2007 Treasure Valley Idaho Air Toxics Study

Final Report

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Executive Summary

An air toxics monitoring study was conducted in 2007 at five sites in the Treasure Valley of Idaho. The Treasure Valley is bounded by the Boise urban area on the eastern side of the valley and rural/agricultural areas near the Oregon border on the western side. This study was funded by the U.S. Environmental Protection Agency (EPA) as a Community Scale Air Toxics Monitoring Project (CSATMP). The primary objective of this program is to help state, local, and tribal entities characterize and understand the hazardous air pollutants (air toxics) present in their communities. Specific goals of this study were to explore the spatial and seasonal trends of air toxic species in the Treasure Valley and to identify sources of the pollutants, in general source categories, where possible.

As in many of the CSATMP studies, 24-hour averaged samples were collected every sixth day for volatile organic carbon (VOC) compounds, carbonyls—in this case primarily aldehydes, and selected toxic metals/trace elements analyzed on high-volume PM_{10} air samples. An extensive quality assurance plan was followed during the study, including independent quarterly audits performed by the Oregon Department of Environmental Quality Laboratory (ODEQ Lab) and collection of co-located samples with 20% of the samples for estimating precision. Data quality assessments indicated that data quality was adequate or good for 21 hazardous air pollutant (HAP) species. A number of additional HAP species were either not detected at any sites, or too sparsely detected to confidently characterize the long-term concentrations for the purposes of health risk analysis.

When compared to the 2003-2005 portion of the national air toxics database summarized statistically by EPA in their Air Toxics Data Analysis Workbook (EPA, 2009b), the levels of most toxic metals and trace elements arsenic and selenium in the Treasure Valley were found to be lower than mean values nationwide, except for the levels of manganese. Manganese levels at all sites throughout the valley lie between the 50th and 75th percentiles of the national distribution. Treasure Valley air toxics largely associated with mobile sources, such as benzene, ranged from approximately the 25th percentile level nationally at the Parma background site to the 75th–95th percentile range at the Mountain View site near the Boise urban core. Formaldehyde and acetaldehyde concentrations are very similar to the national distribution with only formaldehyde at St. Luke's reaching the 75th to 95th percentile range of the national dataset. Both aldehydes are highest in the summer months, and peak at the eastern, urban end of the valley. Summer season aldehyde concentrations may be increased by regional wildfires although there is insufficient data to detect a statistically significant wildfire contribution above the normally elevated summertime aldehyde levels.

Finally, although Parma was selected to represent the background air approaching the valley from the west, the highest levels of some compounds were observed at that site. These observations can probably be attributed to wind erosion and agricultural activities in this rural area. Arsenic and selenium are highest at Parma, even though the levels at Parma are lower than at 95% of the sites nationwide. Two isomers of one compound—*cis*- and *trans*-1,3 dichloropropene (1,3-DCP)—had annual mean concentrations at Parma that are amongst the highest found in a 2002-2006 portion of the national database downloaded

directly from EPA archives (2009c); however, it should be noted that most sites nationwide are urban, so very few have any 1,3-DCP detections at all. The primary use of 1,3-DCP in this region appears to be as a soil fumigant used after harvest to control nematodes.

Receptor modeling using the statistical methods of principal component analysis (PCA) and positive matrix factorization (PMF) identified seven primary air toxics source categories in the Treasure Valley: mobile sources; photochemical production; geologic materials (wind erosion); biomass burning; isopropanol solvent use; other solvents; and a mixed group of sources including coal combustion (cadmium, sulfate, nitrate), chlorinated solvents, and refrigerants, all of which tend to become concentrated during stagnant air conditions. (The 1,3-DCP was not included in the receptor modeling because there were insufficient detections for the statistical analyses.)

A preliminary human health risk screening analysis was conducted to determine whether a more detailed risk analysis is warranted. The maximum concentrations were found to be above the chronic health screening benchmarks for these nine air toxics: acetaldehyde, arsenic, benzene, cadmium, (*cis*- and *trans*-)1,3-dichloropropene, ethyl benzene, formaldehyde, manganese, and methylene chloride. A Health Consultation by the State of Idaho Division of Health is planned to further evaluate the human health risk associated with these species.

A model-to-monitor comparison of the 2007 Treasure Valley air toxics data with two available models, Community Multi-scale Air Quality (CMAQ) and National-Scale Air Toxics Assessment (NATA), was also undertaken. The objective of this exercise was to evaluate whether the model-monitor agreement was of sufficient quality to create best-fit concentration surfaces or maps using both measured and modeled data. These surfaces would provide a more spatially continuous estimate of air toxic concentrations across the Treasure Valley than the five discrete air toxics monitoring sites alone. The NATA model was found to be in better agreement with the measurements than the CMAQ model. The NATA model results agreed within a factor of two with the monitored data at all sites for the aldehydes and toluene. The CMAQ model results agreed within a factor of two at two sites for one species and three sites for another. Overall, the NATA model overestimates the monitored values, while CMAQ underestimates. Though the NATA model prepares results in a spatially irregular manner (summarizing for census tracts as opposed to grid cells), the better agreement and more conservative estimates indicate that it may be a better choice with which to create continuous estimated concentration surfaces for use in the Health Consultation and for public outreach.

1. Overview

This overview discusses the purpose and background behind this project, then provides descriptions of the Treasure Valley airshed; and the locations of the five monitoring sites at which air toxics samples were collected during this study.

1.1. Background

Toxic air pollutants (also referred to as hazardous air pollutants (HAPs) or air toxics) are those pollutants known or suspected to cause cancer or other serious health problems, or cause adverse environmental and ecological effects. (EPA, 2003). Toxic air pollutants may come from a variety of sources including industrial, consumer products, agricultural, mobile, and natural sources. In order to characterize the toxic air pollutants in Idaho's Treasure Valley, the Idaho Department of Environmental Quality (DEQ) obtained funding from the U.S. Environmental Protection Agency (EPA) to undertake a one-year monitoring effort, which occurred from February 2007 to February 2008.

1.1.1. Purpose

The monitoring data has been used to develop a baseline of air toxics ambient concentrations in one of the fastest-growing areas in the nation. The airshed studied encompasses Idaho's most populated counties (Ada and Canyon) and two largest cities (Boise and Nampa). The 2002 National-Scale Air Toxics Assessment model (NATA) predicted the cancer risk for Ada County to be 32 in a million, and 27 in a million for Canyon County (EPA, 2009a). In the NATA study, Ada and Canyon counties ranked first and third in the state of Idaho, respectively, for cancer risk.

Air quality conditions have long been a concern for the Treasure Valley. Due to topography, weather patterns, and rapid growth, the Treasure Valley is subject to some of the most severe wintertime inversions in the intermountain West. During these events, levels of particulate matter 2.5 micrometers or less ($PM_{2.5}$) and particulate matter 10 micrometers or less (PM_{10}) that are above the national health-based standards have been recorded in the valley. The valley also experiences air pollution problems in the summer months as stagnant air conditions and intense sunlight combine to produce unhealthful accumulations of ozone. Monitoring has shown increased levels of ozone in the valley, sometimes to unhealthful levels, during the past several summers. An Ozone Precursor Study, in July through September 2007 coincided with a portion of this study and characterized the precursor and weather conditions leading to high ozone levels in the Treasure Valley (DRI, 2008).

Prior to the current air toxics monitoring effort, DEQ operated a single air toxics monitor in Nampa, Idaho, at Northwest Nazarene University (NNU), during the years 2003-2004. While a Health Consultation was performed with the help of the Idaho Department of Health and Welfare (IDOH) to address risk associated with the air toxics concentrations, the limited dataset did not allow for a comprehensive analysis (ATSDR, 2006). Based on the data gathered, the highest cancer risks were associated with formaldehyde and acetaldehyde. Source apportionment and modeling analyses were not attempted. Among the recommendations from the IDOH were to characterize spatial-temporal distribution of compounds throughout the valley and to identify sources of pollutants. The present air monitoring effort and analyses are intended to address those recommendations.

1.1.2. Funding Source

Funding for this work comes from the Environmental Protection Agency (EPA) Community Scale Air Toxics Monitoring Projects (CSATMP). The funding for these projects is designed to help state, local, and tribal entities characterize and understand the air toxic pollutants present in their communities. This information can then be used to help determine activities that can be implemented to reduce the emissions of toxic air pollutants and thus reduce the negative health effects associated with air toxics. The CSATMP are a component of EPA's air toxics strategy, which has focused on reducing health risk in urban areas.

1.2. Description of the Treasure Valley Airshed

1.2.1. Physical Characteristics

The Treasure Valley lies at 2,150 to 2,870 feet elevation along the Boise and Snake Rivers and south of the Boise Front Range Mountains in Southwestern Idaho. The mountains bordering the north side of the valley reach 7,600 feet and shelter the valley from synoptic winds enough to contribute to deep inversions during wintertime stagnation events. The most populous cities are Boise (202,832 in 2007) and Meridian (64,642 in 2007) on the eastern end, Nampa (79,249 in 2007) and Caldwell (39,889 in 2007) in the center, and Ontario, Oregon (11,245 in 2006) on the far western side of the Valley. The agricultural areas of the Treasure Valley, predominantly in Canyon County, Idaho, and Malheur County, Oregon, are populated with dairy and beef cattle operations and sugar beet, potato, onion, and other crops. Food processing facilities with some coal-fired boilers are located in the Nampa-Caldwell area in the center of the valley while the high-tech/semiconductor industry represents the only other significant manufacturing industry in the valley. Much of the urban and suburban workforce is involved in call centers, health care, education, major corporate headquarters or office operations, tourism, and local, state, and federal government.

1.2.2. Study Period Conditions

The Treasure Valley air toxics monitoring project initiated sample collection on February 17, 2007, and 24-hour averaged samples were collected every sixth day until the final samples were collected February 12, 2008. During this period the Treasure Valley experienced typical meteorological conditions, with only one strong wintertime inversion episode culminating on February 12, 2008, the last sample day of the study. The remainder of the winter brought numerous weather systems that prevented the buildup of strong, persistent multi-day inversions. However, the valley experienced more wildfire smoke than normal from regional fires during July, August, and September 2007, when 9 of 16 sample days were smoke-impacted. Seven days during those months were confirmed to be smoke–free, allowing a comparative analysis of the effects of wildfires on both the background and the urban air toxics levels.

1.3. Monitoring Sites

1.3.1. Monitoring Site Selection

The design of the monitoring network was intended to achieve the following objectives:

To determine the highest concentrations expected to occur in the area covered by the network.

To determine representative concentrations in areas of high population density.

To determine the impact on ambient pollution levels of significant sources or source categories.

To determine general background concentrations levels.

To determine the extent of regional pollution transport among populated areas.

In addition, to assure that the monitoring sites selected for this study would produce a data set that is comparable to data from toxics monitoring conducted elsewhere in the region and nationally, the final selection of specific sites for this study were identified following the rules and guidance provided in the the Network Design and Site Exposure Criteria for Selected Noncriteria Air Pollutants (EPA, 1984)

1.3.2. Monitoring Site Locations

Monitoring sites selected for this study, and the specific monitoring objectives for each site, are described below. These sites, along with the major cities and roadways, are shown in Figure 1-1.

Parma (PAR), background site at the western end of the Treasure Valley.
This location, about 45 kilometers (km) west of Boise and 6 km east of the Oregon border was selected to serve as a transport site, to gauge the levels of HAPs entering the airshed. Parma is a small farming town with a population of 1,831 in 2007. The monitoring site was located on the west edge of town at the City of Parma wastewater treatment site. Parma serves as a good site for determining background levels of air toxics for comparison with the urban air toxics levels in the Idaho portion of the Treasure Valley.

Northwest Nazarene University (NNU), central valley location at Nampa, Idaho.
DEQ monitored air toxics at this location from 2003 to 2004. Nampa is the second-largest city in Idaho with a rapidly growing population of nearly 80,000, and is centrally located in the Treasure Valley, about 30 km from Boise and 64 km from the Oregon border. Nampa has a diverse source profile including Title V (major point sources) and minor sources, light industry, and sprawling residential areas feeding heavy commuter traffic. The NNU campus, located near the center of the Nampa urbanized area, serves approximately 1,600 full-time students, and 8,236 continuing education students each year. Monitored $PM_{2.5}$ concentrations at this site are often the highest in the Treasure Valley.

St. Luke's (STL), at the junction of Interstate 84 and Eagle Road in Meridian. This location is approximately 16 km west of downtown Boise near the southwestern edge of the Boise-Meridian urbanized area and halfway between Boise and Nampa. It is near one of the busiest intersections in Idaho. Eagle Road, approximately 500 meters (m) to the west, is a principal urban arterial with traffic volumes of up to 50,000 vehicles per day. Interstate 84 (I-84), which is 375 m to the south, carries commuter traffic from the western portion of the valley and at its intersection with Eagle Road approaches 100,000 vehicles per day. The area is characterized by a variety of land uses including light industrial, several “big box” retail centers, residential subdivisions, a large planned senior community, and a major hospital. The immediate surroundings, within 150 m, are undeveloped land and sparsely used parking lots. This site is collocated with a Speciation Trends Network (STN) site and is also being prepared to serve as DEQ’s trace gas monitoring site as part of the National Monitoring Strategy.

Mountain View (MTV), in central Boise. Mountain View Elementary School is located just west and north of central Boise on the edge of the first of two topographical benches along the Boise River. It is in a residential area approximately 0.5 km from Chinden Boulevard (US 20/26), a major arterial with mixed light industrial and commercial areas along its length. This site is also about 5 km downwind of the urban core during the night time and the morning commute periods when southeasterly drainage winds predominate. Other monitoring equipment in operation at this site during this study include a continuous $PM_{2.5}$ tapered element oscillating microbalance (TEOM) monitor, a federal reference method $PM_{2.5}$ sampler and a PM_{10} high volume sampler. This site is representative of concentrations in areas of high population density and downwind of an area with high-volume traffic entering downtown Boise.

White Pine (WHP), in southeast Boise. White Pine Elementary School is in a residential area approximately 5 km from downtown Boise on the southeastern edge of the airshed. This region of the study area is one of the fastest growing in Ada County. It is surrounded by residential subdivisions and relatively low-volume traffic. However, it is also 3 km from the Boise Airport, 1-2 km from a light industrial area along Federal Way that includes a Title V facility (a locomotive refurbishing/testing facility), and 5 km from a Title V permitted semiconductor fabricating facility. This serves as a downwind monitoring location; however it receives drainage winds from the industrial facilities south and southeast of it for part of the day.

1.3.3. Characterization of the Areas Surrounding Monitoring Sites

To better understand the character and immediate surroundings of each monitoring site with respect to traffic, population, land use, and industrial activity, see Figure 1-2 through Figure 1-5 and the discussion below.

