to account for the molecular form.

sources (gasoline and diesel fuels). Large industrial sources also contribute substantially to SO_x (about 20%). Voluntary and regulatory programs that have started reducing the sulfur content in fuels will begin to reduce the SO_x and sulfates in our area.

- A “soil” component comprised of analytes typically associated with crustal materials – The soil fraction includes aluminum, silicon, calcium, iron, titanium, and potassium.

Figures 18 through 21 show simplified, major contributors at the speciation sites for the 2008 samples (annual average), as well as on the highest concentration days. Because speciation samples are collected on either every third or sixth day schedules, it’s not possible to capture some of the most elevated concentration days. This schedule results in only a handful of samples (seven for Beacon Hill and three for South End Tacoma) represented in the ‘highest concentration’ pie charts below. Also, as PM_{2.5} concentrations at Beacon Hill are typically lower than at Tacoma South L site, the threshold for a ‘highest concentration day’ is also lower (15 µg/m³ at Beacon Hill vs. 20 µg/m³ at the Tacoma South L site).

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

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

Figure 18: Seattle Beacon Hill Average Contributions 2008

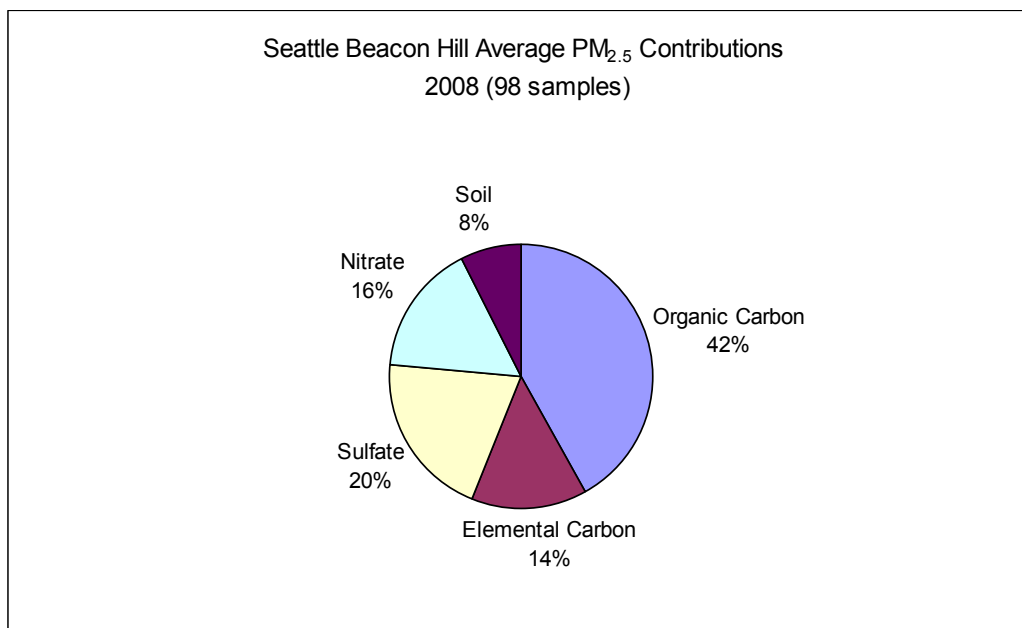


Figure 19: Seattle Beacon Hill Contributions on Highest Days 2008 (7 samples over 15 µg/m³)

Seattle Beacon Hill Average PM_{2.5} Contributions
For Days over 15µg/m³ in 2008 (7 samples)

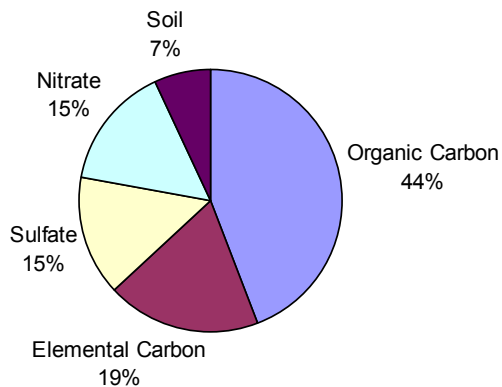


Figure 20: Tacoma South L Average Contributions 2008

Tacoma South L Street Average PM_{2.5} Contributions
2008 (58 samples)

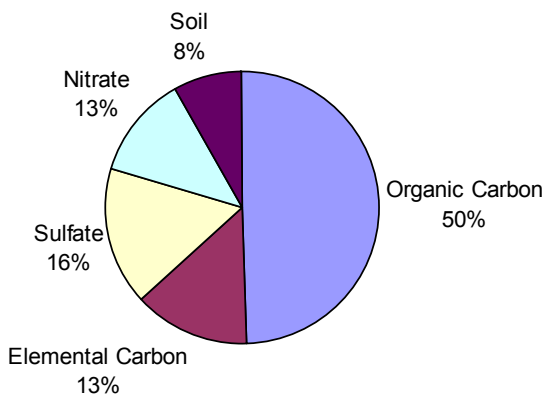
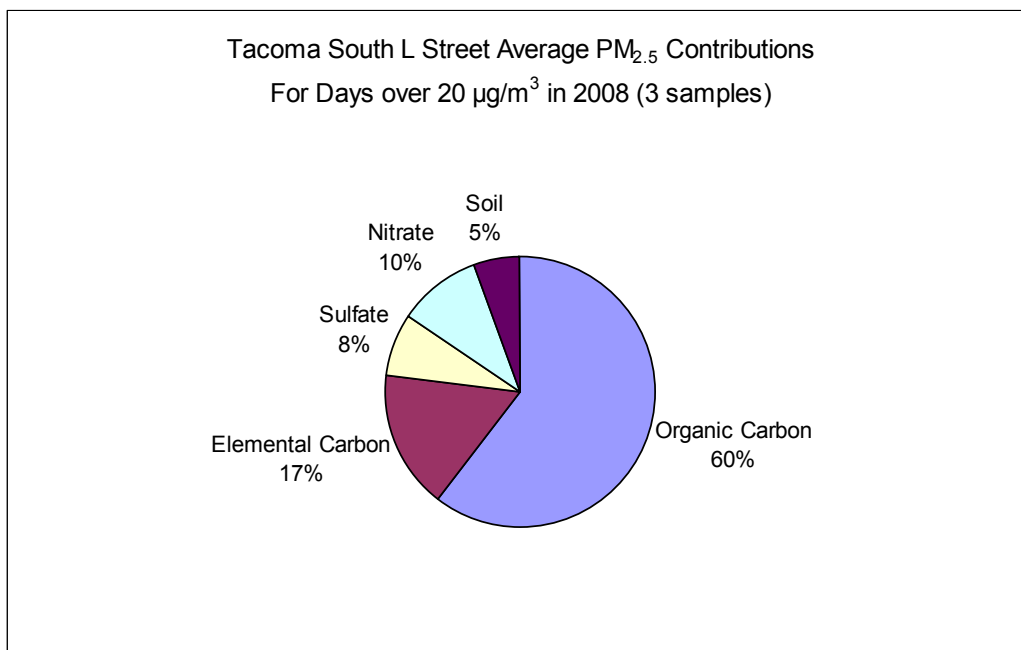


Figure 21: Tacoma South L Contributions on Highest Days 2008 (3 samples over 20 µg/m³)



AETHALOMETER DATA

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

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

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

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

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

OZONE

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

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

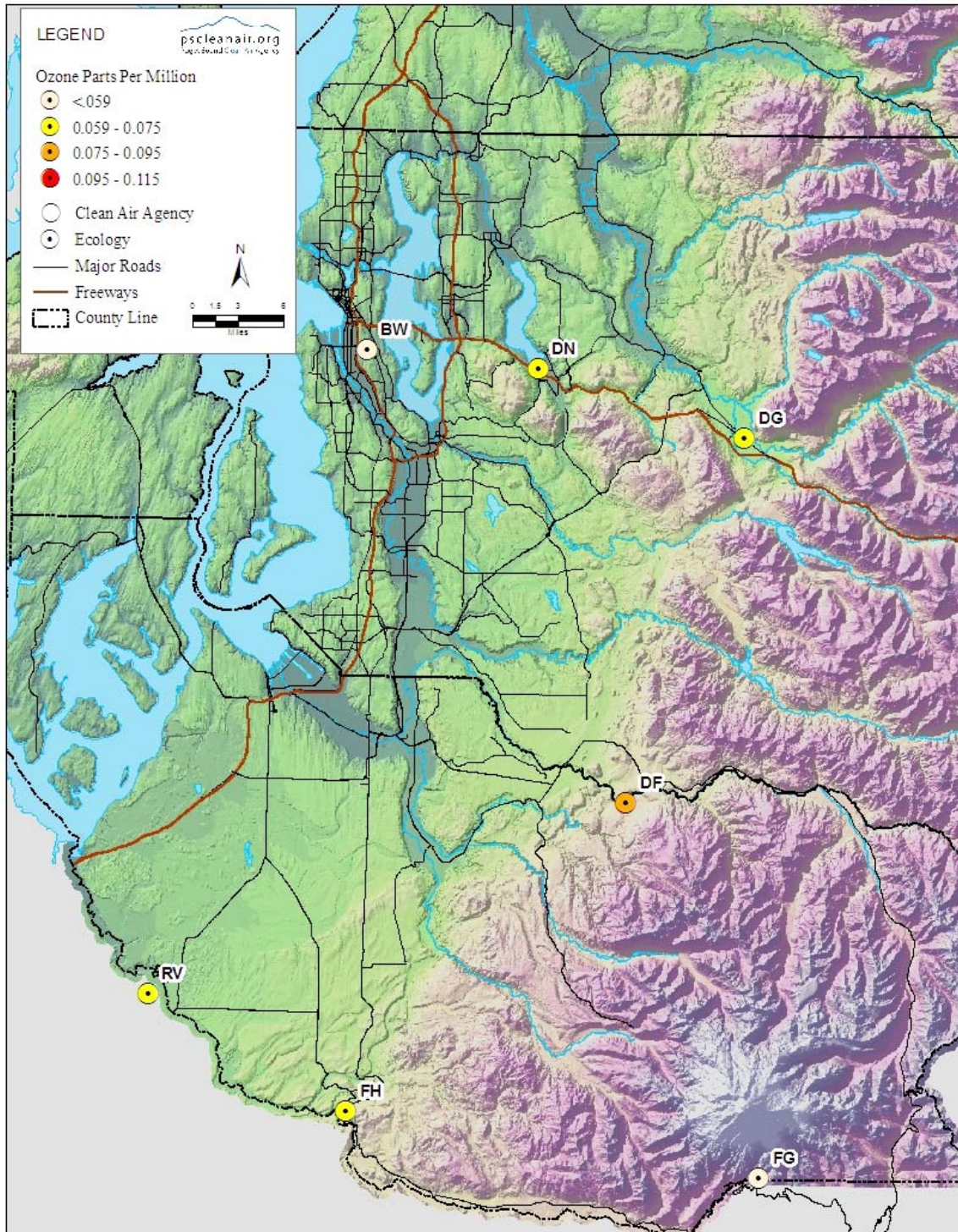
The majority of ozone monitoring stations are located in rural areas of the Puget Sound region, although the precursor chemicals that react with sunlight to produce ozone are generated primarily in large metropolitan areas. The photochemical formation of ozone takes several hours. Thus, the highest concentrations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

²⁶EPA AirNow. How Can Ground-Level Ozone Affect Your Health?; <http://www.airnow.gov/index.cfm?action=static.ozone2#3>.