Traffic. On-road mobile vehicles are sources of a number of air toxics species, including benzene, toluene, ethyl benzene, and xylenes (BTEX compounds); the aldehydes formaldehyde and acetaldehyde; and trace metals lead and arsenic. The total of weekday vehicle miles traveled (VMT) within one kilometer of the St. Luke’s site is 381,400, the highest of any site. The second-highest is Mountain View, with 93,710; however, Mountain View is also downwind of the urban core when southeasterly drainage winds predominate and appears to be more heavily impacted by on-road mobile emissions (DRI, 2008). The greater mobile source impacts at Mountain View probably result largely from night-time, stable drainage winds bringing emissions from the downtown urban core and the I-184 freeway connector down-valley into the Mountain View area during the night and the morning commute time. The relative amount of vehicle traffic on major roadways near each site is shown in Figure 1-2.

Population. Population influences pollutant levels through home heating, particularly residential wood combustion in the winter, lawn and garden maintenance, local traffic, and consumer solvent use. Of the monitoring sites in this study, the most densely populated areas are the residential areas surrounding NNU, White Pine, Mountain View sites, as seen in Figure 1-3.

Land Use. Land-use determines whether a site is impacted more by urban sources or rural and agricultural sources. The four eastern-most sites are primarily surrounded by urban/developed land, with the greatest commercial/light industrial components near Mountain View, NNU, and St. Luke's. In contrast, the Parma site is surrounded closely by wetlands and wastewater lagoons, with a number of agricultural fields within 1-2 kilometers, including alfalfa, potatoes, and onions. See Figure 1-4. In addition to field crops, the agricultural area near Parma includes a number of beef and dairy cattle operations.

Light Industrial and Permitted Air Pollutant Sources. The only light industrial air pollutant sources within the vicinity (1 km) of the HAPs monitoring sites are dry cleaners that lie along the Chinden Boulevard area near Mountain View and near NNU. Mountain View has the largest number of auto body shops within one kilometers (6). A light industrial area also lies 2-5 km southeast of the White Pine site along Federal Way, including trailer manufacturing, metal working, along with two facilities that have Title V (i.e., major source) air quality permits (a locomotive refurbishing/testing facility and a semiconductor fabricating facility). See Figure 1-5. Finally, although not shown, there are some light industrial operations and onion warehouses 1-2 km from the Parma site.

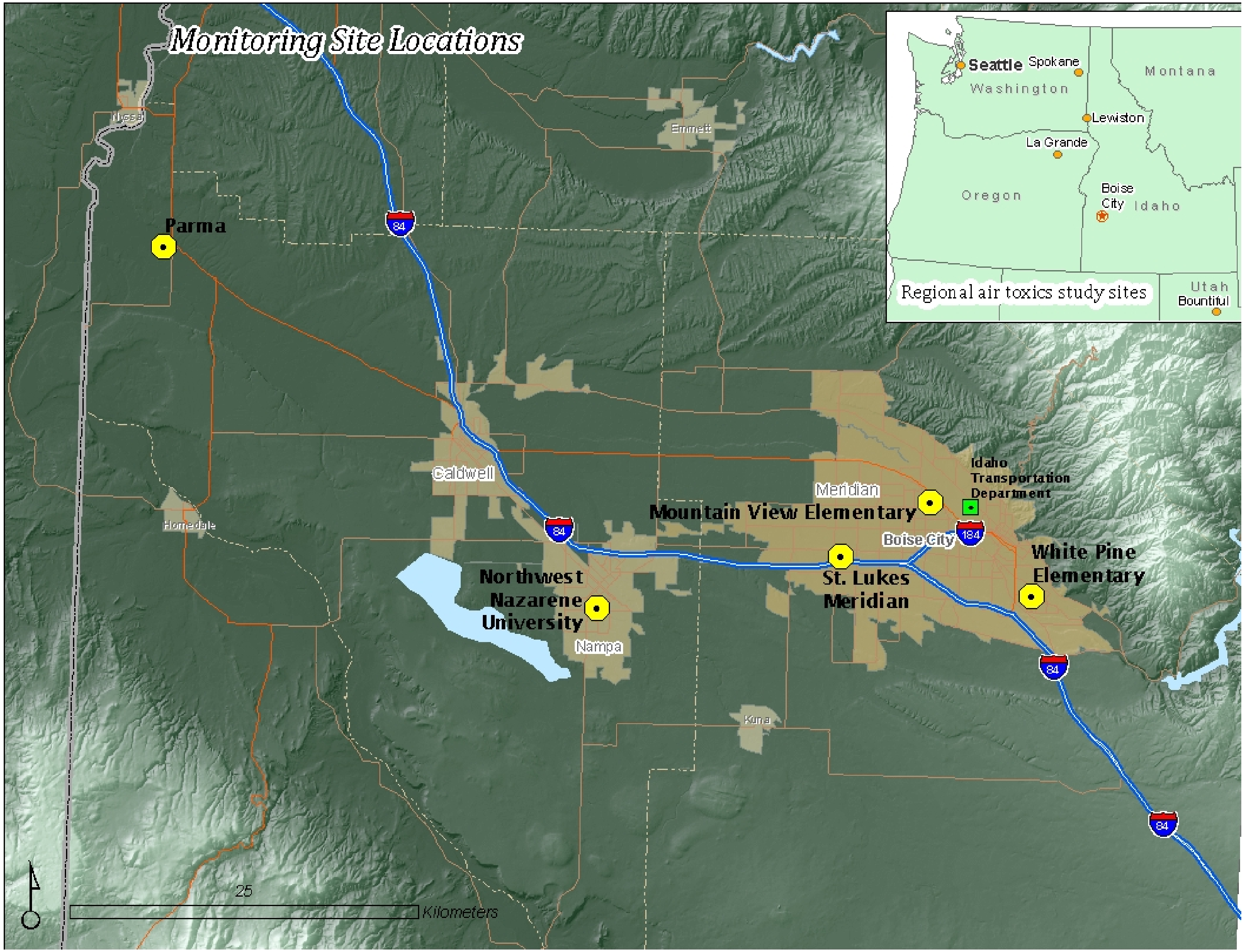

Figure 1-1. Monitoring site locations

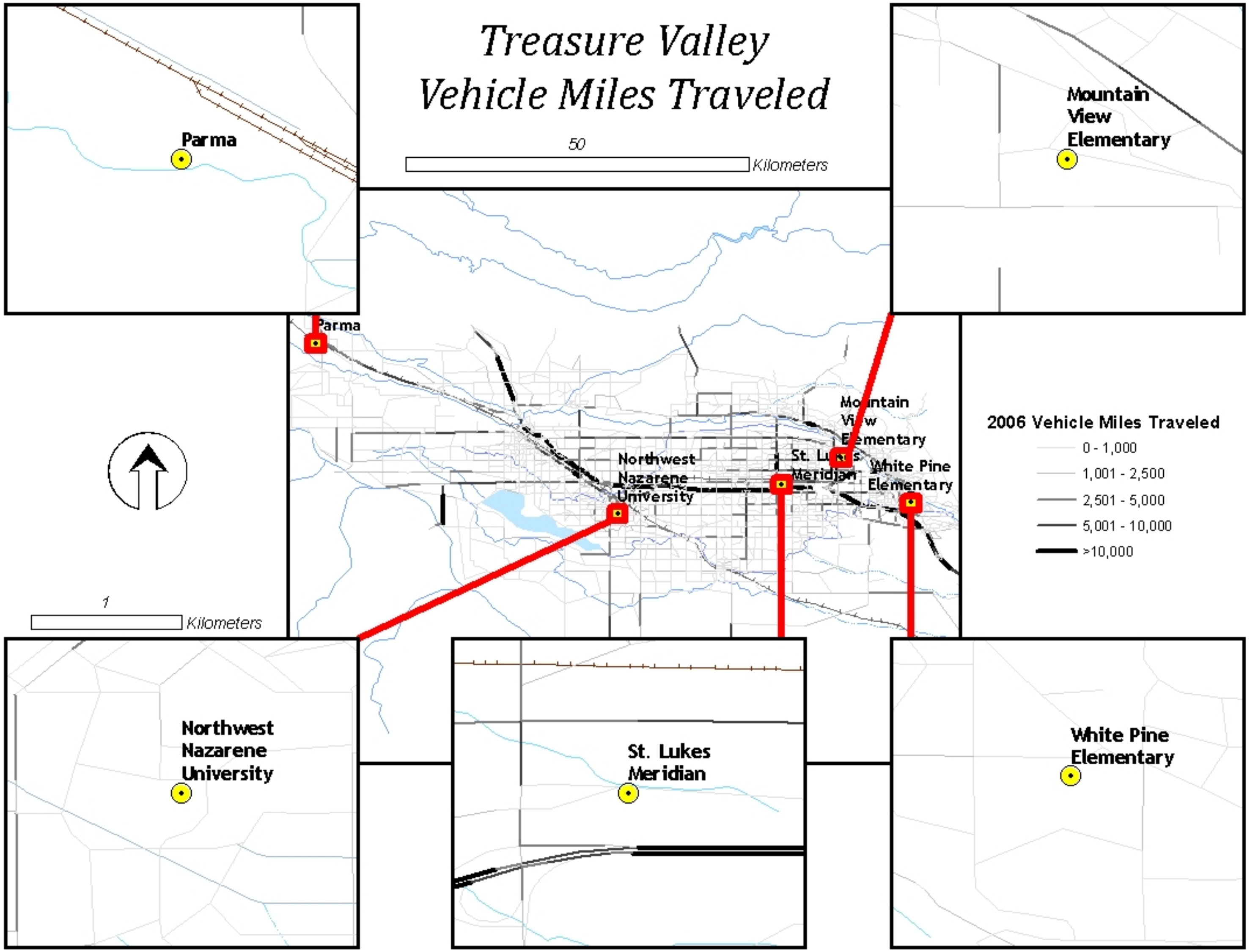

Figure 1-2. Vehicle miles traveled on nearby roadways

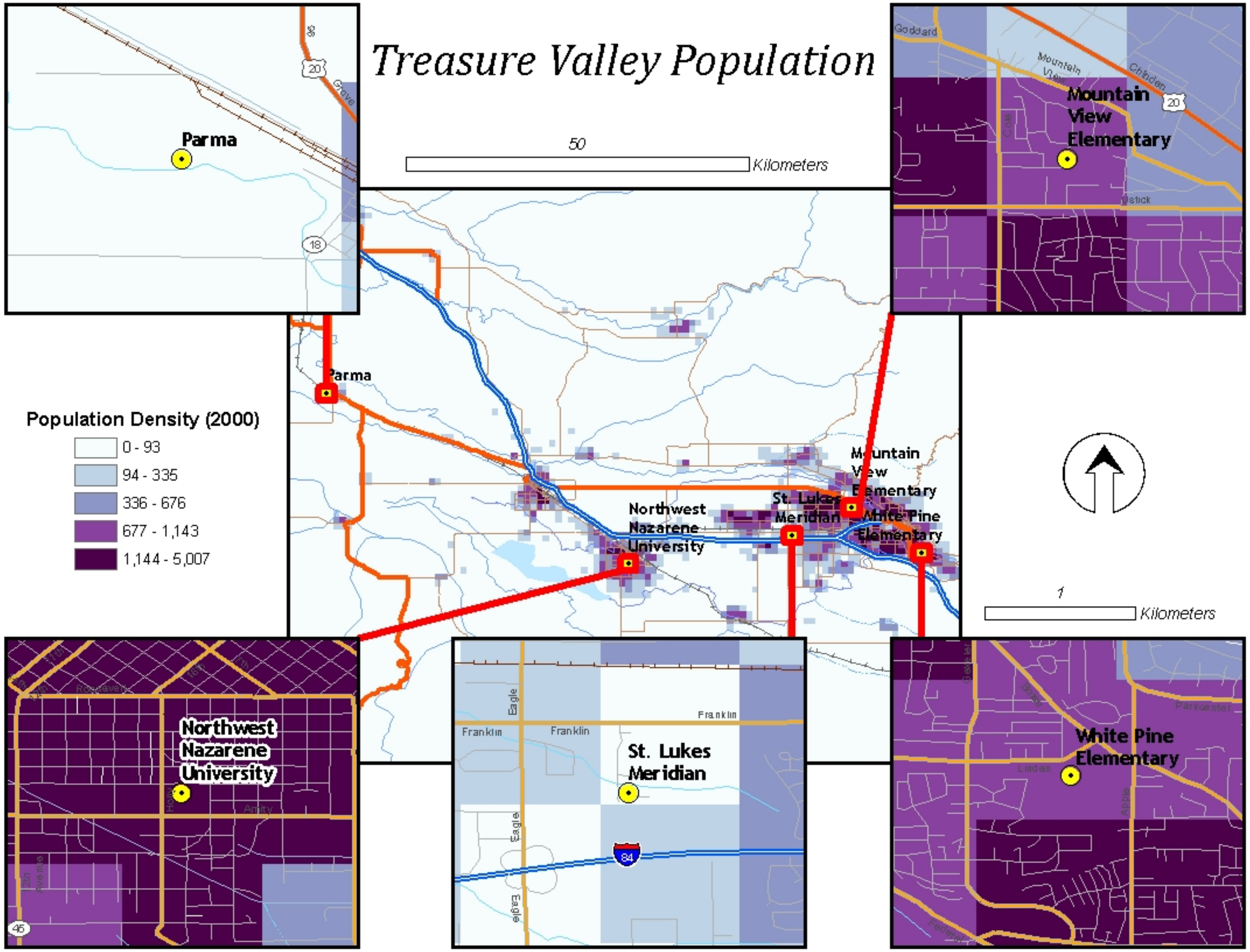

Figure 1-3. Population density

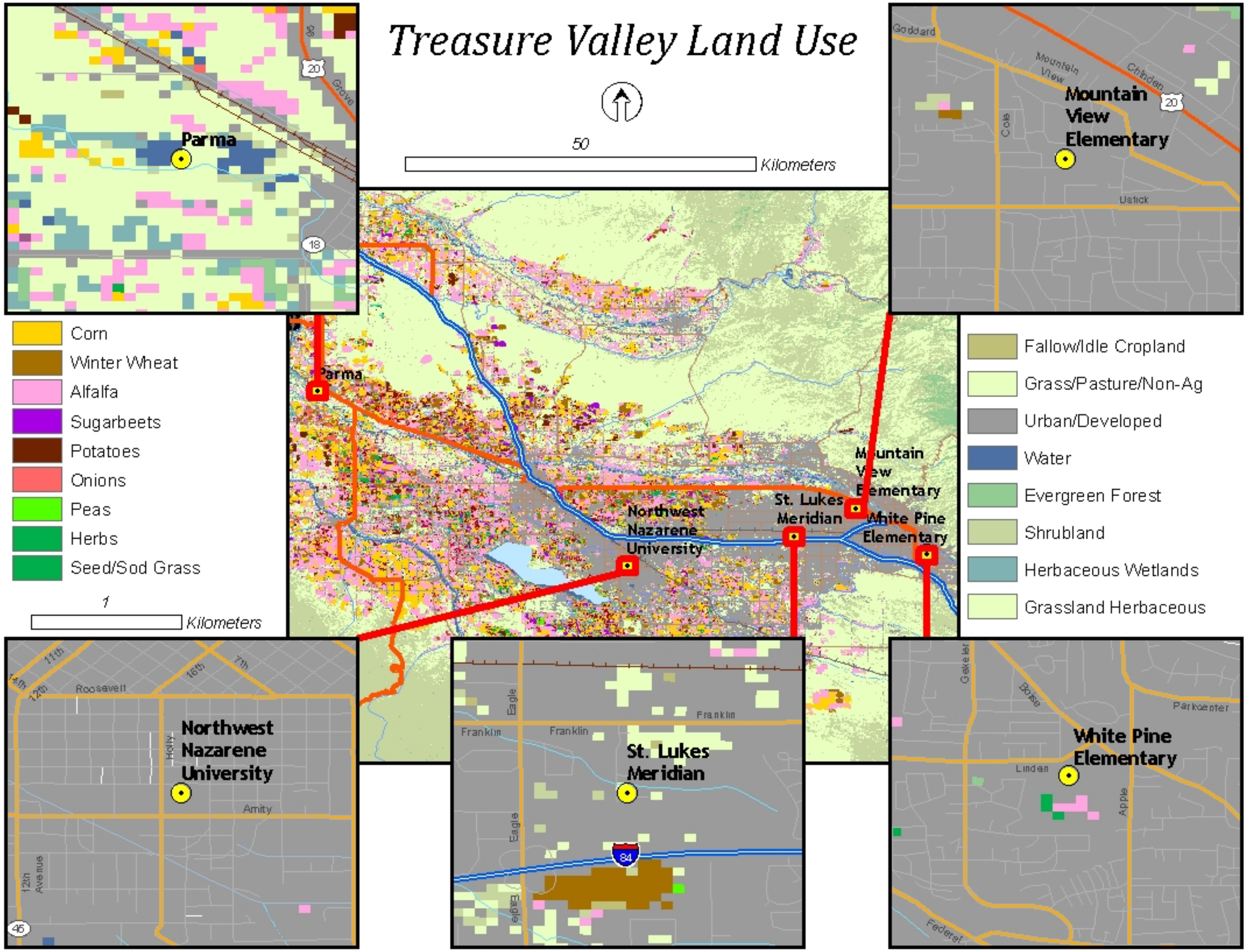

Figure 1-4. Land use and agricultural activity

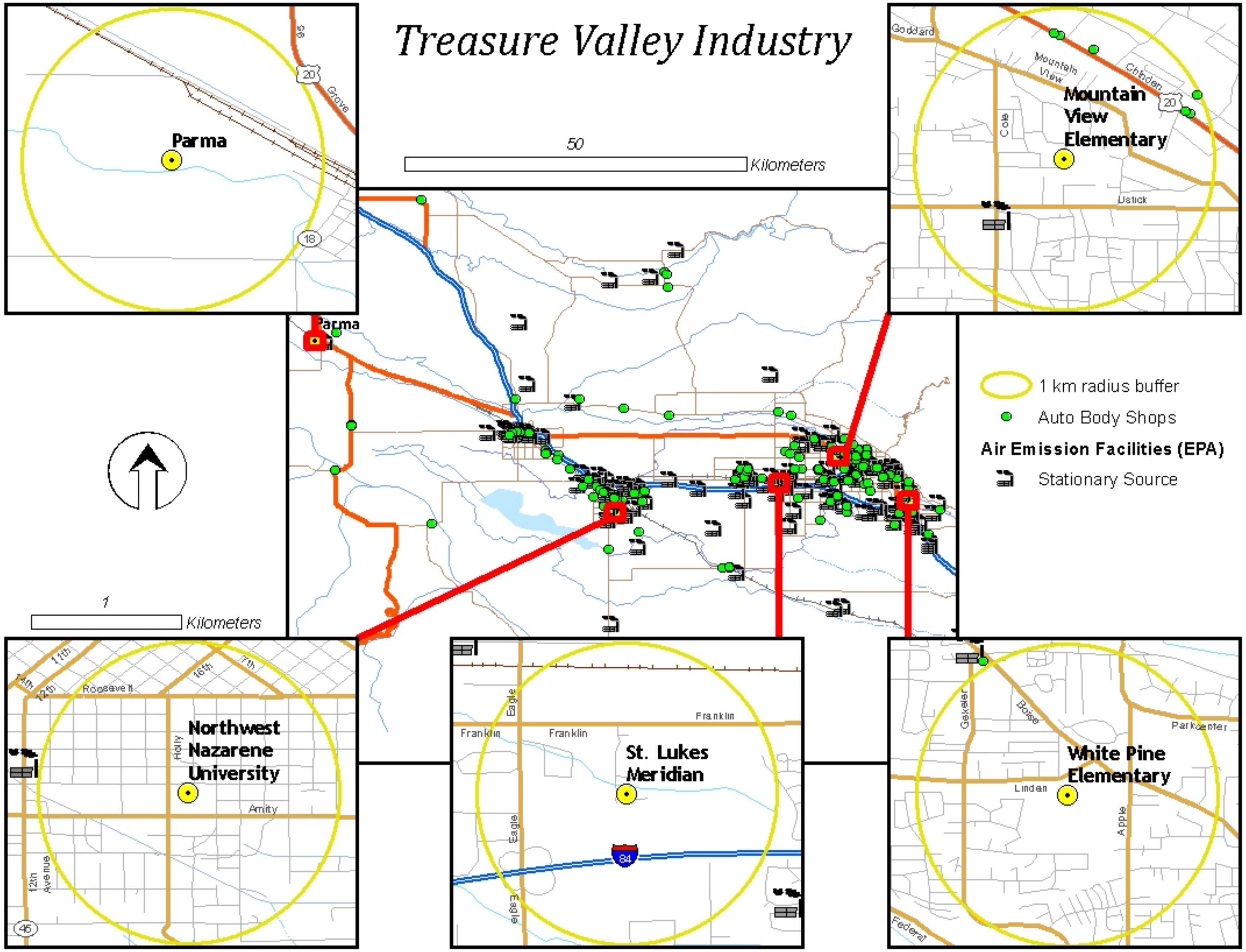

Figure 1-5. Light industrial and permitted air pollutant sources

2. Sampling and Analysis Methods

This section identifies the analytes included and methods used in this study, describes the data quality assurance process and procedures, and provides an assessment of the suitability of the data for human health risk screening.

2.1. Analytes

Analytes targeted in the sampling program include hazardous air pollutant (HAP) metals/trace elements in particulates 10 micrometers and smaller (PM_{10}), carbonyl compounds (ketones and aldehydes), and volatile organic carbon (VOC) compounds. (Black carbon monitoring was also attempted to probe diesel particulate matter variation in the Treasure Valley, but the monitoring suffered from data quality problems and is not reported here.) In addition to the HAP species, a number of non-HAP species are typically also reported since they are determined in the analysis and they can sometimes contribute source identification information. The HAP and non-HAP analytes reported in this study are listed in Appendix A according to their chemical class. Alternative names and CAS numbers are also shown to prevent any confusion in comparing these analytes to those in other studies.

2.2. Methods Used

Integrated 24-hour samples were collected for all HAP analyses. All sampling for both gas phase and particulate analyses was done on a one-in-six day schedule to coincide with the national particulate network schedule. Standard EPA Method TO-15 was used to measure VOCs; Method TO-11A was used to measure carbonyls, i.e., aldehydes and ketones; and Method IO-3.5 was used to measure PM_{10} metals beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), lead (Pb), manganese (Mn) and nickel (Ni) and non-metal trace elements arsenic (As) and selenium (Se). The Oregon DEQ Laboratory (ODEQ Lab) provided “certified clean” sampling media and canisters for carbonyls and VOCs, conducted all analyses and performed quarterly field audits. The ODEQ Lab also performed the intial phase of data validation based on field audit and laboratory quality assurance (QA) findings, and loaded all data directly into EPA’s Air Quality System (AQS) air monitoring database.

The analytical methods used in this study are described below.

2.2.1. Volatile Organic Compound Sampling

A detailed description of sampling for volatile organic compounds using SUMMA canisters can be found in EPA Method TO-15 (EPA, 1999a). An evacuated stainless steel canister is connected to the sampling system which pumps ambient air directly into the canister. A timer is used to begin and end sampling at midnight on successive days. A steady sampling rate is maintained over the 24-hour period by means of a pump, solenoid valve, and critical orifice.

2.2.2. Carbonyl Compound Sampling

Sampling for gaseous carbonyl compounds (aldehydes and ketones) occurs concurrently with VOC collection. A dinitrophenylhydrazine (DNPH) cartridge is attached to the sampling line and air is drawn through an ozone scrubber prior to passing through the cartridge. Details of the method are given in EPA Method TO-11A (EPA, 1999b).

2.2.3. Particulate Metals/Trace Element Sampling

Sierra-Anderson high-volume PM_{10} samplers were used for collecting inorganic metals and trace element samples. For this project, a special consideration was that the filter media should be compatible with the analytical methodology to allow multi-element analysis, so quartz PM_{10} filters were used to sample all particulate HAP metals. EPA Method IO-3.5 was used to analyze the metal/trace element concentrations (EPA, 1999c).

2.2.4. Supplemental Information from Related Studies

Two other studies were in progress during all or part of the period of this study, and the results from those studies were used in interpreting these results.

Speciation Trends Network (ongoing). The Speciation Trends Network site for Idaho is collocated at the St. Luke’s HAPs monitoring site. This program collects $PM_{2.5}$ samples and analyzes them for a wide range of metals, non-metal trace elements, and other particulate species including sulfate, nitrate, ammonium, elemental carbon, organic carbon, and chloride. The STN samples were collected every third day during the period of the HAPs study, including every HAPs sample day. This dataset was of value in identifying the origins of the emissions. Of particular value are the potassium, organic carbon, and elemental carbon concentrations, which aid in confirming any fire-impacted days, and the sulfate, nitrate and ammonium components of secondary aerosols which accumulate during stagnation events and therefore serve as an indicator for those events.

2007 Ozone Precursor Study. In July, August, and September 2007, the Desert Research Institute (DRI, 2008) conducted an ozone precursor study in the Treasure Valley, which involved continuous monitoring for oxides of nitrogen (NOx) and ozone at five sites and semi-quantitative automatic gas chromatography (auto-GC) analysis for hydrocarbons at two sites, one of which was co-located with the St. Luke’s air toxics monitors. On several HAPs sample days during this period, near-hourly concentrations of some HAPs species were recorded, providing some diurnal variation information which, like the STN data, were very useful in identifying source contributions and the emissions and meteorological conditions that may combine to produce them.

2.3. Data Quality Assessment

The data quality assurance program used in this study is described in this section, and an assessment is made of the suitability of the data for human health risk screening.

2.3.1. Quality Assurance Program Overview

2.3.1.a. Quality Assurance Project Plan

Data quality assurance for this project began with the development of a quality assurance project plan (QAPP; DEQ, 2006) which outlines the management systems, procedures, and criteria for ensuring and assessing data quality throughout this project.

2.3.1.b. Monitoring system preparation

The initial field activities conducted to assure data quality involved the siting and preparation of sample collection platforms, sampling equipment acceptance testing and set up, and sample media shipping and receiving preparations. This activity required more time than expected, resulting in a February 2007 start date and a February to February annual cycle.

2.3.1.c. Field QA

Field quality assurance (QA) activities include the completion of sample log sheets, site log books, chain of custody records, and sampler flow and pressure checks. Sampler flows and sample times were recorded on sample log sheets and delivered to the laboratory for determination of analyte concentration in air and assessment of sample validity.

2.3.1.d. Field Audits

Independent, project-specific systems and performance audits were conducted by the ODEQ Lab on 3 occasions: March 13, May 7, and August 27, 2007. Audit reports were provided to Idaho DEQ monitoring program management, and problems were addressed by DEQ’s Boise Regional Office staff responsible for field sampling activities.

2.3.1.e. Laboratory QA

Samples collected during this study were analyzed by the ODEQ Lab. In addition, laboratory staff provided independent field QA audits to check sampler operation, sample flows, and sample handling and storage operations. Based on sample log sheets and independent field performance audits, the ODEQ Lab invalidated data that did not meet both sample collection and laboratory QA requirements, and flagged data as “estimated” values when non-fatal data quality issues were found.

2.3.1.f. Database QA

All analytical data were certified by the ODEQ Lab and loaded by them directly into AQS, EPA’s national air monitoring database. HAPs (air toxics) data for this project were downloaded from AQS and independently checked against the database constructed from the original laboratory reports. This database was then reviewed for data quality and processing. The data validation process involved the steps outlined below. The species-specific and sample-specific validation findings and the final data quality judgments are listed in Appendix B.

Data Validation Process Steps

First, all data identifications in the database given as “missing” or “void” were eliminated and those cells left blank.

Second, any values that were identified as “estimated” because they “exceeded the analytical range” were carefully reviewed. It was concluded that based on knowledge of analyte sources and expected behavior, these values were expected to be elevated and thus they were retained in the database as “estimated” values. They included data from five formaldehyde samples taken in late June and July when photochemical activity is expected to be high, and one value each for *cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene from the Parma site at the peak period of soil fumigation involving this compound. These sample values were retained as “estimated” in the database because a) the calibration curves are very linear even at the upper end so these should be reasonably accurate estimates, b) the flagged formaldehyde concentrations reflect the same formaldehyde-to-acetaldehyde ratios observed in other mid-summer samples, and c) the highest values of these pollutants are important components of the air toxics risk and including them would be the most conservative approach to estimating risk. The samples restored on this basis are identified in Appendix B.

Third, all remaining “estimated” data with data quality flags indicating a potential data quality issue were eliminated from the database as invalid sample results and the cells were left blank, indicating “missing” samples. The database was reviewed before and after this step to assess the relative impact of this conservative approach to assuring the highest possible data quality. As a result of this comparison, no significant change in site mean concentration values occurred, so it was determined that removing all remaining “estimated” values with data quality issues to assure the highest possible level of data quality was a reasonable approach, even though data completeness statistics for some species suffered somewhat.

Finally, time series plots, species-species correlations, and seasonal site-to-site comparisons were used to identify any remaining samples that appeared to behave abnormally. This resulted in several instances of suspicious sample concentrations that were subsequently invalidated as not representative of ambient conditions. These instances are also identified in Appendix B.