²⁷EPA Health and Environmental Effects of Ground Level Ozone; <http://www.epa.gov/ttn/oarpg/naaqsfm/o3health.html>.

²⁸EPA Health and Environmental Effects of Ground Level Ozone; <http://www.epa.gov/ttn/oarpg/naaqsfm/o3health.html>.

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



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

Figure 22 presents data for each monitoring station and the 8-hour federal standard. Although ozone levels have remained fairly stable, ozone is still a concern for the region because EPA revised its 8-hour ozone standard from 0.08 parts per million (ppm) to 0.075 ppm in March 2008, and has expressed intent to further strengthen the standard in 2010.²⁹ The new standard was finalized on March 27, 2008 in response to the determination that the former standard was not sufficiently protective of human health.³⁰

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

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

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

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

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

²⁹EPA. EPA to Reconsider Ozone Pollution Standards; http://www.epa.gov/air/ozonepollution/pdfs/O3_Reconsideration_FACT%20SHEET_091609.pdf. September 2009.

³⁰EPA. 2008 Revised Ground-Level Ozone Standards; <http://www.epa.gov/air/ozonepollution/actions.html>.

Figure 22: Ozone for Puget Sound Region

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

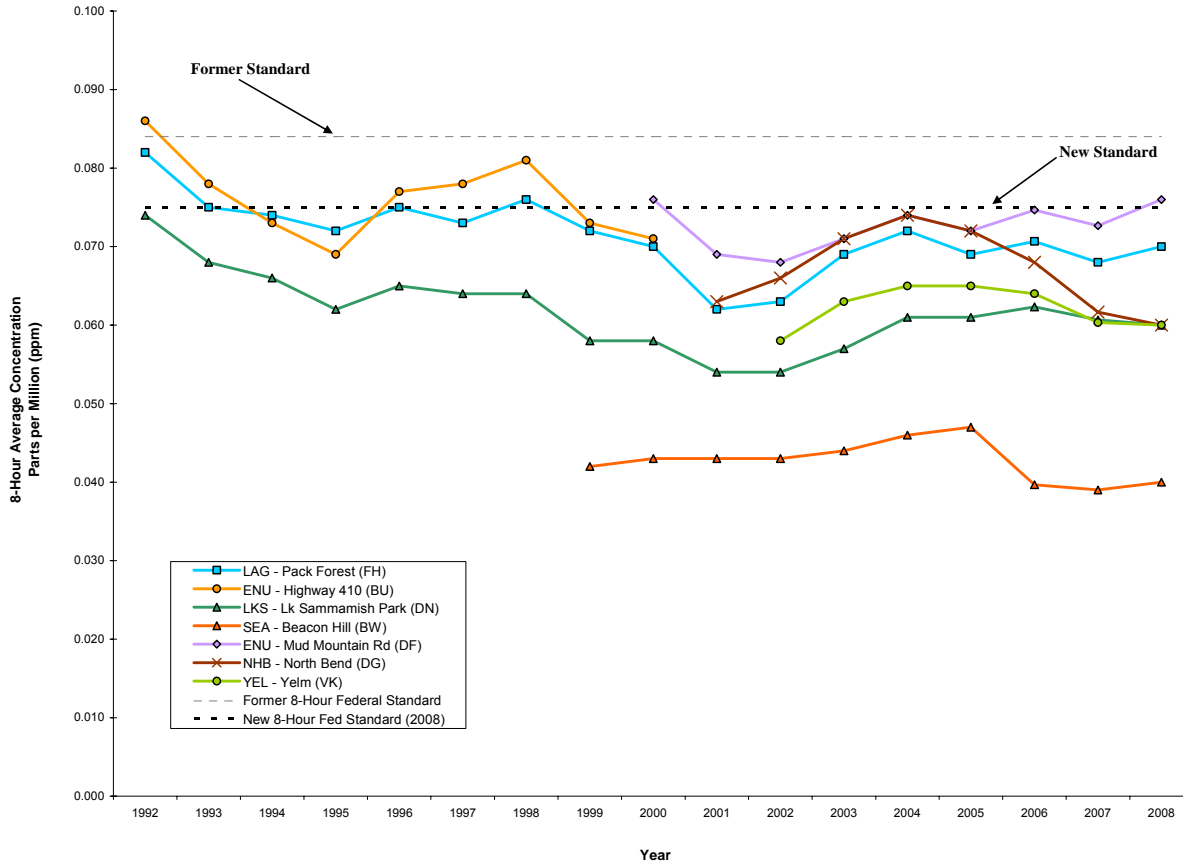
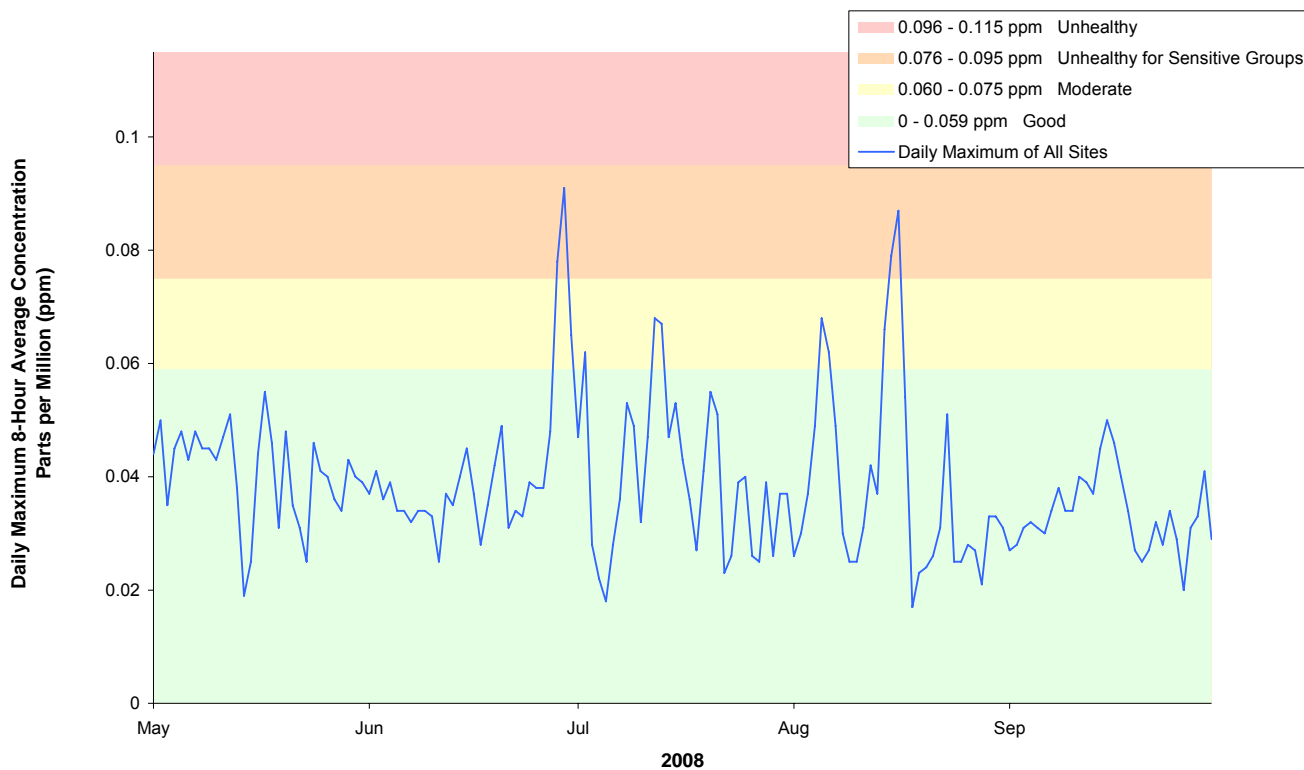


Figure 23: Ozone (O₃) for Puget Sound Region May-September 2008

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



NITROGEN DIOXIDE

Nitrogen dioxide (NO₂) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and oxygen in the atmosphere. NO₂ can cause respiratory symptoms such as coughing, wheezing, and shortness of breath in people with respiratory diseases such as asthma.³¹ Long-term exposure can lead to respiratory infections.

The term “NO_x”, which is frequently used, is defined as NO + NO₂. NO₂ will react with volatile organic compounds (VOCs) and can result in the formation of ozone. NO_x, NO + NO₂, can form nitrates in the atmosphere, a component of fine particulate matter. On-road vehicles such as trucks and automobiles and off-road vehicles such as construction equipment and port cargo-handling equipment are the major sources of NO_x. Industrial boilers and processes, home heaters, and gas stoves also produce NO_x.