2.3.2. Data Quality Objectives

Data quality criteria identified as goals in the QAPP were used by the ODEQ Lab in database validation and by Idaho DEQ in making the overall data quality assessments for each species. Data quality objectives are listed in Table 2-1.

Table 2-1. Data Quality Objectives

Parameter	**Reporting Units**	**Precision (RPD)**[a]	**Accuracy (Bias)**	**Complete-ness**	**Minimum Reporting Limits**
Metals/trace elements	µg/m^3 [b]	10%	± 10%	>75%	0.01 - 0.001
Aldehydes (Carbonyls)	µg/m^3 [b]	10%	± 15%	>75%	0.02 - 0.07
Volatile Organic Compounds	ppbv[c]	10%	± 15%	>75%	0.1 – 1.0

a. average relative percent difference; b. micrograms per cubic meter; c. parts per billion by volume (original reporting units). All VOC concentrations were converted to µg/m^3 for this report.

2.3.2.a. Precision

Precision is determined by using co-located sample collection and analysis and computing the average relative percent difference (RPD) for each species.

Co-located Monitoring. Duplicate samples for each type of measurement were collected every sample day at the St. Luke's site. These samples were designated as duplicate samples and comparison of these two samples was used to provide a measure of sampling precision.

Percent Difference (d_i). The relative percentage difference, d_i, for each co-located sample pair is calculated by using the following equation, where X_i represents the concentration produced from the primary sample, or aliquot, and Y_i represents the concentration reported for the duplicate sample.

$$d_i = \frac{Y_i - X_i}{(Y_i + X_i)/2} \times 100$$

For each species, the average relative percent difference (RPD) was calculated as the arithmetic average of the absolute values of all RPD values (sign ignored).

To assure robust precision estimates, the QAPP indicated that for each analysis method duplicate samples would be collected for every tenth sample. For simplicity of operations, a co-located sampler for each analysis method was installed at the St. Luke's sample site and duplicate samples were obtained during every sample period. This resulted in a 1 in 5 frequency of co-located samples or approximately 20%. Precision estimates are shown in Table 2-2 and Table 2-3.

2.3.2.b. Accuracy

Accuracy was evaluated by the ODEQ Lab through three field audits and through their Laboratory Quality Assurance Program. The audits indicated periodic problems with high-volume sampler flow rates and with a carbonyl sampler leak on one occasion, which invalidated all aldehyde data from the Mountain View site from May 18 through August 28, 2007.

Flow Rate Audits (Field). A flow rate audit is accomplished by measuring the sampler's normal operating flow rate using a certified flow rate transfer standard. Details are provided in each specific reference method.

Accuracy of a Single Sampler, Single Check Basis (d_i). The percentage difference (d_i) for a single flow rate audit *i* is calculated using the following equation, where X_i represents the audit standard flow rate (known) and Y_i represents the indicated flow rate.

$$d_i = \frac{Y_i - X_i}{X_i} \times 100$$

Instrument Checks (Lab). Balance checks are frequent checks of the working standards. The ODEQ Lab uses class 1 weights in accordance with ASTM[1] standards for its primary and secondary (working) balance standards and NIST[2]-supplied standards for both metals and gases.

Instrument Accuracy, Single Check *(d_y)*. The difference, d_y, for each check is calculated using the following equation, where *X* represents the certified value (known) and *Y* represents the reported value.

$$d_y = Y - X$$

2.3.2.c. Completeness

Completeness is a quality measure that is determined at the end of the project. Percent completeness is calculated as the ratio of the number of valid samples obtained to the number of scheduled samples. Completeness statistics are summarized in Table 2-2 and Table 2-3 along with minimum reporting limits (MRLs) and precision data.

2.3.2.d. Representativeness

This is a measure of how well the reported results reflect the actual ambient air concentrations and is primarily determined by the project design and the siting of the measurement stations. The representativeness of sample sites used in this study is discussed in Section 1.3.2, Monitoring Site Locations.

2.3.2.e. Comparability

Comparability reflects the ability to make comparisons between this dataset and ambient air toxics data collected in other geographic areas. It is primarily assured through the use of standard methods of sampling and analysis. In addition, comparability with other datasets is dependent on utilizing the same or similar methods of data analysis, similar minimum reporting limits (MRLs), similar data validation processes, and by reporting results in similar units. These factors are assessed below:

Similar Methods. The vast majority of air toxics sampling and analysis conducted in the United States over the last 5-10 years used the same three 24-hour collection and analytical methods utilized in this project for metals, VOCs, and carbonyls.

Minimum reporting Limits. Detection limits vary by laboratory and are determined individually for each pollutant analyzed by each method. The minimum reporting limits (MRLs) for the ODEQ Lab analyses, converted to units of $\mu g/m^3$ using site average conditions, are shown in Table 2-2 and Table 2-3.

Data Validation Methods. Data validation steps followed in this project generally reflect the practices identified in EPA’s Air Toxics Data Analysis Workbook (EPA, 2009b) and reflected in other Community Air Toxics Monitoring programs.

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[1] ASTM International, formerly the American Society for Testing and Materials.

[2] National Institute for Standards and Technology.

Standardized Units. Finally, to ease comparisons with other air toxics observations nationally and regionally, and to allow direct comparison to benchmarks used in risk evaluation, these air toxics species concentrations have all been converted into the units "micrograms per cubic meter" ($\mu g/m^3$) at local temperature and pressure conditions (LC). Carbonyls are already reported by the laboratory in these units so no changes are required. The conversion of gas-phase VOCs from "parts per billion by volume" (ppbv) to "$\mu g/m^3$" units requires correction of the molar volume to local conditions using the temperature and pressure averaged over each sampling period. The 24-hour averaged temperature and pressure at each sampling site recorded during the period of each sample collection were used to adjust sample concentrations from ppbv to $\mu g/m^3$. When temperature and pressure values were not available, temperature and/or pressure conditions from nearby adjacent sample sites for the same day were used. A minor correction was made to allow for the slight differences in pressure resulting from elevation differences up to 66 feet between the White Pine and Parma sites. In addition, on one occasion when local temperature and pressure conditions were not available, Boise airport conditions averaged over the appropriate 24- hour period were used.

2.3.3. Data Quality: Suitability for Use in Risk Evaluation

The purpose of this section is to assess the suitability of the annual average concentrations determined in this study for making health risk evaluations.

Data quality objectives are shown in Table 2-1. The parameters used to judge data quality are the minimum reporting limits (MRLs), the precision as indicated by the relative percent difference (RPD) between the St. Luke's primary (STL) and co-located (STL-D) samples, sampling program completeness rates, and the percentage of samples with concentrations above the MRL. The most important criteria in determining the confidence we have in the long-term average concentrations (for comparison to chronic risk benchmarks) is the percentage of species detections above the MRL. When too many sample results are below the MRL, the long-term average concentrations are dominated by the default replacement values of one-half of the MRL. As the rate of detections above the MRL drops below 10%, the average concentration primarily reflects the analytical system sensitivity rather than actual air concentrations.

We rated the percentage of sample results above the MRL according to the scheme recommended by Sonoma Technology in their Assessment of the National Database (Hafner and McCarthy, 2007). Based on that scheme, high confidence is given to any species detected more than 75% of the time, moderate confidence is given to any species detected 50-75% of the time, and less confidence is given to any species detected less than 50% of the time. DEQ has combined this scheme with similar ratings based on the success experienced in this study in meeting the precision, completeness and detection limit goals shown in Table 2-1.

The data quality assessment parameters are quantified in Table 2-2 and Table 2-3 below, along with a summary rating reflecting the overall confidence we have in using these data to properly characterize the long-term average concentrations and in their suitability for characterizing risk. The overall confidence reflects the degree to which the four numerical data quality objectives of Table 2-1 are met for each analyte.

As seen in Table 2-3 and Table 2-4, numerous HAP species were either not detected in this study or were so infrequently detected that we have low confidence that the resulting long-term averages properly characterize the risk. This is a normal occurrence in most urban toxics studies of this nature because the primary multi-species sampling and analysis methods (e.g., for VOCs) are not capable of reliably detecting such a wide variety of trace gases at sub-parts-per-billion (or sub-$\mu g/m^3$) levels.

Nevertheless, for most of the typical “risk-driver” species (i.e., for most of the species that often contribute to a significant fraction of the air toxics-related risk in most urban areas), the completeness, precision, and detectability statistics suggest an overall moderate to high level of confidence in the long-term average concentrations obtained from this dataset. The traditional urban risk-driver compounds observed with a moderate or high level of confidence include benzene, acetaldehyde, formaldehyde, and arsenic. On the other hand, several compounds that often contribute some increment of risk in other cities, that were not adequately detected in this study include acrylonitrile, nickel, chromium, 1,1,2,2-tetrachloroethylene, 1,3-butadiene, and vinyl chloride. These compounds are listed in Table 2-3 along with other species detected infrequently.

Table 2-2. Data Quality Assessment Summary – Species Frequently Detected

HAP?[a]	**Chemical Class**	**Species**	**MRL**[b] **$(\mu g/m^3)$**	**Average RPD**[c]	**No of Samples**	**% Complete**	**No. >MRL**	**% > MRL**	**Overall Level of Confidence**[d]
HAP	VOC	methyl chloride	0.20	9.3	292	79.8%	281	96.2%	Highest
	VOC	dichlorodifluoromethane	0.47	7.5	294	80.3%	285	96.9%	Highest
HAP	Metalloid	arsenic	0.0001	9.9	282	77.0%	263	93.3%	Highest
	VOC	trichlorofluoromethane	0.54	9.7	292	79.8%	230	78.8%	Highest
HAP	Carbonyl	propionaldehyde	0.04	2.8	265	72.4%	273	97.2%	High
HAP	Carbonyl	formaldehyde	0.02	2.3	258	70.5%	263	99.2%	High
HAP	Carbonyl	acetaldehyde	0.03	0.9	257	70.2%	267	99.6%	High
	Carbonyl	isovaleraldehyde	0.06	5.5	244	66.7%	229	87.7%	High
	Carbonyl	hexanal	0.06	1.5	243	66.4%	210	80.8%	High
HAP	VOC	toluene	0.36	10.2	305	83.3%	285	93.4%	High
HAP	Metal	manganese	0.001	10.5	277	75.7%	259	93.5%	High
	Carbonyl	butyraldehyde	0.05	3.9	265	72.4%	263	93.6%	High
	Carbonyl	benzaldehyde	0.06	6.2	249	68.0%	196	73.7%	High
HAP	VOC	benzene	0.31	16.1	301	82.2%	275	91.4%	High
HAP	Metal	lead	0.001	18.2	289	79.0%	217	74.8%	High
HAP	VOC	m,p-xylene	0.83	8.1	305	83.3%	187	61.3%	High
	VOC	n-heptane	0.39	8.0	310	84.7%	106	34.2%	Moderate
	Carbonyl	n-valeraldehyde	0.06	2.4	246	67.2%	179	68.1%	Moderate
	VOC	chloroethane	0.25		309	84.4%	117	37.9%	Moderate
HAP	Metal	cobalt	0.000075	10.6	287	78.4%	167	58.2%	Moderate
	VOC	2-hexanone	0.39	34.1	313	85.5%	91	29.1%	Moderate
HAP	VOC	methylene chloride	0.33	23.2	297	81.1%	130	43.8%	Moderate
HAP	VOC	*cis*-1,3-dichloropropene	0.43	0.0	313	85.5%	17	5.4%	Moderate
HAP	VOC	o-xylene	0.42	6.1	312	85.2%	135	43.3%	Moderate
HAP	Non-metal	selenium	0.00012	13.2	299	81.7%	133	44.5%	Moderate
HAP	Metal	beryllium	0.00001	19.8	292	79.8%	122	41.8%	Moderate
HAP	VOC	2,2,4-trimethylpentane	0.45	6.0	297	81.1%	111	37.4%	Moderate
HAP	VOC	n-hexane	0.34	9.7	309	84.4%	59	19.1%	Moderate
	VOC	1,2,4-trimethylbenzene	0.47	9.1	311	85.0%	92	29.6%	Moderate
HAP	VOC	*trans*-1,3-dichloropropene	0.43		314	85.8%	12	3.8%	Moderate
HAP	Metal	cadmium	0.0001	18.1	309	84.4%	76	24.4%	Moderate
	VOC	cyclohexane	0.33		312	85.2%	56	17.9%	Moderate
HAP	VOC	ethyl benzene	0.42	4.2	299	81.7%	68	22.7%	Moderate

a. indicates if species are EPA-listed Hazardous Air Pollutants; b. minimum reporting level; c. average relative percent differences; d. based on data quality assessment parameters in this table; indicates aggregate confidence in using annual means to properly characterize long-term exposure and chronic risk.

Table 2-3. Data Quality Assessment Summary – Species Infrequently Detected

HAP?[a]	Chemical Class	Species:	MRL[b] ($\mu g/m^3$)	Average RPD[c]	No. of Samples	% Complete	No. >MRL	% > MRL	Overall Level of Confidence[d]
HAP	VOC	carbon tetrachloride	0.60	1.3	311	85.0%	74	23.8%	Low
HAP	VOC	acrylonitrile	0.21		314	85.8%	19	6.1%	Low
HAP	VOC	methyl isobutyl ketone	0.39		314	85.8%	18	5.7%	Low
HAP	VOC	bromomethane	0.37	8.1	313	85.5%	29	9.3%	Low
	Carbonyl	p-tolualdehyde	0.07	0.0	276	75.4%	18	6.1%	Low
	Carbonyl	m-tolualdehyde	0.07	6.7	279	76.2%	13	4.4%	Low
	Carbonyl	crotonaldehyde	0.05	6.7	286	78.1%	13	4.3%	Low
	VOC	isopropyl alcohol	0.24	132.3	309	84.4%	131	42.4%	Low
	VOC	p-dichlorobenzene	0.58		314	85.8%	1	0.3%	Low
	VOC	1,3,5-trimethylbenzene	0.47		314	85.8%	6	1.9%	Low
HAP	VOC	chlorobenzene	0.44		313	85.5%	7	2.2%	Low
HAP	VOC	chloroform	0.47		314	85.8%	2	0.6%	Low
HAP	VOC	hexachloro-1,3-butadiene	1.02		314	85.8%	3	1.0%	Low
HAP	VOC	styrene	0.41		314	85.8%	4	1.3%	Low
	VOC	p-ethyltoluene	0.94		313	85.5%	3	1.0%	Low
HAP	Metal	nickel	0.001	33.3	329	89.9%	4	1.2%	Low
	VOC	chlorodibromomethane	0.82		314	85.8%	1	0.3%	Low
HAP	Metal	chromium	0.0032		324	88.5%	2	0.6%	Low
HAP	VOC	1,1,2,2-tetrachloroethylene	0.65		314	85.8%	1	0.3%	Low
HAP	VOC	carbon disulfide	0.30		314	85.8%	1	0.3%	Low
	Carbonyl	o-tolualdehyde	0.07		285	77.9%	1	0.3%	Low
HAP	VOC	1,2,4-trichlorobenzene	2.84		314	85.8%	2	0.6%	Low

a. indicates if species are EPA-listed Hazardous Air Pollutants; b. minimum reporting level; c.average relative percent differences; d. based on data quality assessment parameters in this table; indicates aggregate confidence in using annual means to properly characterize long-term exposure and chronic risk.