Motor vehicle and non-road engine manufacturers have been required by EPA to reduce NO_x emissions from cars, trucks, and non-road equipment. As a result, emissions have reduced dramatically. NO₂ in itself is not considered a significant pollution problem in the Puget Sound area. However, NO_x emissions are important, as they affect ozone and nitrate formation.

EPA proposed a strengthened national ambient air quality standard for nitrogen dioxide on June 26, 2009.³² EPA proposed to keep the current annual health-based standard for nitrogen dioxide and add a 1-hour standard to be more protective of short-term exposures. Nitrogen dioxide levels in the Puget Sound region, as currently monitored by Ecology, are typically below (cleaner than) the levels being proposed in the new standard. However, potential changes to where NO₂ is monitored (for example, closer to roadways) may affect this – it’s unclear at this time what these changes may be. EPA plans to promulgate a new NO₂ standard by January 2010.

Ecology maintains one monitoring site for nitrogen dioxide at the Beacon Hill monitoring site. In 2007, the monitoring technique and equipment changed slightly to record NO_y instead of NO_x to incorporate the notroxyl compounds, which are important in monitoring ozone formation chemicals and fine particulate matter. The additional notroxyl compounds are in trace amount in comparison to NO₂. Figure 24 shows NO₂ concentrations through 2005. In 2006, no data were recorded due to the relocation of the Beacon Hill monitor to a different location on the same property. In 2007 and 2008, the concentration of NO₂ is represented as NO_y - NO since NO₂ is no longer directly recorded. The annual average for each year has consistently been less than half of the current federal standard, as shown in Figure 24 and in the statistical summary on page A-14 of the Appendix.

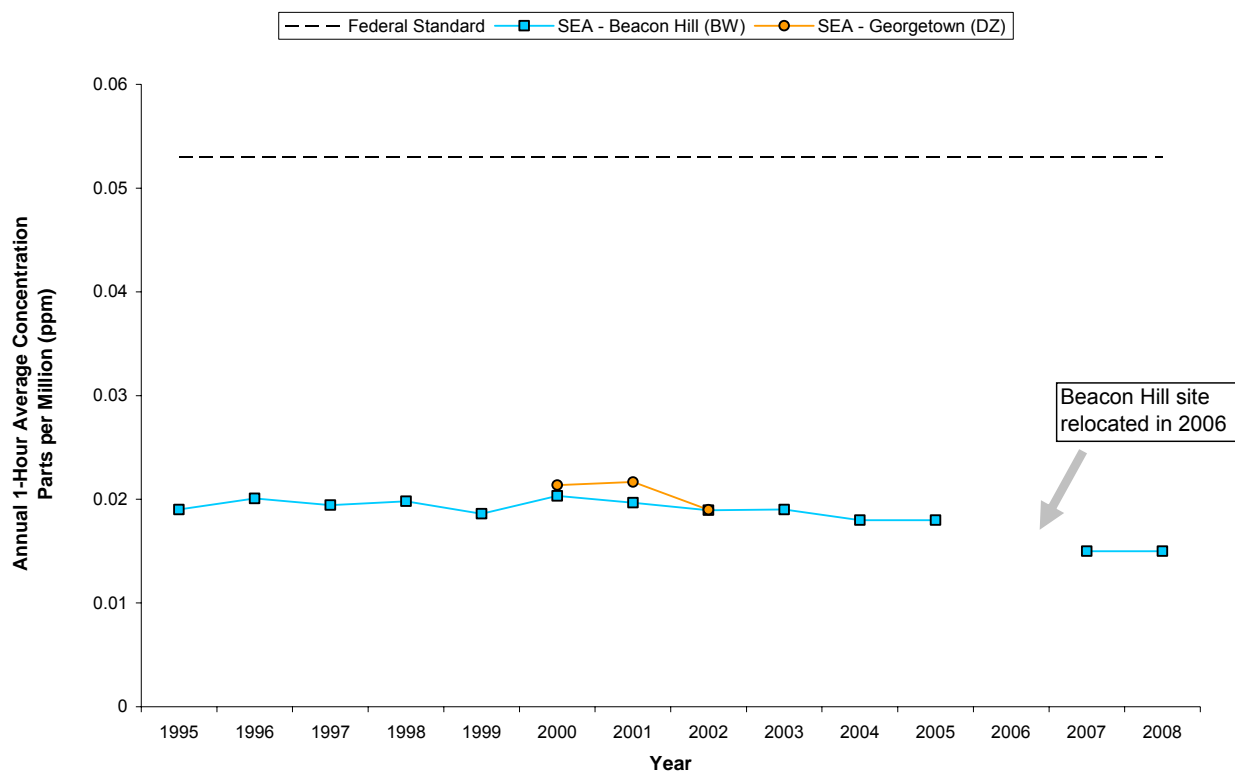
The maximum 1-hour average of NO_y- NO, measured in 2008, was 0.065 ppm on August 6. Visit www.epa.gov/air/urbanair/nox/index.html for additional information on NO₂.

³¹EPA, Airnow, NO_x Chief Causes for Concern; <http://epa.gov/air/urbanair/nox/chf.html>.

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

Figure 24: Nitrogen Dioxide (NO₂) (1995-2005) and Reactive Nitrogen (2007-2008)

Annual Mean of 1-Hour Averages vs Standard



CARBON MONOXIDE

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

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

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

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

The CO national ambient air quality standard is based on the 2nd highest 8-hour average. Figure 25 shows the 2nd highest 8-hour concentrations and the federal standard (9 ppm) for the Puget Sound region. There currently are no CO monitoring stations in Kitsap, Pierce, or Snohomish Counties.

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

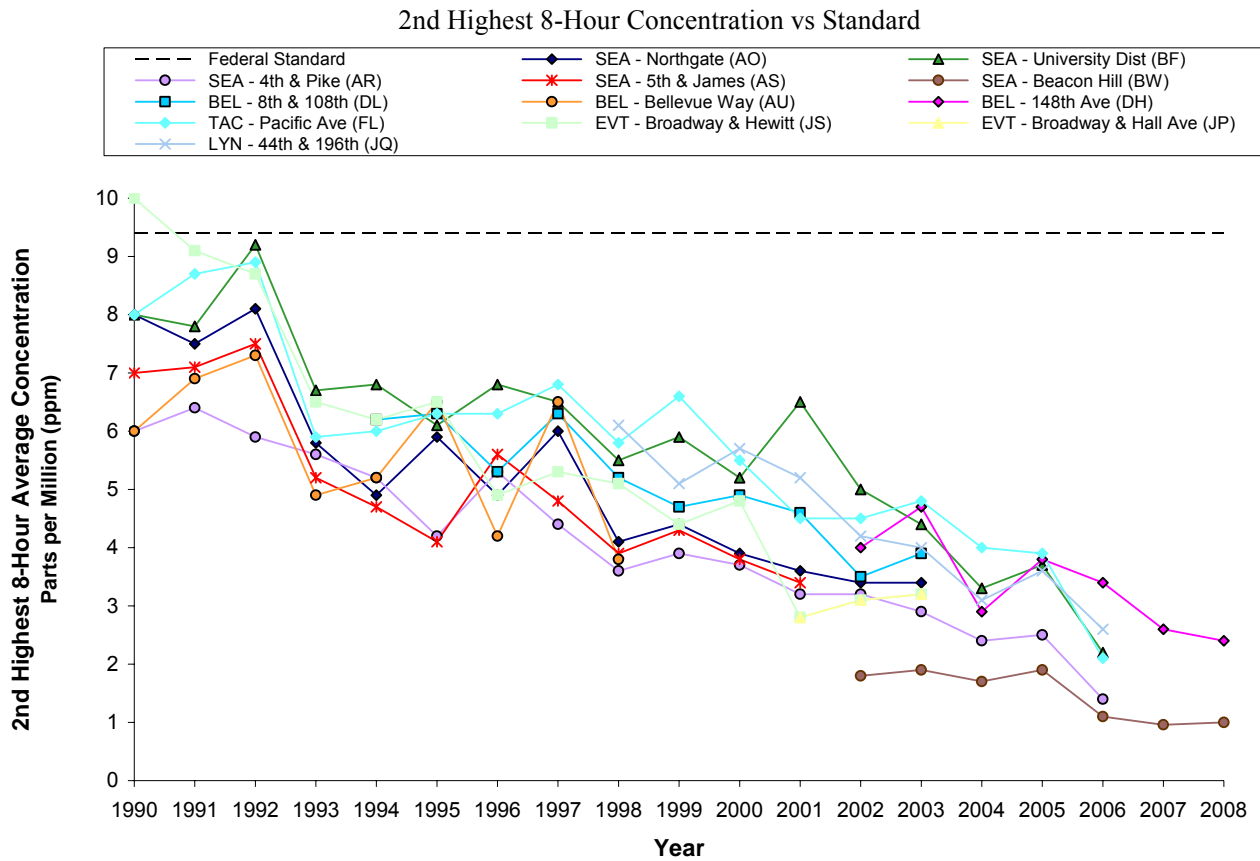
The EPA federal standards also include a 1-hour standard for CO of 35 ppm, not to be exceeded more than once a year. Measured 1-hour concentrations in the Puget Sound area are historically much lower than the 35 ppm standard, and therefore 1-hour CO trends are not graphed.

As of the publication of this report, EPA had begun a NAAQS review process for carbon monoxide. EPA plans to propose CO standards in fall 2010 (with potentially no change), with the publication of a final standard in spring 2011.³³

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

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

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



SULFUR DIOXIDE

Sulfur dioxide (SO₂) is a colorless, reactive gas produced by burning fuels containing sulfur, such as coal and oil, and by industrial processes. Historically, the greatest sources of SO₂ were industrial facilities that derived their products from raw materials such as metallic ore, coal, and crude oil, or that burned coal or oil to produce process heat (petroleum refineries, cement manufacturing, and metal processing facilities). Today, on-road vehicles, diesel construction equipment, and marine vessels release significant SO₂ emissions to the air.