Table 2-4. HAP Analytes Not Detected in Any Sample

Analyte Species Not Detected
1,1,2,2-tetrachloroethane
1,1,2-trichloroethane
1,3-butadiene
bromoform
chloroprene
ethylene dibromide(dibromoethane)
ethylene dichloride (1,2-dichloroethane)
ethylidenedichloride(1,1-dichloroethane)
methylchloroform(1,1,1-trichloroethane)
methyltertbutylether (MTBE)
propylene dichloride (1,2-dichloropropane)
trichloroethylene
vinyl bromide
vinyl chloride

3. Summary of Air Toxics Levels Measured in This Study

3.1. Descriptive Statistical Results

Summary tables for each of the five monitoring locations are provided in Appendix C. Each table provides the mean, median, maximum concentration, standard deviation, minimum reporting limit (MRL), count of valid samples, and number of valid detections for each pollutant. All concentrations are reported in $\mu g/m^3$. To simplify analysis and to make data comparable to other air toxics studies and to national statistics, non-detect values were substituted with a value of one-half of the MRL. A non-detect does not mean that a pollutant is not present, only that it was below the detection (or reporting) limit of the sampling method. Choosing one-half of the MRL is somewhat arbitrary but is a common practice and is the convention for the national database published by EPA that provides one source of comparison data used in evaluating the results of this study (EPA, 2009c). The true concentration is somewhere between zero and the detection limit, so one-half of the MRL provides a reasonable, and usually conservative surrogate. (Note: some analyses, such as temporal-seasonal trends analysis and analyses used in source apportionment work, are more appropriately performed without making this substitution, to allow analysis of trends, and such cases will be identified.)

The annual mean concentrations for key air toxics measured in this study are shown in Figure 3-1 through Figure 3-6. These figures show 95% confidence intervals computed assuming that the data for each species is normally distributed. The assumption of normality is only valid for some of the species; however, it is used to provide a uniform indication of variability. The more abundant trace metals, manganese and lead, are shown in Figure 3-1. Manganese appears slightly higher at Parma on an annual basis; however, none of the differences among sites in annual means for either manganese or lead are significant. Annual means for trace metals are shown in Figure 3-2. In this case, a statistically significant gradient increasing from White Pine to Parma is apparent for arsenic and for selenium. Annual means for the HAP aldehydes formaldehyde, acetaldehyde, and propionaldehyde are shown in Figure 3-3. The VOC HAP species that are largely associated with mobile sources, including benzene, are shown in Figure 3-4. A consistent pattern is apparent, with significantly higher annual means at Mountain View, the site nearest the urban core and conjunction of major arterials entering the city center. Figure 3-5 shows annual mean values for a number of other VOCs which are generally not mobile source-related. The solvent hexane is significantly higher in southeast Boise at the White Pine site (similar to the non-HAP solvents not shown: isopropanol and cyclohexane). Acrylonitrile is highest in Parma, while the solvents methyl chloride and methylene chloride peaks at St. Luke's, and carbon tetrachloride is uniformly distributed, reflective of a largely background pollutant. Finally, two isomers (*cis*- and *trans*-) of 1,3-dichloropropene, shown in Figure 3-6, are highest at Parma. There are lower levels observed at Nampa. There was a single detection at St. Luke's and no detections further east, reflective of its application almost exclusively as a soil fumigant in local agriculture.

The spatial and seasonal variations for these pollutants are described in more detail in the next section.

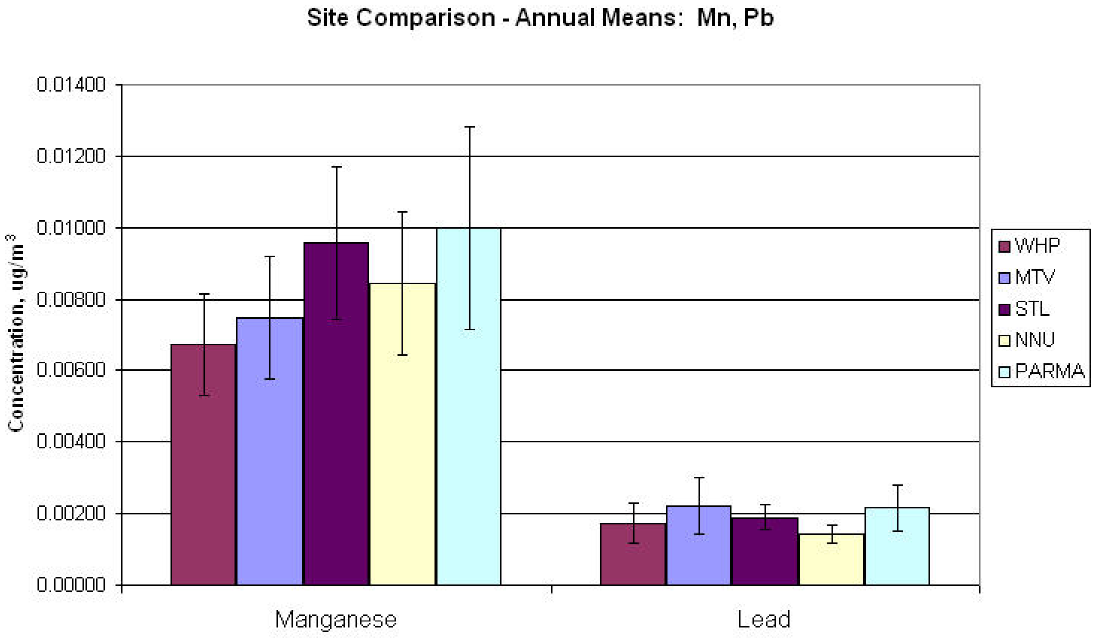

Figure 3-1. Annual mean concentrations of more abundant metals, manganese and lead, by monitoring site. Confidence intervals (95%) are represented by error bars.

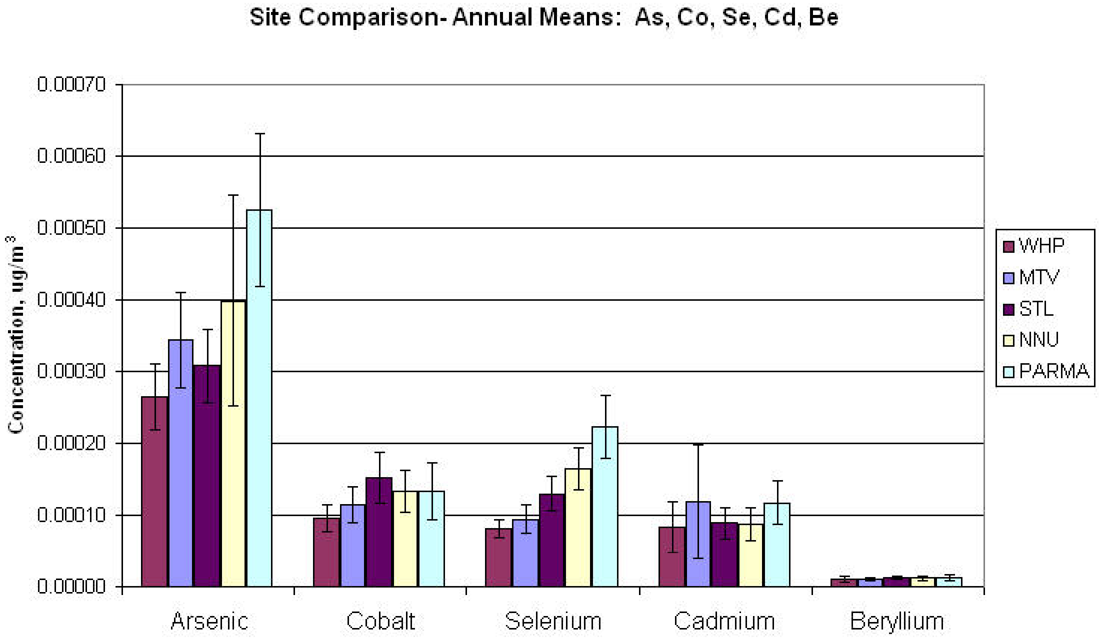

Figure 3-2. Annual mean concentrations of metals/trace elements by monitoring site. Confidence intervals (95%) are represented by error bars.

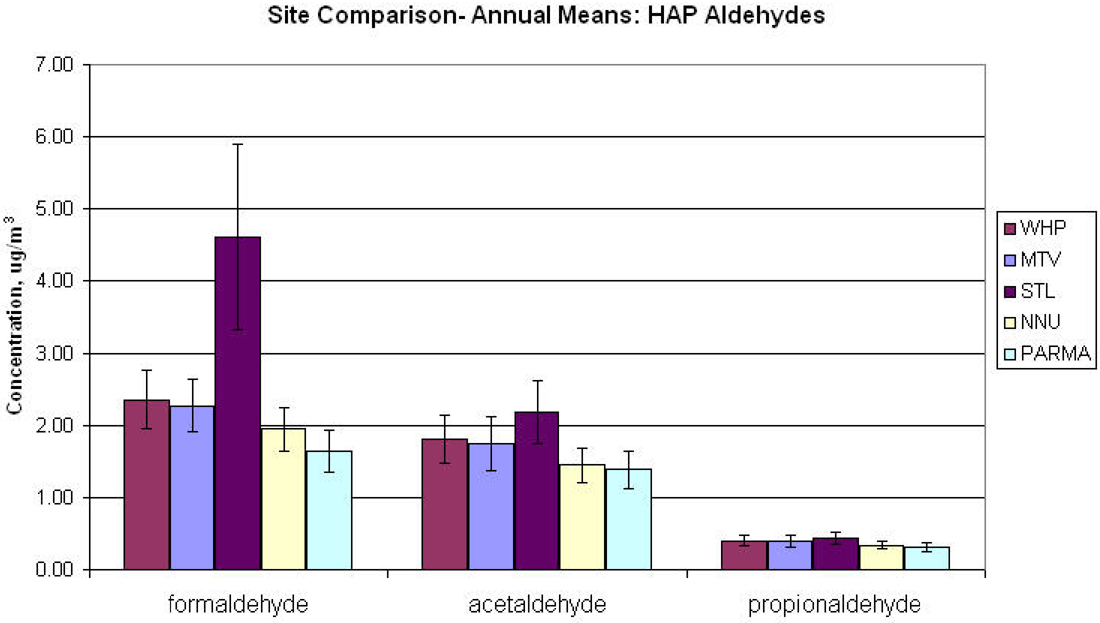

Figure 3-3. Annual mean concentrations of HAP aldehydes by monitoring site. Confidence intervals (95%) are represented by error bars.

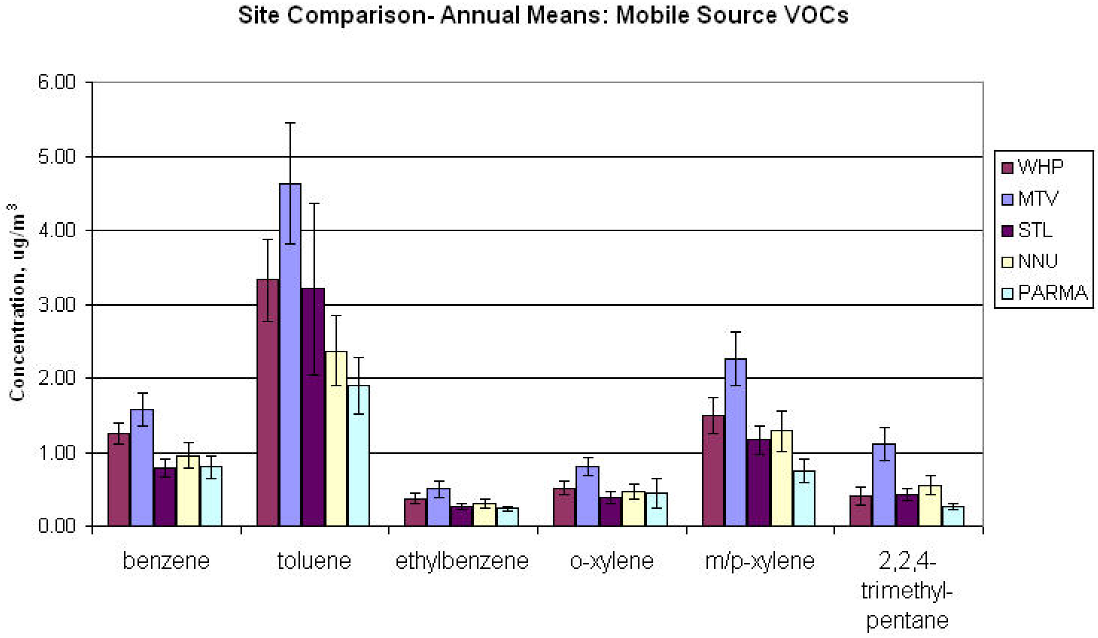

Figure 3-4. Annual mean concentrations of VOCs largely associated with mobile sources and fuels, by monitoring site. Confidence intervals (95%) are represented by error bars.