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

The Puget Sound area has experienced a significant decrease in SO₂ from sources such as pulp mills, cement plants, and smelters in the last two decades. Additionally, levels of sulfur in diesel and gasoline fuels have decreased due to EPA regulations. The Puget Sound Clean Air Agency stopped monitoring for SO₂ in 1999 because of these decreases. Monitoring sites for SO₂ were historically sited in or near former industrial areas. Ecology monitored SO₂ at the Beacon Hill site from 2000-2005. In 2006 the SO₂ monitor was relocated to a different location on the same property. The monitor was not operating most of 2006, so no data are reported for that year.

Figures 26 and 27 show the maximum 24-hour and 1-hour concentrations, respectively, at individual monitoring sites. The July 1994 spike shown on these graphs was the result of a short-term release from an Everett paper mill. The maximum measured SO₂ concentrations in 2008 were below all federal and regional standards. The maximum 24-hour and 1-hour Beacon Hill averages in 2008 were 0.073 ppm on August 22 and 24 and 0.011 ppm on August 16 and 17, respectively.

At the time of publication of this report, EPA was in the process of reviewing the SO₂ NAAQS, with a proposed timeline for a new standard (potentially no change) in 2010.³⁴

Statistical summaries for SO₂ data from the Beacon Hill site are available on page A-16 of the Appendix.

Additional information on SO₂ is available at www.epa.gov/air/urbanair/so2/index.html.

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

Figure 26: Sulfur Dioxide (SO₂) 24-Hour Average for Puget Sound Region

Maximum 24-Hour Average vs Standard

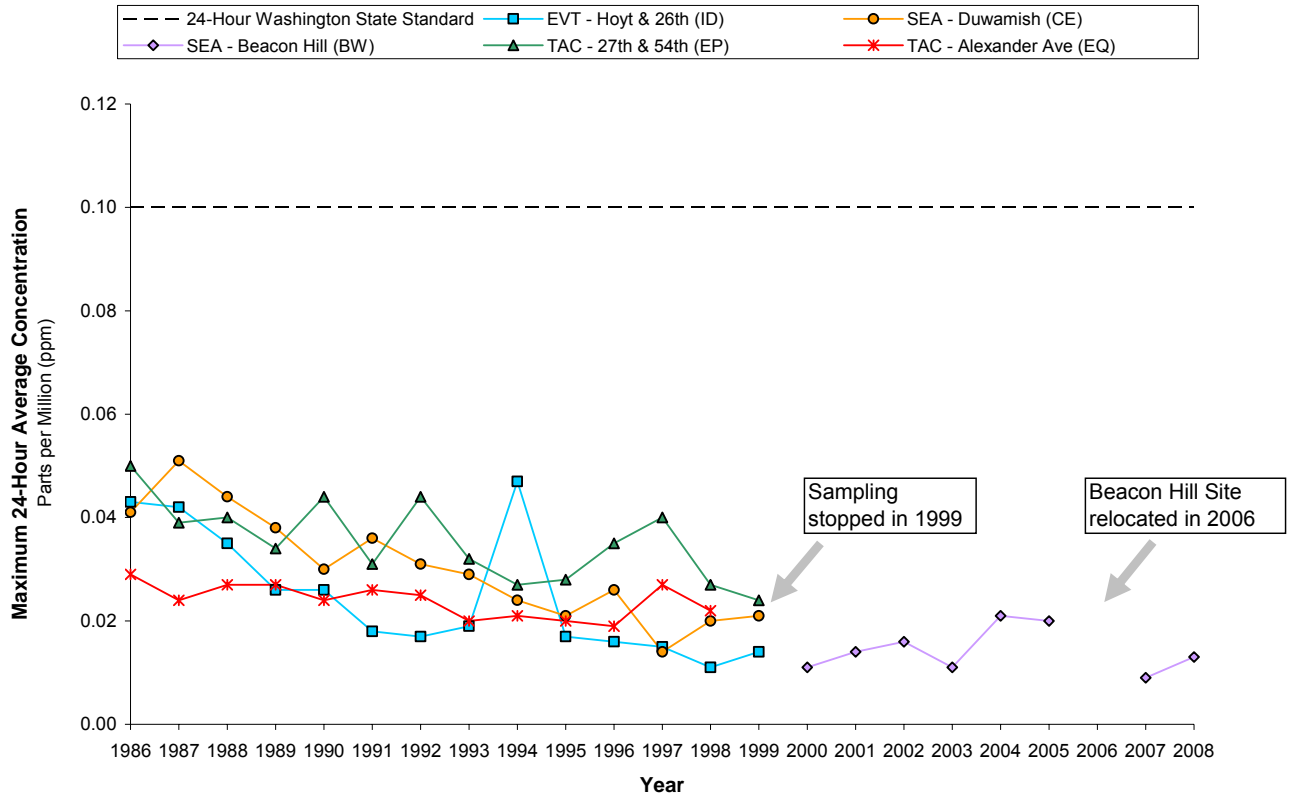
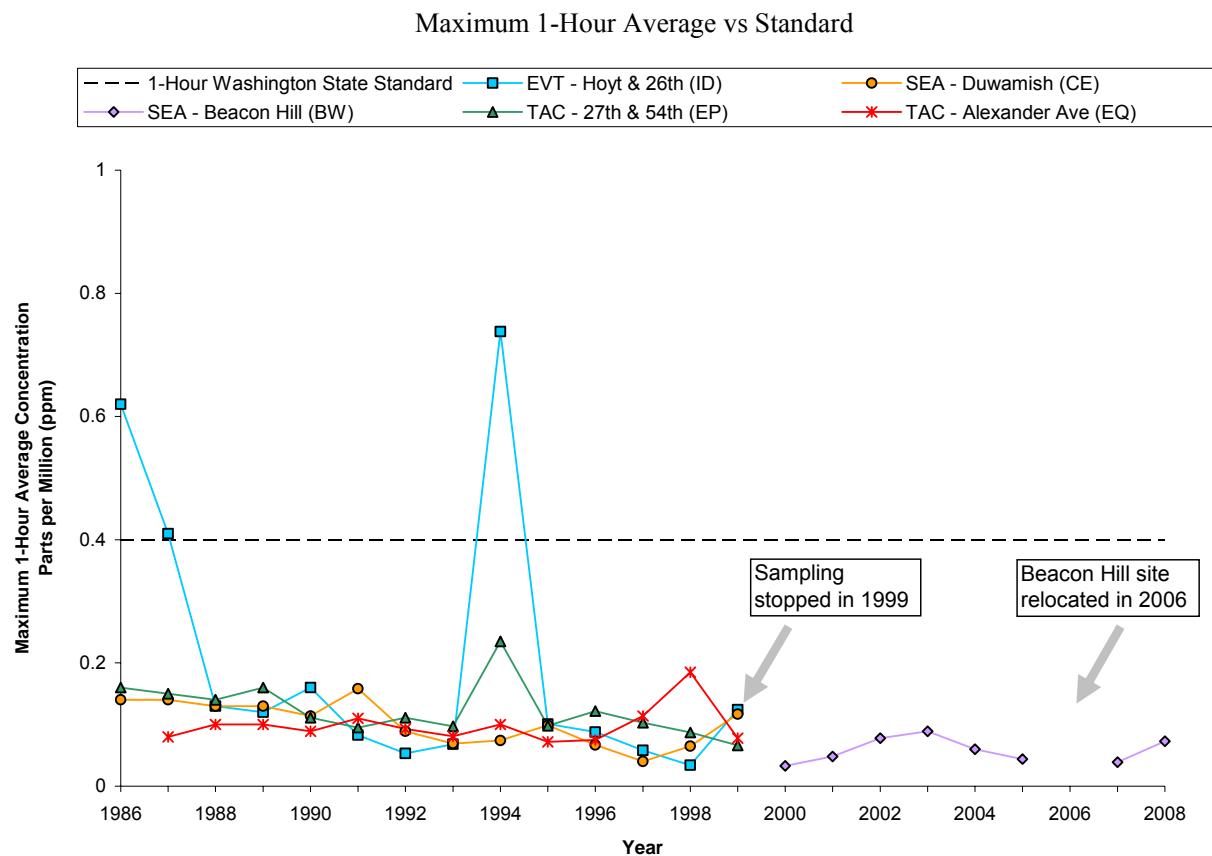


Figure 27: Sulfur Dioxide (SO₂) 1-Hour Average for Puget Sound Region



LEAD

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

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

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

Lead has not been monitored for comparison to the federal standard in the Puget Sound area since 1999.³⁵ Since the phase-out of lead in fuel and the closure of the Harbor Island secondary lead smelter, levels of lead in ambient air has decreased substantially. For a historic look at the Puget Sound region's lead levels, please see page 87 of the 2007 Air Quality Data Summary located at <http://www.pscleanair.org/news/library/reports/2007AQDSFinal.pdf>.

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

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

³⁵Lead is a pollutant that is both a criteria air pollutant and an air toxic. Lead is no longer monitored by FRM as a criteria air pollutant in Puget Sound; however, the lead fraction of PM_{2.5} is measured at speciation monitors.

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

VISIBILITY

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

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

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

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

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

Figure 28: Puget Sound Visibility

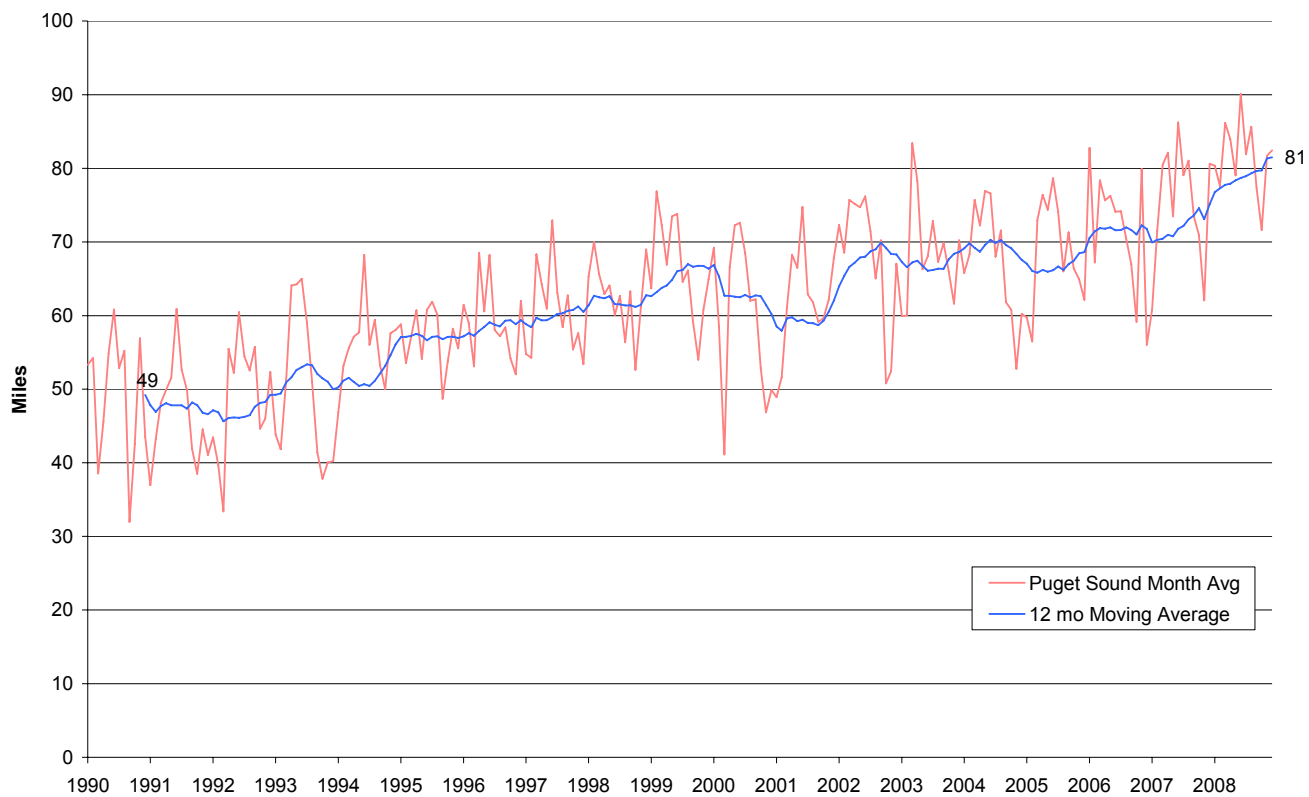


Figure 29: King County Visibility

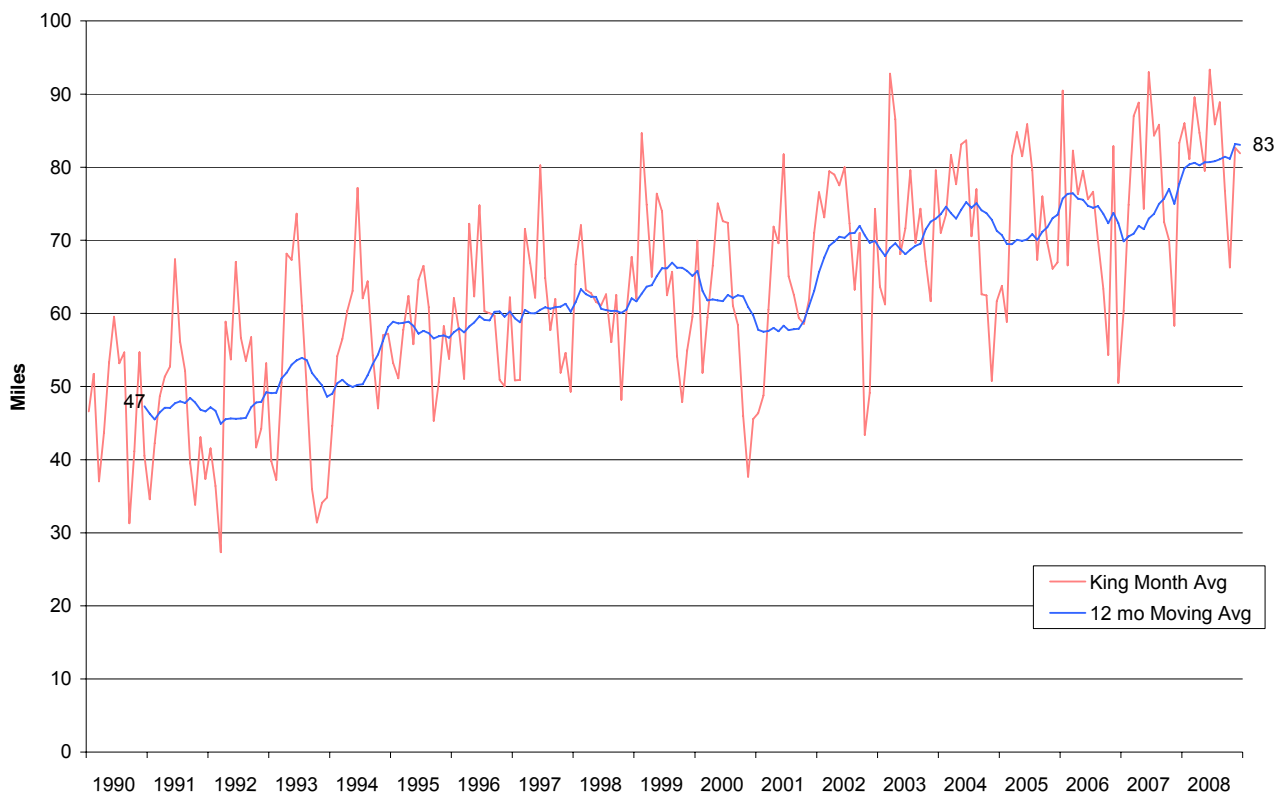


Figure 30: Kitsap County Visibility

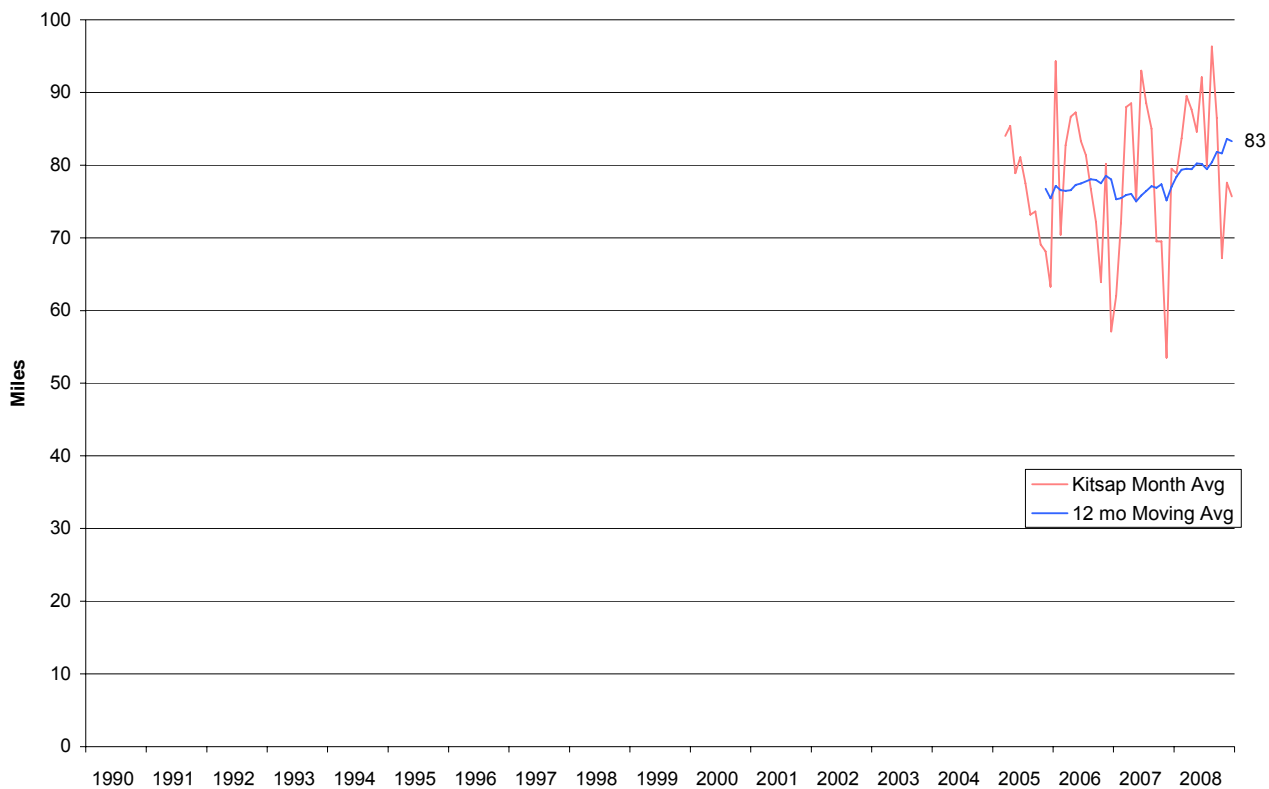


Figure 31: Pierce County Visibility

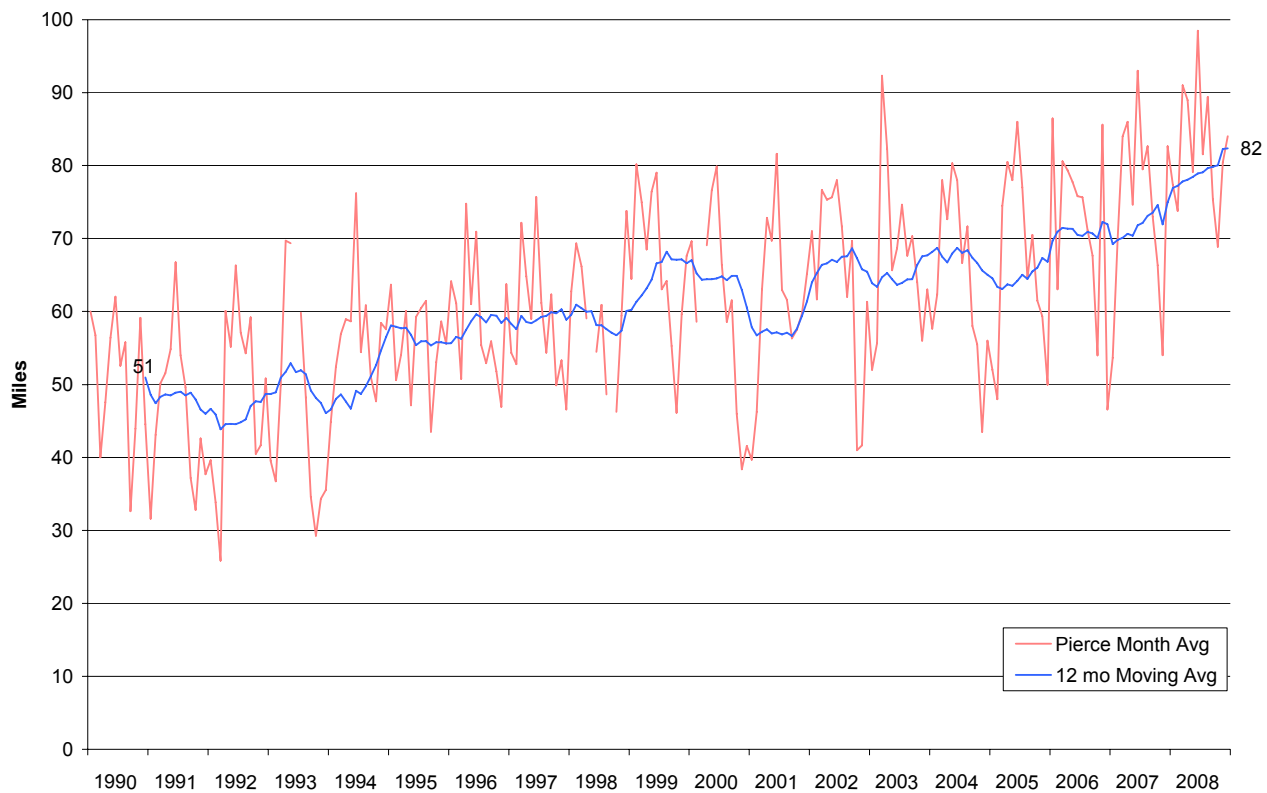
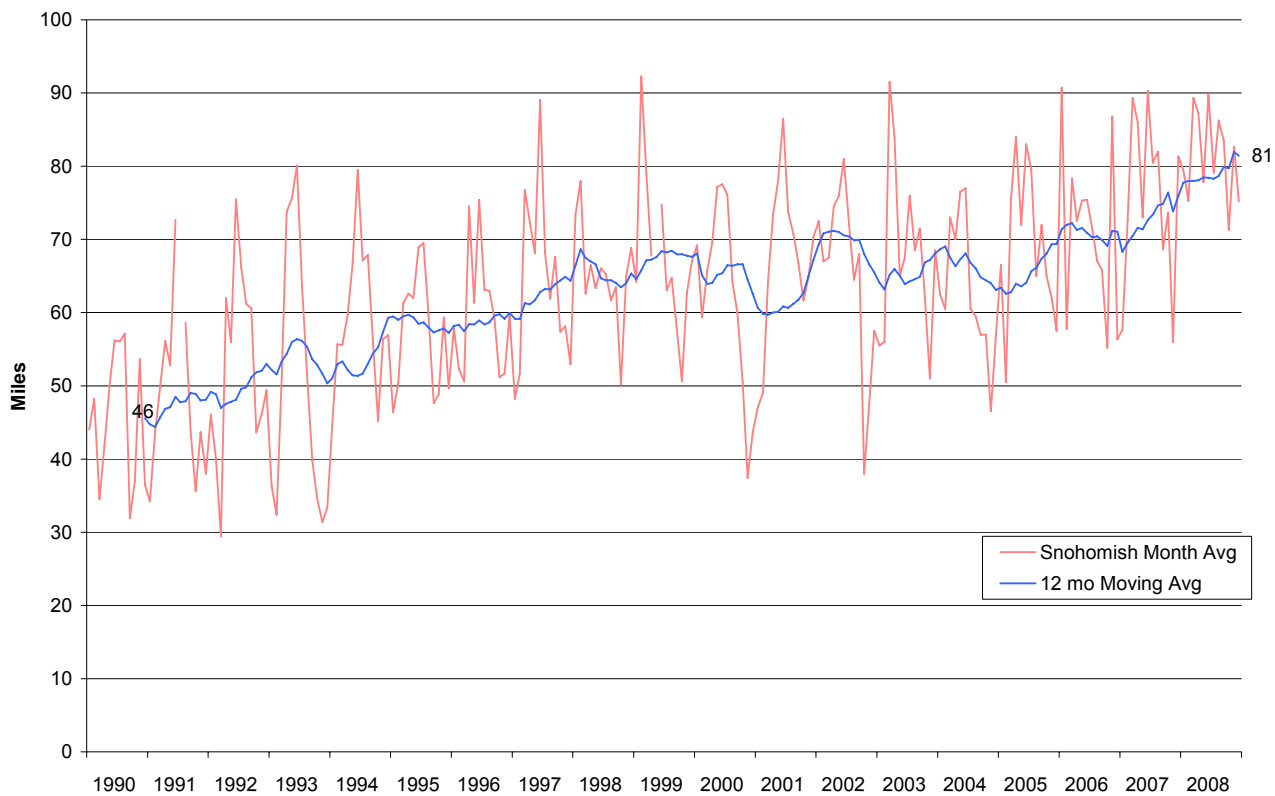


Figure 32: Snohomish County Visibility



AIR TOXICS

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

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

RELATIVE RANKING BASED ON CANCER RISK & UNIT RISK FACTORS

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

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

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

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

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