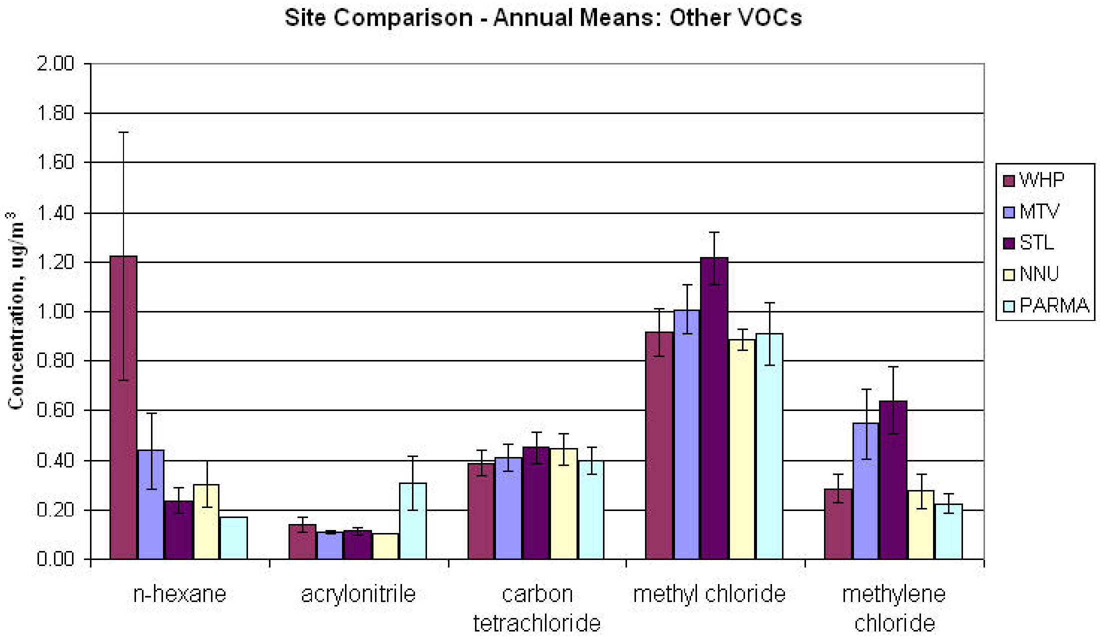

Figure 3-5. Annual mean concentrations of other selected VOCs by monitoring site. Confidence intervals (95%) are represented by error bars.

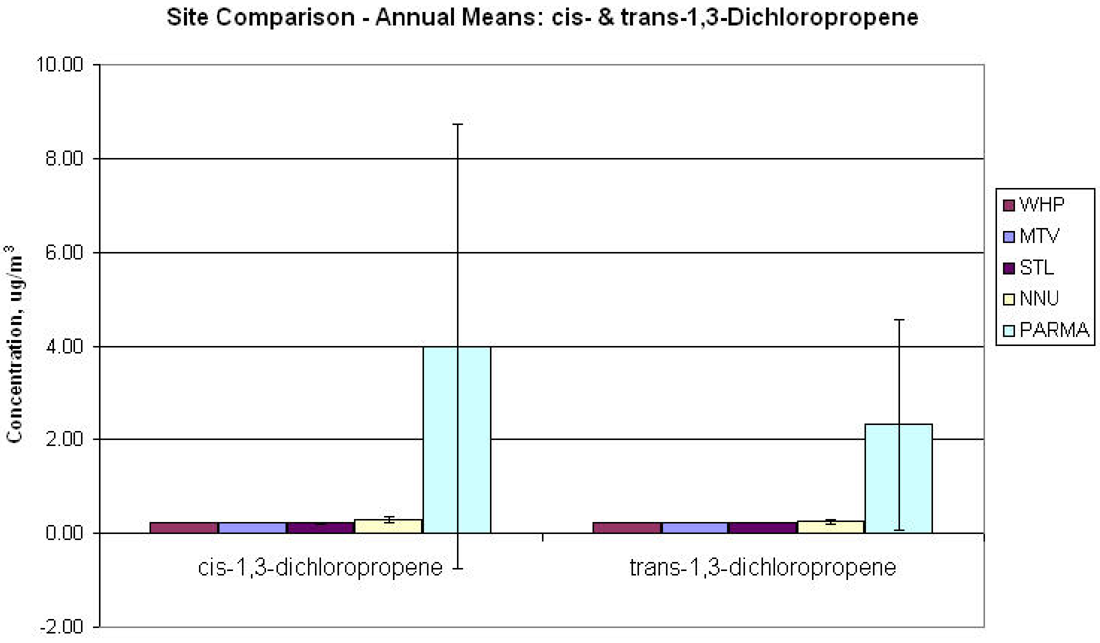

Figure 3-6. Annual mean concentrations of 1,3 dichloropropene isomers by monitoring site. Confidence intervals (95%) are represented by error bars.

3.2. Spatial-seasonal Variation of Key Species

The patterns of spatial and temporal variation in air toxics concentrations are important characteristics because they provide important clues to the sources and conditions that lead to increased levels, and they provide information about the overall frequency and nature of exposure. Figure 3-7 through Figure 3-13 depict both the seasonal variation of each key air toxic observed in this study and the spatial trends from east to west, which generally reflect the urban to rural trend except that the easternmost site, White Pine (WHP) in southeast Boise, is somewhat on the eastern fringe of the urban areas while the next site to the west, Mountain View (MTV), more closely represents the urban core and drainage flows from the downtown area. Non-detect values are replaced by zeroes in this analysis (rather than one-half of the MRL) to avoid obscuring the spatial and seasonal trends.

Figure 3-7 through Figure 3-13 are grouped by similar species so that similar trends can be recognized. Metals (and non-metal elements arsenic and selenium) are grouped according to abundance with manganese, lead, and arsenic (Mn, Pb, As) shown in Figure 3-7, and the other trace elements, beryllium, cadmium, cobalt, and selenium (Be, Cd, Co, Se) shown in Figure 3-8. Aldehydes are grouped in Figure 3-9, and the BTEX aromatic compounds (benzene, toluene, ethyl benzene, and xylenes), which are largely vehicle–related, are shown together in Figure 3-10 so that their similar patterns can be seen. The BTEX compounds are generally highest at Mountain View and lowest at Parma on the western, side of the valley. The remainder of the key HAPs species are shown together as aliphatics and acrylonitrile in Figure 3-11, single-carbon chlorinated VOCs (carbon tetrachloride, methyl chloride, and methylene chloride) in Figure 3-12, and finally, the 1,3-dichloropropene *cis*- and *trans*- isomers, which co-occur in some soil fumigants, are shown together in Figure 3-13. Each marker symbol represents a seasonal average concentration and each contiguous line represents one season, with the other seasons in order from left to right. Only seasonal averages with 10 or more of the planned 15 or 16 samples (each 3 months) are included as valid seasonal averages, and missing markers or "breaks" in the lines indicate sites for which less than 10 valid samples were available. Seasons are March-April-May for spring, June-July-August for summer, September-October-November for fall and December-January-February for winter. The February sample days are drawn partly from the early part of the study in February 2007 and partly from February 2008. Confidence intervals are not shown, due to the small number of samples (10-16) for each season.

3.2.1. Spatial Variation

For ease in understanding spatial variation, the sites from east to west are ordered from left to right in Figure 3-7 through Figure 3-13, with the Boise urban core represented by Mountain View (MTV) and the rural upwind site by Parma (PAR).

Spatial variation of HAPs species is typically related to nearby land use. Mobile source/urban source toxics generally trend from lowest levels in the western rural site (Parma) to higher levels in the near-urban core Mountain View site and slightly lower than the urban core at the White Pine and St. Luke's sites, both of which are on the edge of the urban area. This trend is clear for all the mobile-source related toxics, as shown in Figure 3-10 (BTEX compounds) and also for 2,2,4–trimethylpentane, another gasoline constituent shown in Figure 3-11. Finally, when other sources don't dominate, this trend can also be seen for lead and arsenic (summer), for lead and manganese (winter), and for aldehydes (in the fall when photochemical aldehyde production decreases).

3.2.2. Seasonal Variation

Metals and trace elements arsenic and selenium concentrations tend to be highest in the spring and summer when winds are higher, soils are dryer, and agricultural tilling and fertilizing is greatest. This type of temporal pattern appears to occur primarily with species that may be present in soils susceptible to wind erosion in the rural areas and may be enhanced in agricultural soils and fertilizers, including manganese, cadmium and selenium. These seasonal trends are reinforced by clear spatial trends for these metals which are always lowest in the urban areas and increasing in Nampa and Parma, although the relative influence of native soils versus agriculturally-enriched soils and direct fertilizer application is not clear.

Aldehydes are generally highest in the summer when photochemical activity is highest, and lowest in the winter. However, the aldehydes also appear to be highest at Mountain View and St. Luke's where the motor vehicle traffic has its greatest influence, so both sources of aldehydes appear to be reflected in these data. In addition, wildfires during the summer appear to enhance aldehyde levels at all sites.

The BTEX compounds benzene, toluene, ethyl-benzene, and xylenes (o-xylene and m&p xylenes reported together) are primarily gasoline- and motor vehicle-related. There is a very consistent relationship amongst the BTEX compounds, all of which are generally highest in the spring, summer, and fall, and lowest in the winter. This is somewhat unexpected since dispersion is better in the warm months, however, evaporation from fuels is also higher and that may be a dominant factor in BTEX seasonality.

Figure 3-11 shows the spatial-temporal patterns of 2,2,4-trimethyl pentane, n-hexane, and acrylonitrile. The first of these compounds, 2,2,4-trimethylpentane, is a common gasoline ingredient which co-occurs with the BTEX compounds shown in Figure 3-10: it peaks at Mountain View and is the lowest at Parma, the same pattern seen in the BTEX compounds.

N-hexane is a trace component in gasoline but may also be used as a solvent. It is highest in the summer and fall, but even more dramatically, has a strong west-to-east gradient peaking at White Pine. Isopropanol (not shown) has a similar pattern; however, poor precision statistics (132% RPD) resulted in a low level of confidence in the isopropanol data. Finally, the health risk analysis below indicated that neither of these compounds are a human health concern so additional analysis was not conducted.

Acrylonitrile was infrequently detected; therefore, data for it is of low quality. However, there were some detections of acrylonitrile at White Pine in the spring and summer and more detections of it at the Parma site, also in the spring and summer.

Chlorinated single-carbon VOCs shown in Figure 3-12 reflect little seasonal variation; however, both methyl chloroform and methylene chloride appear to be somewhat higher in the summer and fall, peaking at the St. Luke's site.

Finally, 1,3-DCP seasonal variations, shown in Figure 3-13, reflect the most dramatic seasonal pattern, as a result of its usage as a fumigant in the agricultural areas, almost entirely in the fall after crops are harvested.

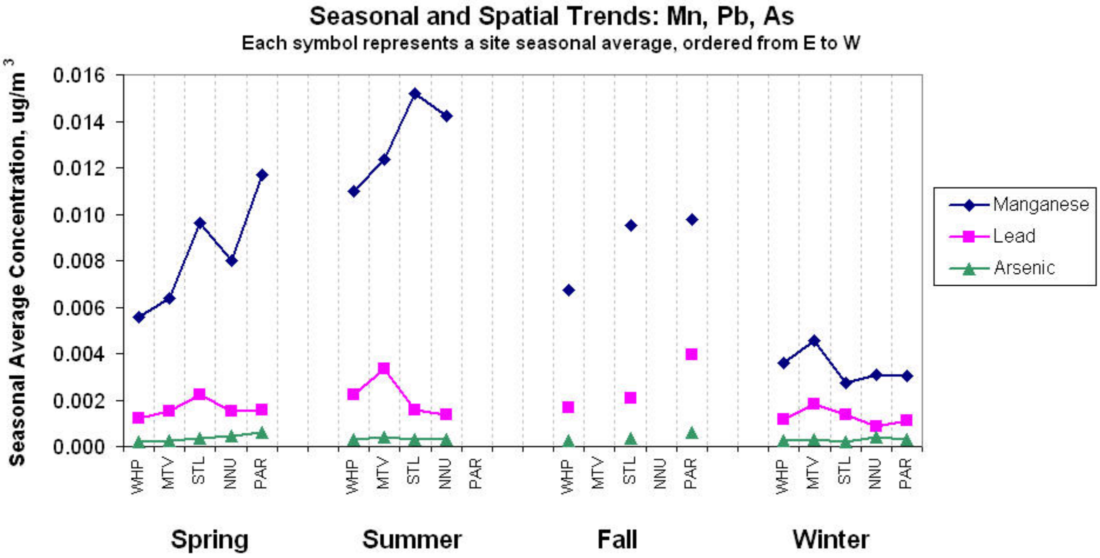

Figure 3-7. Seasonal and spatial trends for the elements manganese, lead, and arsenic.

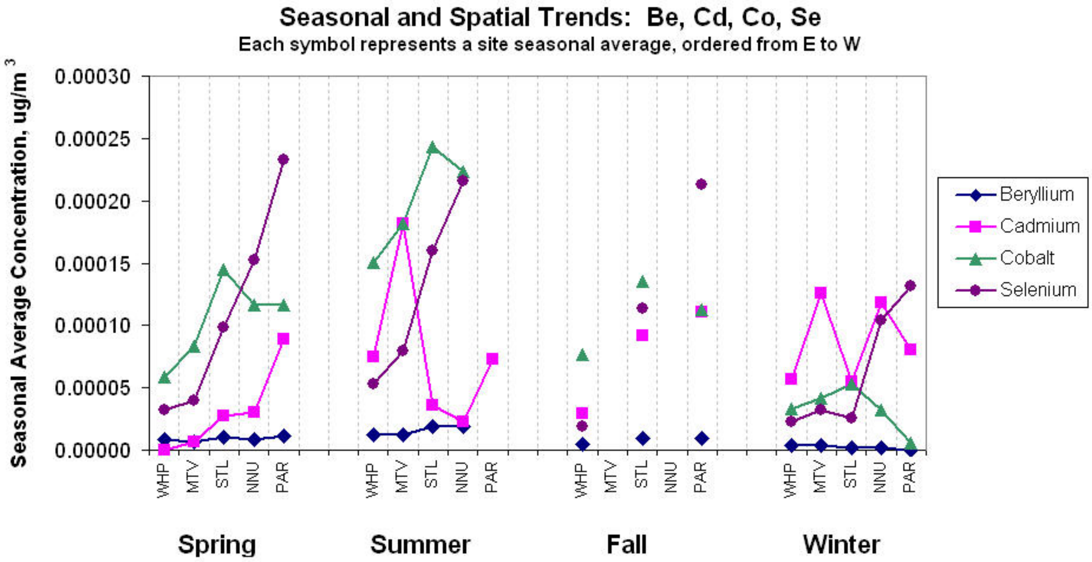

Figure 3-8. Seasonal and spatial trends for the trace elements beryllium, cadmium, cobalt, and selenium.