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

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

IRIS = Integrated Risk Information System

URF = Unit Risk Factor

OEHHA = California EPA's Office of Environmental Health and Hazard Assessment

M = metal

PM₁₀ = fine particles less than 10 micrometers in diameter

TSP = total suspended particulate

na = no unit risk factor available from this source

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

HEALTH EFFECTS OTHER THAN CANCER

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

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

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

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

AIR TOXICS GRAPHS

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

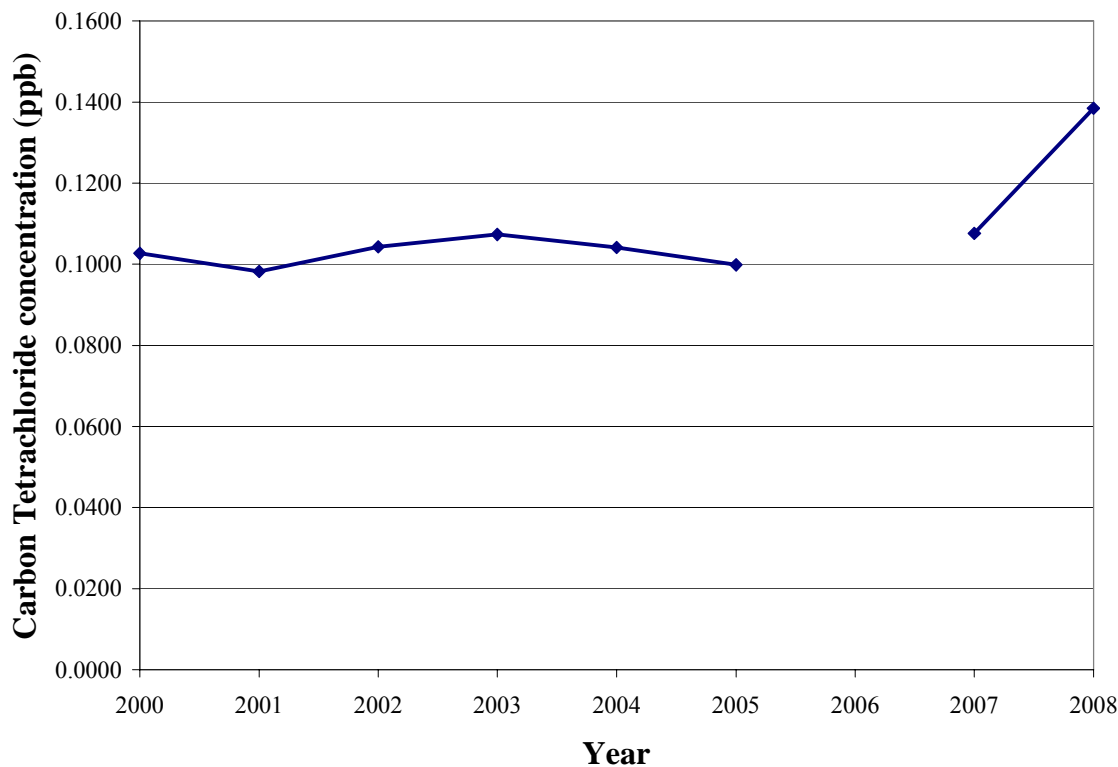
³⁸EPA, Acrolein Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/acrolein.html>.

Carbon Tetrachloride

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

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

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



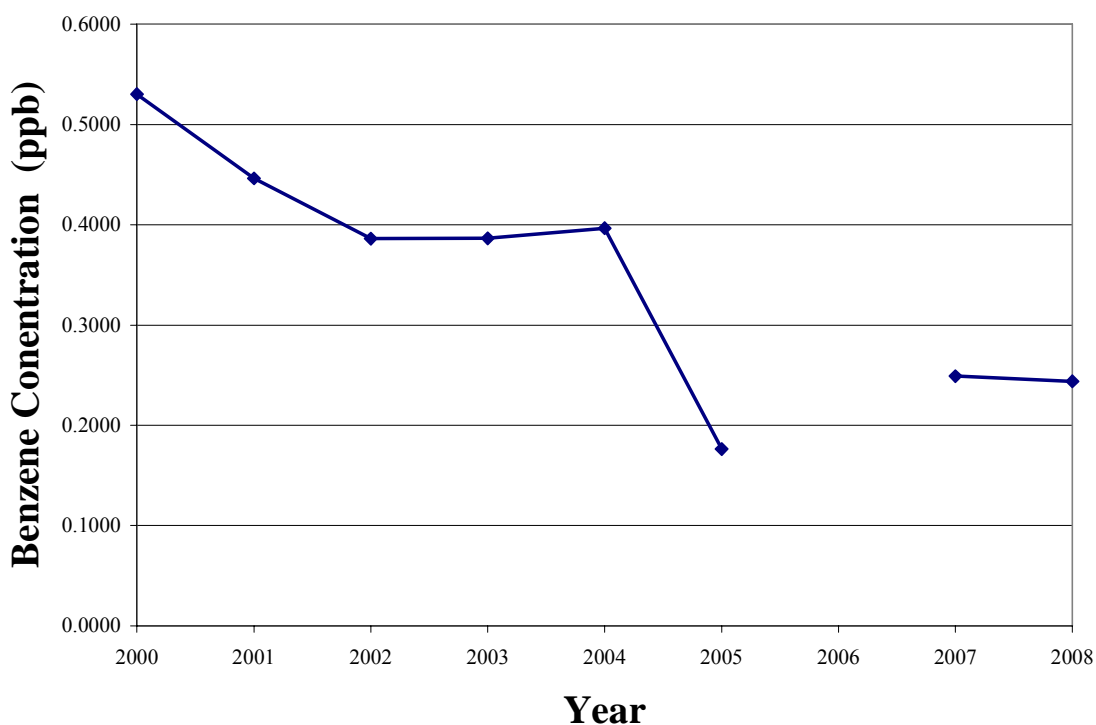
³⁹EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/carbonte.html>.

Benzene

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

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

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



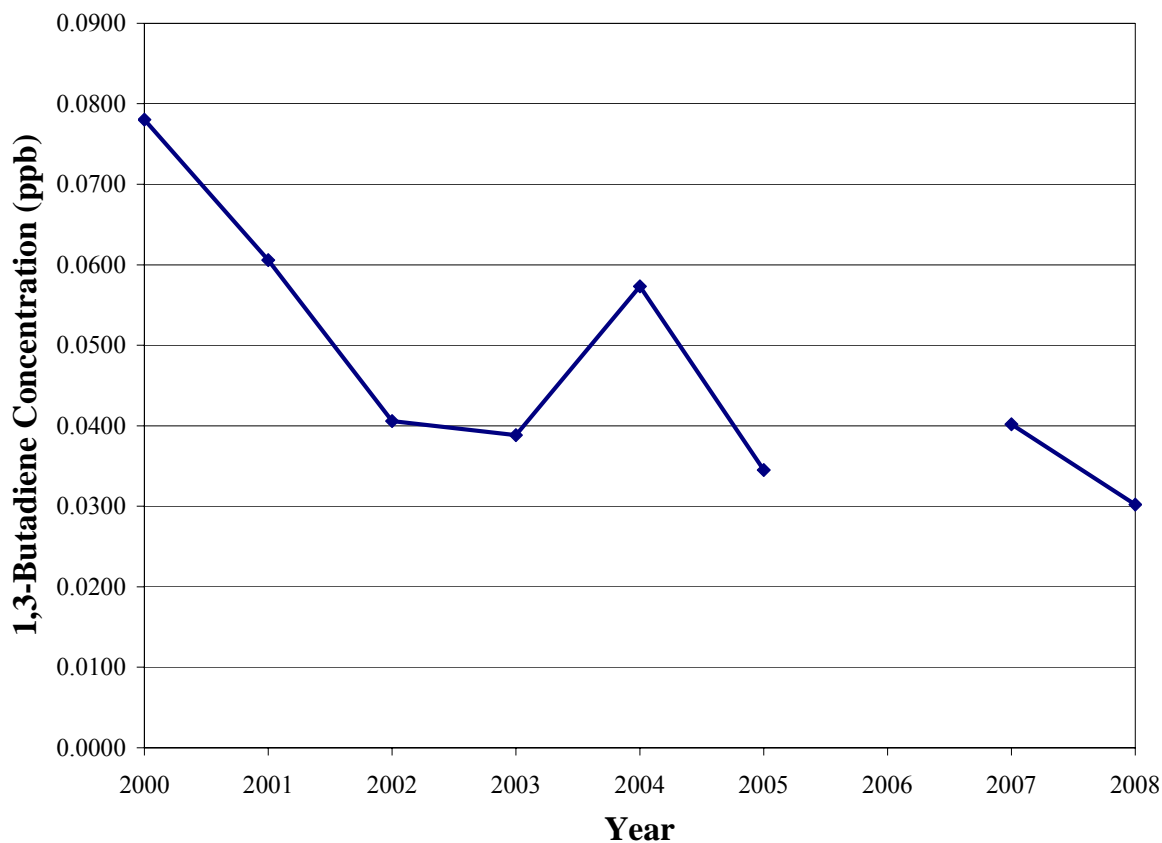
⁴⁰EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/benzene.html>.

1,3-Butadiene

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

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

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



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

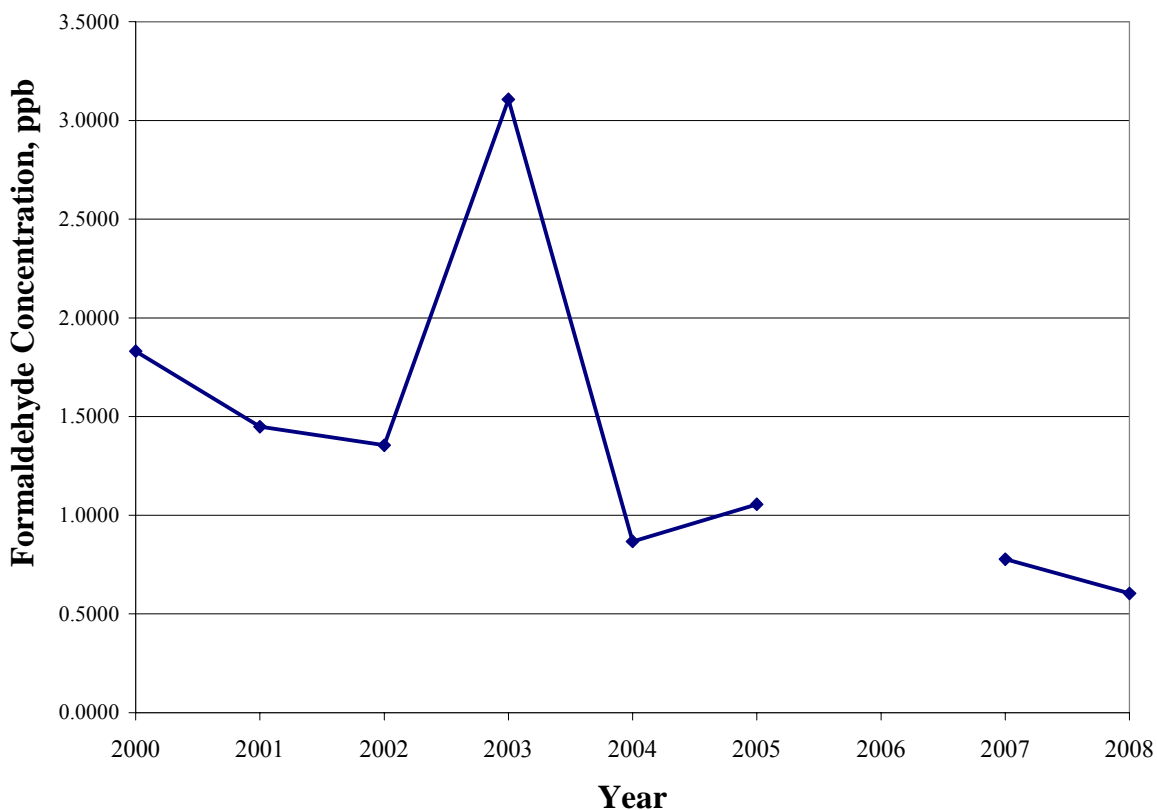
Formaldehyde

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

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

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

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



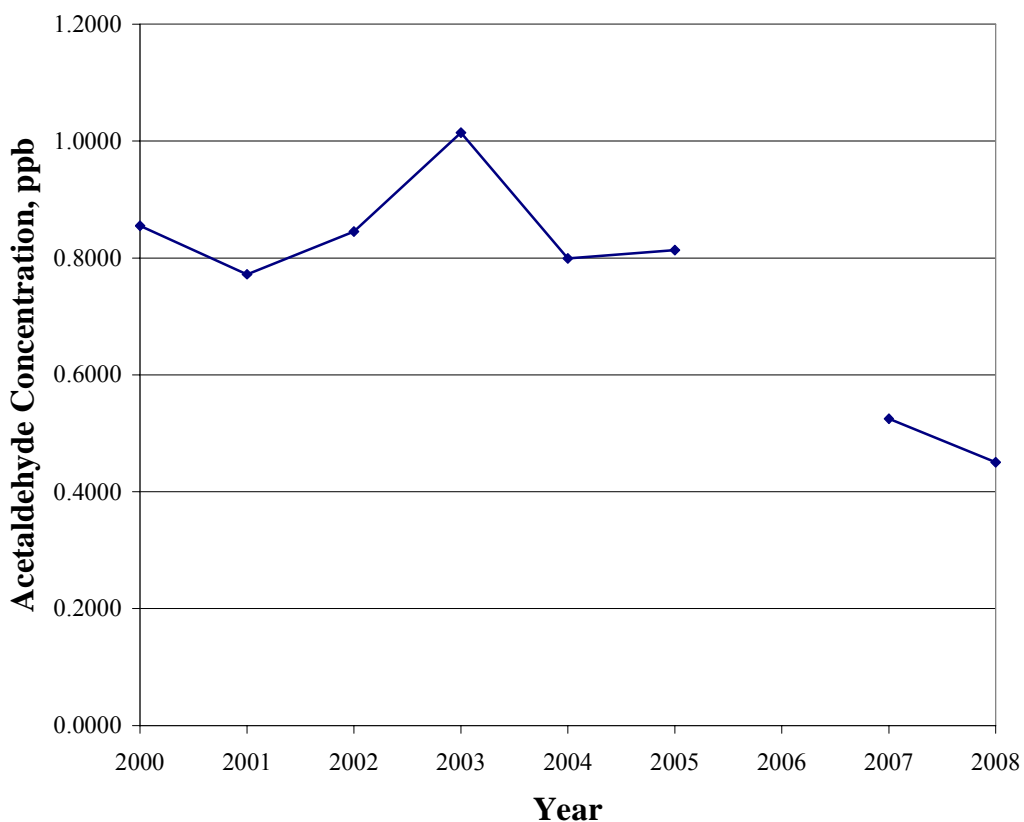
⁴²EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/formalde.html>.