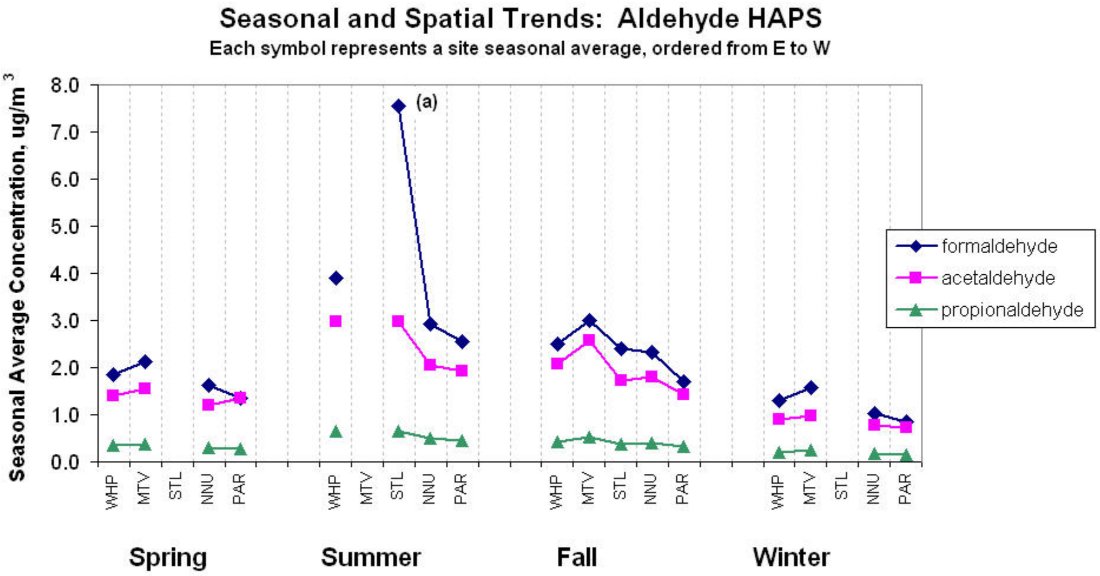

Figure 3-9. Seasonal and spatial trends for the aldehyde (carbonyl) HAPs formaldehyde, acetaldehyde and propionaldehyde. Note (a): There may be a unique local source contribution to formaldehyde at the St.Luke's site.

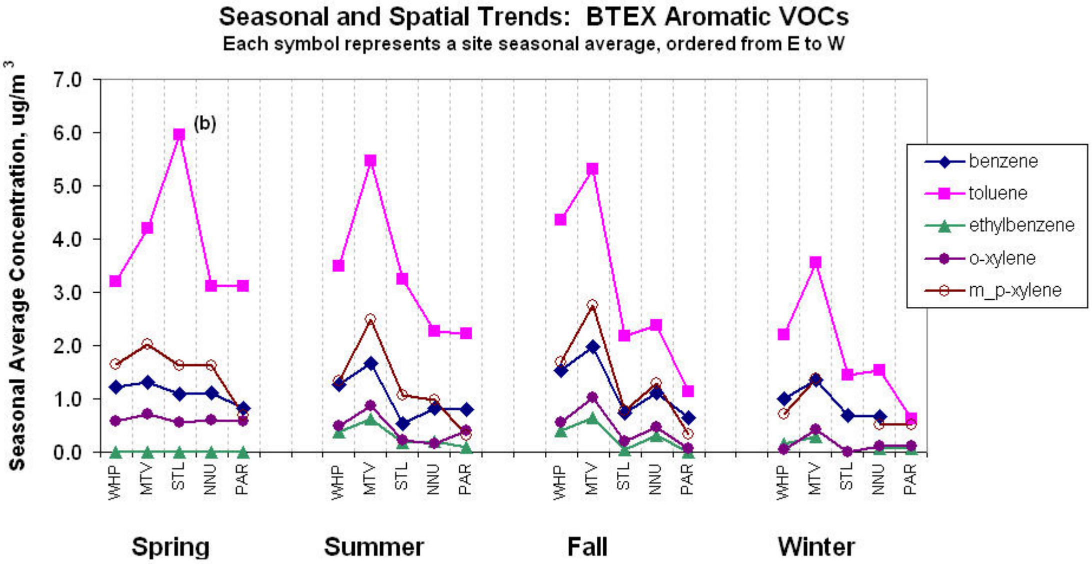

Figure 3-10. Seasonal and spatial trends for the mobile source-related BTEX compounds. Note (b): Toluene at St. Luke's in the spring is dominated by a single high value observed at both primary and duplicate samplers.

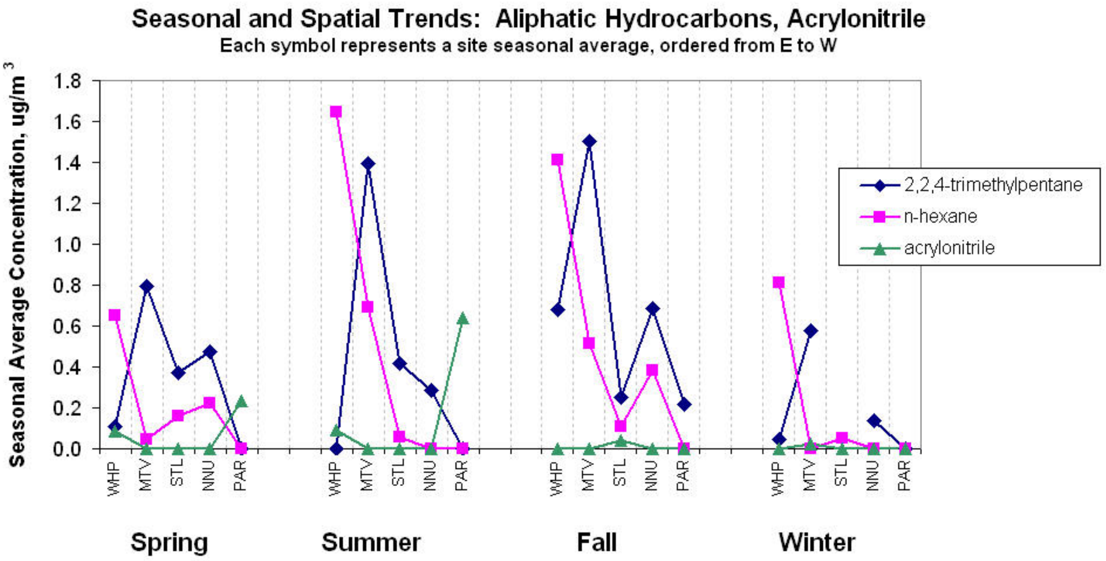

Figure 3-11. Seasonal and spatial trends for aliphatic (single-bonded) species and acrylonitrile.

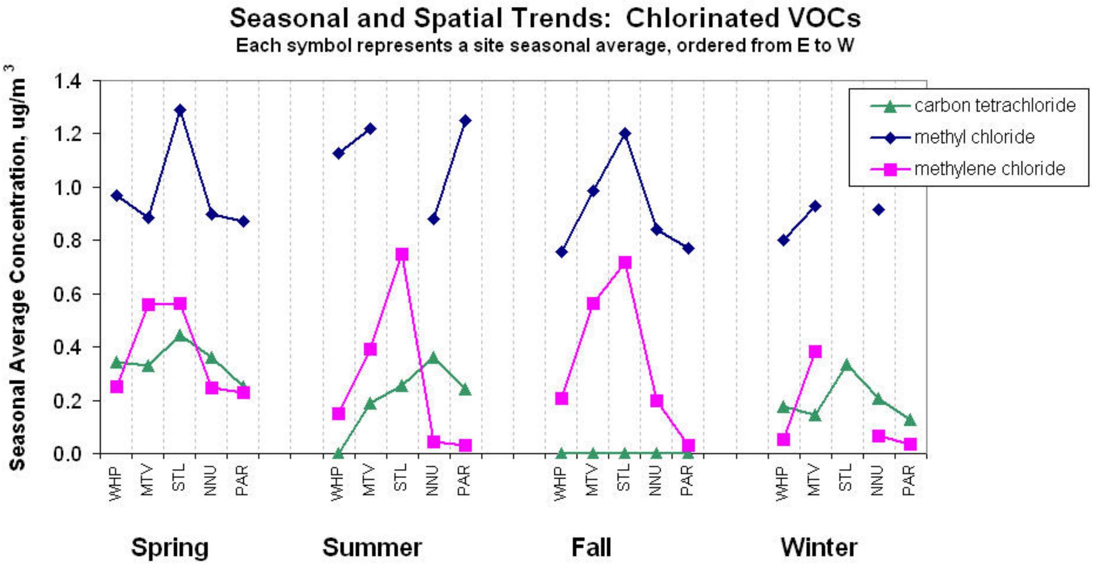

Figure 3-12. Seasonal and spatial trends for single-carbon chlorinated species. There was a detection problem with carbon tetrachloride, which is well known to be globally distributed at levels of approximately 0.6 μ/m^3 with little seasonal variation. Little seasonal variation is seen in the other two species. The highest levels of the common solvents methyl chloride and methylene chloride seem to be at St. Luke’s.

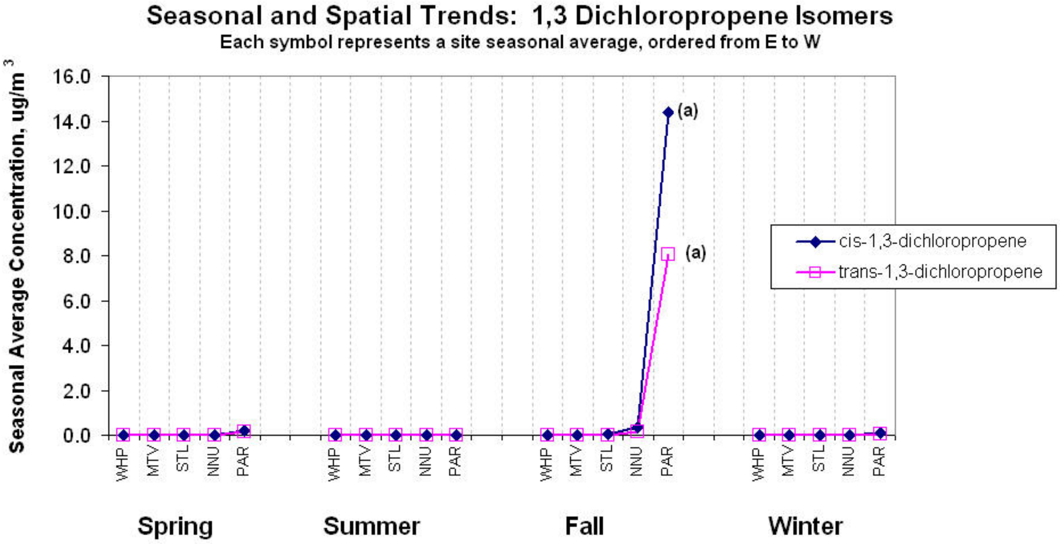

Figure 3-13. Seasonal and spatial trends for *cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene. These two isomers are cogeners of dichloropropene, present together in soil fumigants used for several weeks, primarily in the fall, to control nematodes in potato, sugar beet, and onion production. The highest concentrations of these isomers were observed at the Parma site. Note (a): one sample at Parma during the fall is "estimated" because it was reported at concentrations above the analytical range (see Appendix B, note 6).

3.3. Comparison with the National Database

In order to understand the air toxics levels in any single study, it is useful to compare the study data to a national database of air toxics measurements. This data is available from EPA (2009c) and summary statistics for the years 2003-2005 were recently published in EPA's *Air Toxics Workbook* (EPA, 2009b). Figure 3-15 through Figure 3-18 represent the annual mean concentrations observed during this study in comparison to the 2003 – 2005 national database distributions for each key compound. The national database typically includes over 500 site-year records for each species, with an annual mean concentration for each site, each year of its operation. For comparison purposes, the median and 5th, 25th, 75th, and 95th percentile annual averages from the national dataset for each species are plotted in box plots, while the aggregated annual average for all Treasure Valley sites, along with the lowest and highest single-site annual averages, are depicted for comparison. Figure 3-14 shows the meaning of the statistical structures used in the subsequent figures. The national data is represented by the thick bar with two shades of gray. The vertical line near its center is the median of all annual average values for all sites in 2003, 2004, and 2005. The darker grey box surrounding the median represents the interquartile range (25th – 75th percentile) of annual averages, and the lighter grey bars represent the 5th to 25th percentile and 75th to 95th percentile annual averages on either side of the central 50% of the data. The overall 5-site average observed in this study is represented by the white diamond and the end of the thick black line to its left indicates the lowest single-site annual average observed during this study while the end of the thick black line to the right indicates the highest single-site annual average in this study.

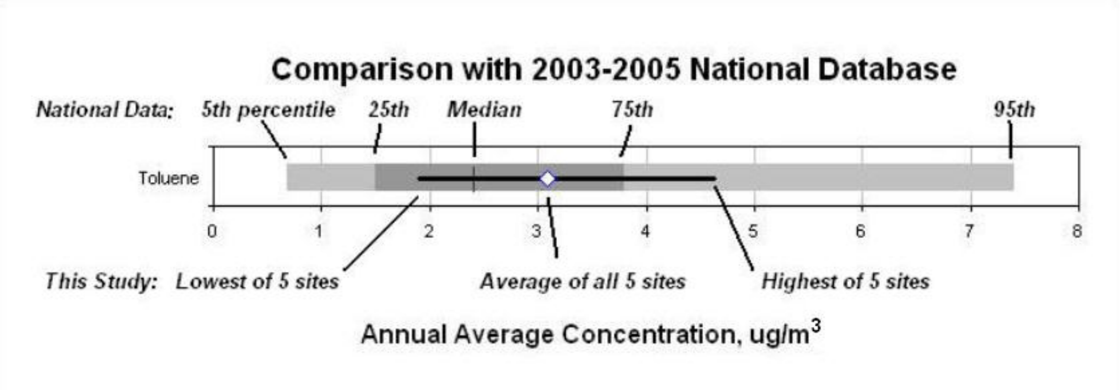

Figure 3-14. Example graph explaining the presentation of national database statistics and the data observed in this study. National statistics are represented on the thick gray bar, and data from this study are represented by the white diamond and black range line on either side of it.

Abundant elements–manganese, lead, arsenic. Treasure Valley levels of the most abundant HAPs metals and elements, manganese, lead, and arsenic, are compared to the 2003-2005 national database in Figure 3-15. Arsenic and lead annual averages in this study are both below the 5th percentile annual averages of sites nationally. Manganese for all Treasure Valley sites is above the national dataset median annual average concentration but below the 75th percentile annual average concentration.