Acetaldehyde

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

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

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



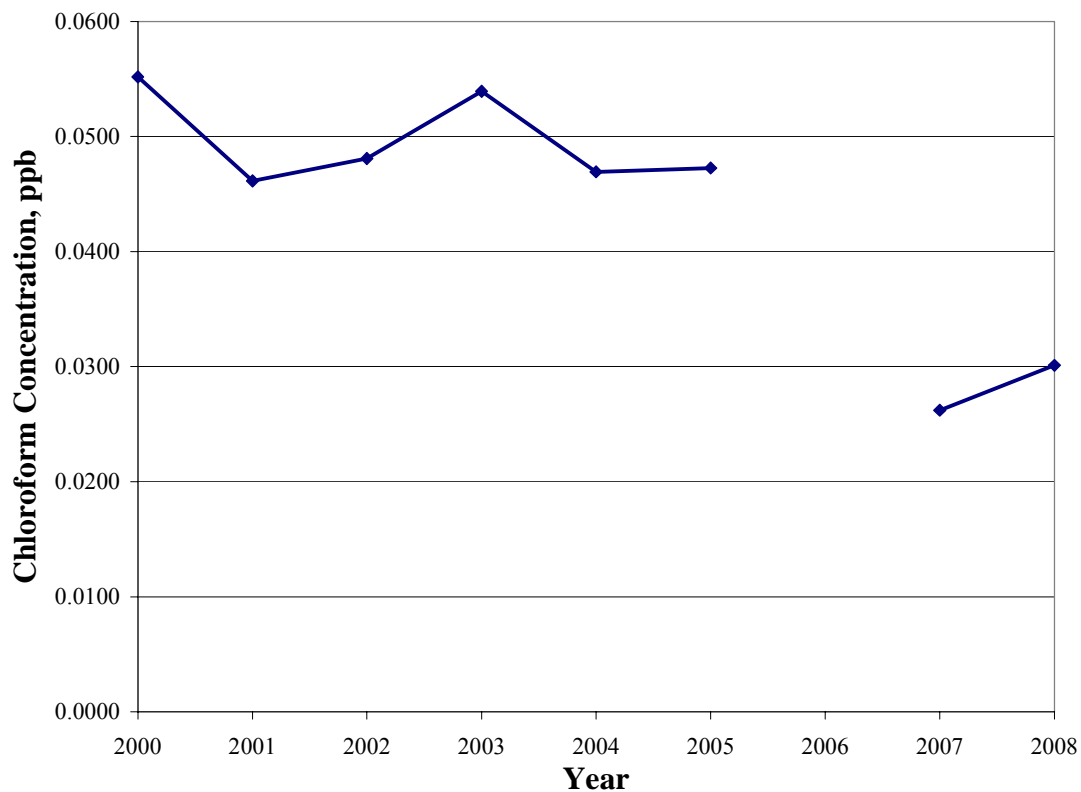
⁴³EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/acetalde.html>.

Chloroform

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

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

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



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

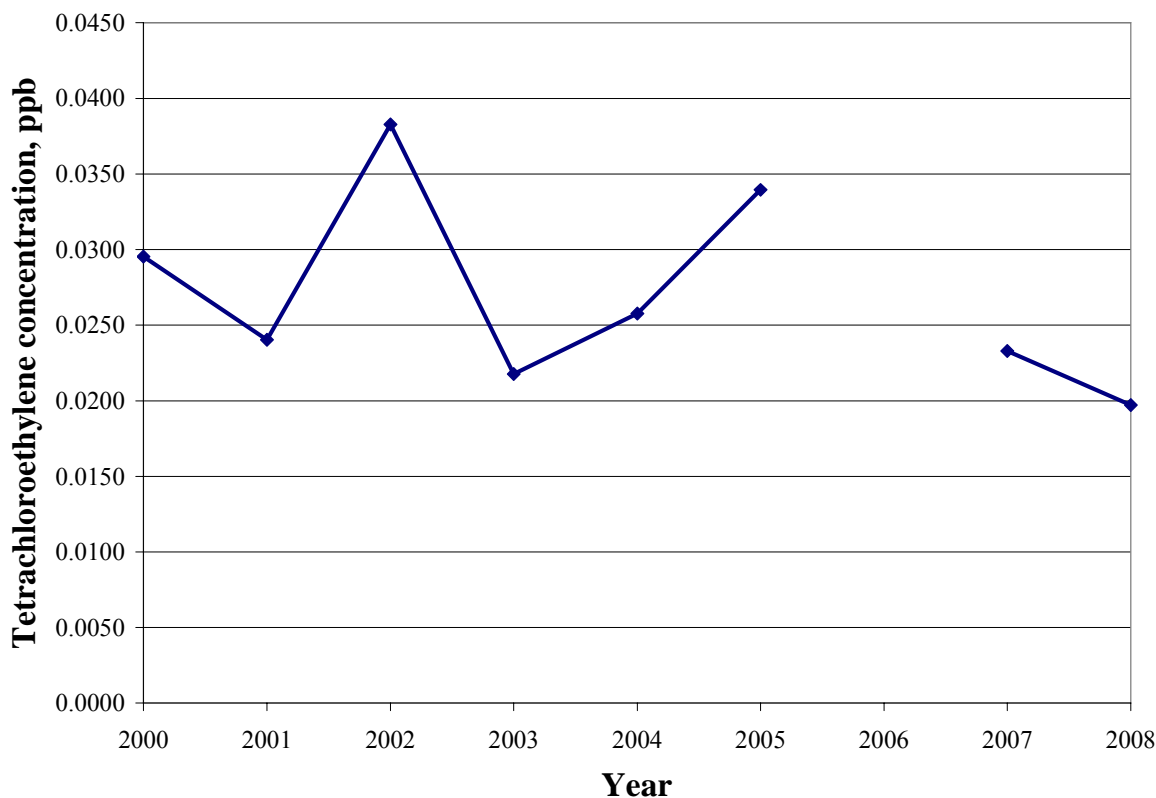
⁴⁵Seattle Public Utilities. 2008 Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/stellent/groups/public/@spu/@fom/documents/webcontent/spu01_003889.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform; http://www.ci.seattle.wa.us/util/About_SPU/Water_System/Water_Quality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

Tetrachloroethylene

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

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

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



⁴⁶EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html>.

⁴⁷Agency Regulation III, Section 3.03; <http://www.pscleanair.org/regulated/businesses/regulations.aspx>.

Trichloroethylene

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

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

METALS

Table 4 (2008 Beacon Hill Air Toxics Ranking), shown previously in this section, includes estimated potential cancer risks for several PM₁₀ metals monitored at Beacon Hill, as well as total suspended particulate (TSP) hexavalent chromium. Hexavalent chromium and arsenic posed the greatest potential cancer risks. Other metals were below non-cancer screening levels (see Appendix page A-21).

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

Hexavalent Chromium

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

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

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

⁴⁸EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html>.

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

Arsenic

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

Nickel

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

Cadmium

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

Lead

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

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

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

Lead is uniquely listed as both an air toxic and a criteria pollutant. For more information on the review of the national ambient air quality standards for lead, please see page 54.

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

⁵¹EPA Hazard Summary; <http://www.epa.gov/iris/subst/0273.htm>.

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

⁵³EPA Hazard Summary; <http://www.epa.gov/ttn/atw/hlthef/lead.html>.

Beryllium

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

Manganese

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

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

⁵⁵EPA National Air Toxics Assessment; <http://www.epa.gov/ttnatw01/hlthef/manganes.html>.

DEFINITIONS

GENERAL DEFINITIONS

Air Quality Index

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

| Breakpoints for Criteria Pollutants | | | | | | | AQI Categories | |
|-------------------------------------|---|---|--|-------------|--------------------------|--------------------------|----------------|--------------------------------|
| O ₃ (ppm) 8-hour | O ₃ (ppm) 1-hour ^(a) | PM _{2.5} (µg/m ³) | PM ₁₀ (µg/m ³) | CO (ppm) | SO ₂ (ppm) | NO ₂ (ppm) | AQI value | Category |
| 0.000–0.059 | — | 0.0–15.4 | 0–54 | 0.0–4.4 | 0.000–0.034 | (b) | 0–50 | Good |
| 0.060–0.075 | — | 15.5–40.4 | 55–154 | 4.5–9.4 | 0.035–0.144 | (b) | 51–100 | Moderate |
| 0.076–0.095 | 0.125–0.164 | 40.5–65.4 | 155–254 | 9.5–12.4 | 0.145–0.224 | (b) | 101–150 | Unhealthy for sensitive groups |
| 0.096–0.115 | 0.165–0.204 | 65.5–150.4 | 255–354 | 12.5–15.4 | 0.225–0.304 | (b) | 151–200 | Unhealthy |
| 0.116–0.374 | 0.205–0.404 | 150.5–250.4 | 355–424 | 15.5–30.4 | 0.305–0.604 | 0.65–1.24 | 201–300 | Very unhealthy |
| (c) | 0.405–0.504 | 250.5–350.4 | 425–504 | 30.5–40.4 | 0.605–0.804 | 1.25–1.64 | 301–400 | Hazardous |
| (c) | 0.505–0.604 | 350.4–500.4 | 505–604 | 40.5–50.4 | 0.805–1.004 | 1.65–2.04 | 401–500 | |

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

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

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

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

Airshed

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

Air Toxics

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

Certified Wood Stove and Fireplace Inserts

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

Criteria Air Pollutant (CAP)

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

Hazardous Air Pollutant (HAP)

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

Temperature Inversions

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

Uncertified Wood Stove or Fireplace Insert

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

Unit Risk Factor (URF)

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

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 all compounds determined to have negligible photochemical reactivity by EPA and listed in 40 CFR 51.100(s) in effect July 1, 2005.