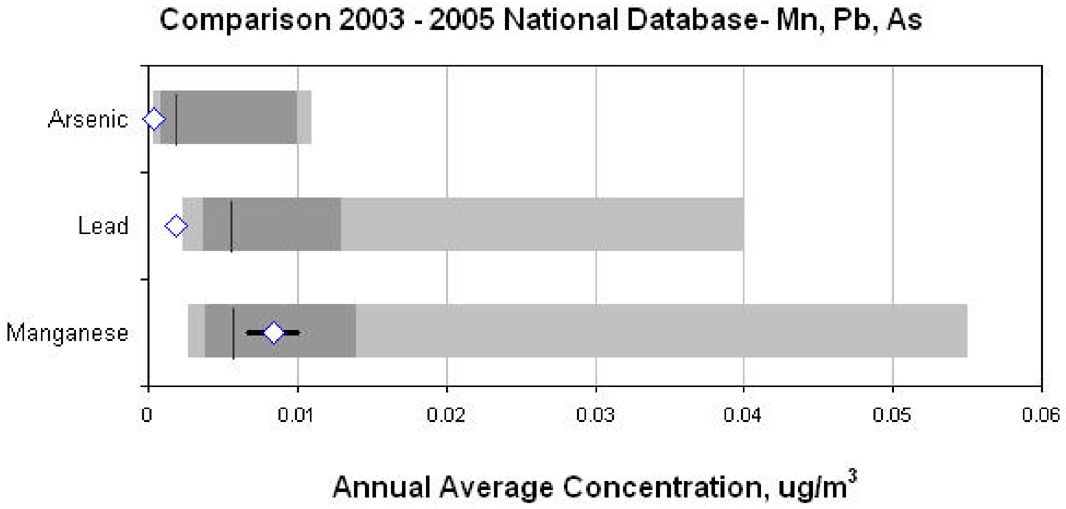

Figure 3-15. Comparison of abundant elements (manganese, lead, and arsenic) concentrations with national database. (EPA, 2009b). Arsenic and lead annual averages are both below the 5th percentile of sites nationally. Manganese is above the national median annual concentration but below the 75th percentile value.

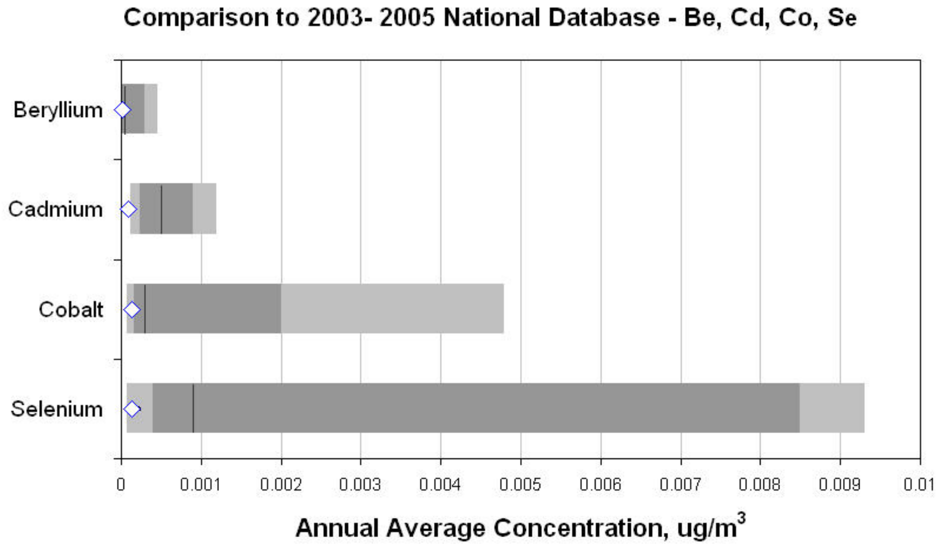

Figure 3-16. Comparison of trace elements (beryllium, cadmium, cobalt, and selenium) concentrations with the 2003 – 2005 national database. (EPA 2009b). All four are in the lower quartile of the national dataset.

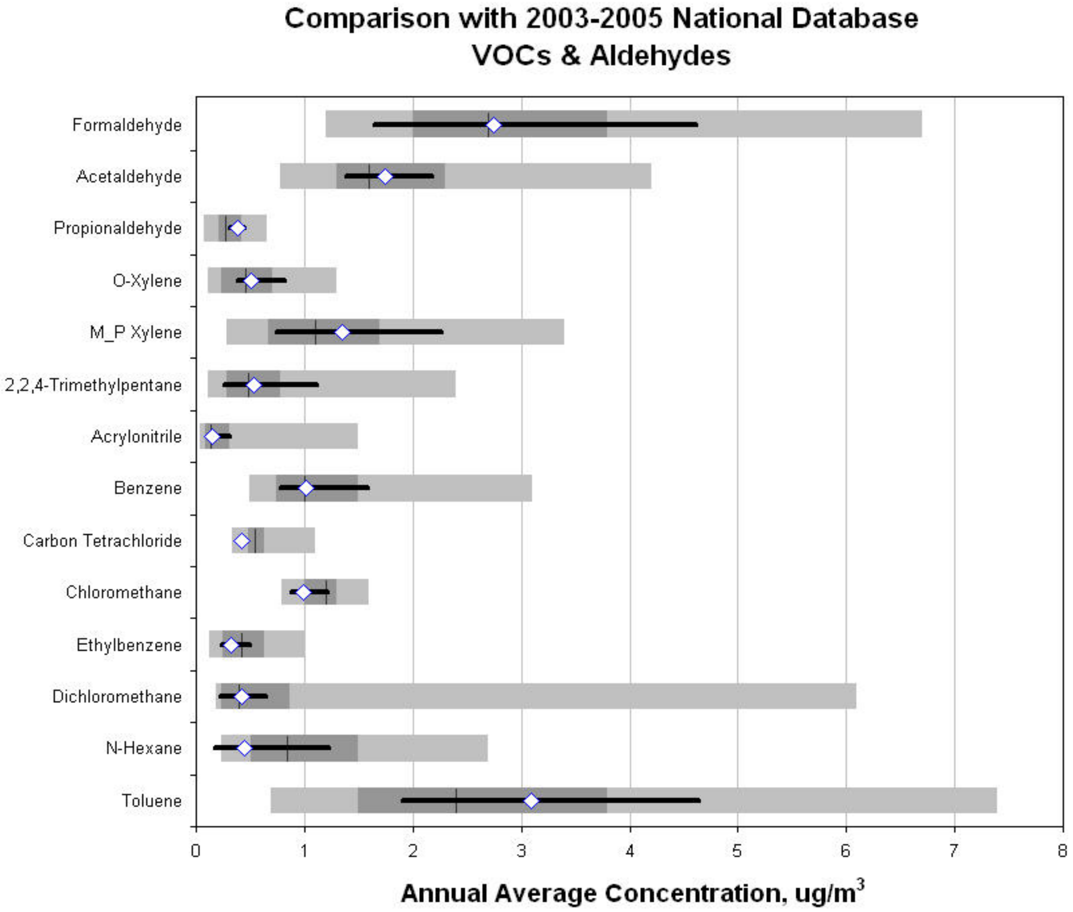

Figure 3-17. Comparison of primary aldehyde and VOC concentrations with the 2003 – 2005 national database. (EPA 2009b).

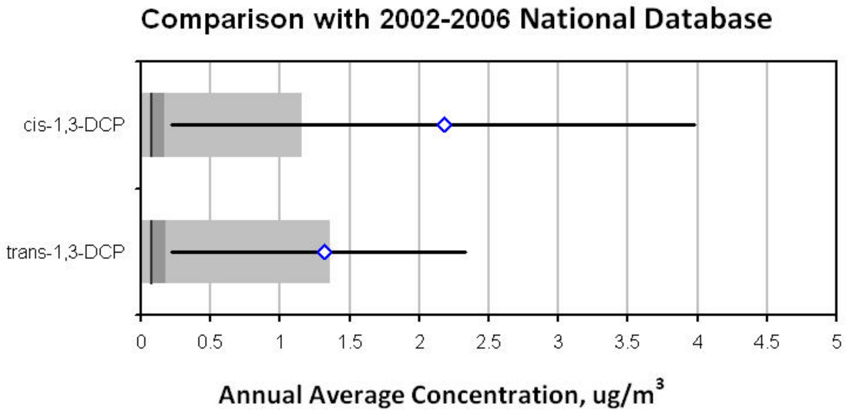

Figure 3-18. Comparison of *cis*- and *trans*- isomers of 1,3-dichloropropene concentrations (1,3-DCP) with the 2002 – 2006 portion of the national database. (EPA, 2009c). Annual means averaged over the NNU and Parma site together (blue diamonds) are at (*trans*-1,3-DCP) or above (*cis*-1,3-DCP) the 95th percentile values nationally, while the maximum annual averages (right end of "error bars"), occurring at the Parma site, are higher than the highest annual mean values in the national database for both isomers.

Trace elements beryllium, cadmium, cobalt, selenium. Trace element concentrations are compared to the national dataset in Figure 3-16. All are below the 25th percentile for sites nationwide.

VOCs and Aldehydes. Concentrations of primary VOC and aldehyde are compared to the national dataset in Figure 3-17**.** Aldehyde annual average concentrations are generally slightly greater than the median of the annual averages nationwide; however, formaldehyde at St. Luke's is above the 75th percentile nationally, probably due to a conjunction of sources influencing that site, including mobile, photochemical, wildfires, and possible solvent- or construction-related materials. The annual average concentrations for the BTEX compounds are generally in the third quartile (between 50th and 75th percentile) of the national dataset, although benzene is very close to the median site annual average concentration in the national dataset and the highest annual mean value, observed at Mountain View, is just above the 75th percentile of the national distribution of annual means. The dichloromethane valley-wide average is very near the national median annual average; however, the valley-wide annual averages for the other solvent-related compounds such as chloromethane and n-hexane are around the 25th percentile area of the national dataset.

1,3- Dichloropropene. Concentrations of the *cis*- and *trans*- isomers of 1,3-dichloropropene (1,3-DCP) are compared to the national dataset in Figure 3-18. The annual mean 1,3-DCP concentrations at Nampa are amongst the highest in the nation and the annual means at Parma appear to be higher than the highest annual mean concentrations recorded in the national database. (The 2003-2005 summary statistics in the *Air Toxics Data Analysis Workbook* (EPA, 2009b) do not include 1,3-DCP, so the original data was retrieved from EPA's web site directly, for the years 2002-2005 (EPA, 2009c). The highest annual mean concentrations observed in this study are at the Parma site where the annual average concentration of the *cis*- isomer (3.98 $\mu g/m^3$) is greater than the highest annual average values reported for any site in the national database (1.15 μg/m^3) and the average annual Parma concentration for the *trans*- isomer (2.33 μg/m^3), is also greater than the highest detected annual average nationwide (1.36 μg/m^3). (Note, one site in Kentucky has slightly higher values reported in the national database; however, their data summary reports (Kentucky DAQ, 2003, 2004, and 2005) and their staff (Tim Smith, Kentucky DEP, personal communication) both indicate that these values in the database are in error and nearly all sample results were non-detects). The left-hand error bars, reflecting Treasure Valley urban sites and the national median annual average, are grouped close together because they both represent an absence of 1,3-DCP, shown here at approximately one-half of the MRL. Although the annual mean 1,3-DCP concentrations at Parma appear to be the highest in the nation, it is important to note that while the vast majority of long term air toxics monitoring sites are in urban/ industrial and suburban areas, and in remote rural areas, heavily agricultural areas are very poorly represented so it is difficult to put these values into proper context. Preliminary discussions with EPA staff familiar with other 1,3-DCP monitoring suggests that for agricultural areas, the Parma values observed in this study are typical and do not suggest a reason for concern.

3.4. Comparison with Remote Background Levels

The background concentrations of air toxic compounds in remote areas of North America (McCarthy et. al. 2006) provide lower limit concentrations for the purpose of data validation, and by their differences with the measured values here, give some indication of the regional anthropogenic contributions in the Treasure Valley. The remote background concentrations reported by McCarthy et. al. (2006) are shown in Table 3-1 along with the site annual average concentrations measured in the Treasure Valley. The minimum reporting limits (MRLs) reported in this study are also shown.

As seen in Table 3-1, the annual mean concentrations for dichlorodifluoromethane, methyl chloride, trichlorofluoromethane, and carbon tetrachloride (in bolded italics) are all lower (20-40%) than the remote North American background concentrations reported by McCarthy et. al. (2006). The fact that levels of these species are lower than the "remote" North American background suggests that the mean values for these species in this study may be suspect. For carbon tetrachloride, 23.8% of the sample results were below the detection limit, and since carbon tetrachloride has a well-known global concentration around 0.6 μg/m^3, the value reported here is clearly too low, probably as a result of detection limit problems and substitution of one-half of the MRL for non-detects. Methyl chloride is only about 20% lower than the remote background. The refrigerants dichlorodifluoromethane and trichlorofluoromethane are 40% lower than remote background reported by McCarthy et al. (2006). This is not an important issue in this study, since neither is an air toxic (or HAP); however, it should be noted that as time goes on, global levels of banned products will gradually decline and the measured levels, particularly in lightly populated areas of the west, are likely to be more frequently observed below the historical "remote background" levels.

Table 3-1. Comparison of Annual Means with Remote Background, µg/m^3

Species	Remote Background (McCarthy et. al., 2006)	Treasure Valley Average, All Sites	Treasure Valley MRL[a]
acetaldehyde	0.16	1.75	0.03
formaldehyde	0.18	2.75	0.02
dichlorodifluoromethane	***2.70***	***1.88***	***0.47***
methyl chloride	***1.20***	***0.99***	***0.20***
benzene	0.14	1.01	0.31
trichlorofluoromethane	***1.40***	***1.00***	***0.54***
methylene chloride	0.09	0.42	0.33
carbon tetrachloride	***0.62***	***0.42***	***0.60***
chloroform	0.05	> 99% ND	0.47
1,1,2,2-tetrachloroethylene	0.02	> 99% ND	0.65
1,1,1-trichloroethane	0.18	100% ND	0.40

a. MRL – minimum reporting limit

Note: Compounds shown in bold italics are 20 – 40% lower than McCarthy et. al. “Remote Background”.

3.5. Comparison with Other Locations in the Region

In addition to the national database and the remote background levels, it is of interest to compare the Treasure Valley air toxics concentrations to other locations in the region. We would expect similar-sized urban areas to have similar levels and less-populated/rural areas in the same region to have levels similar to those at the Parma rural site. The data available for this purpose include two one-year multi-site studies, one in the Spokane, Washington urban area (WSU, 2005), and one with sites in both the Lewiston urban area and rural Nez Perce Tribal lands (the Nez Perce sites) in central Idaho (Mary Fauci, personal communication, 2009). Another primary source of air toxics data in the region is the National Air Toxics Trend Stations (NATTS) program. The NATTS monitoring sites typically use the same 24-hour sampling methods as those used in this study and are included in the EPA air toxics national database (EPA, 2009c) with the same units and statistical measures, so the results are reasonably comparable. Three regional NATTS sites were chosen for comparison: 1) the Beacon Hill site in urban Seattle, Washington, 2) the Viewmont High School site in suburban Bountiful, Utah, just north of Salt Lake City and 3) the La Grande, Oregon site in rural northeastern Oregon.

The Seattle, Bountiful, Spokane, and Lewiston LSOB (Lewiston State Office Building) sites are urban/suburban in nature, while the La Grande site and two of the Nez Perce Tribal sites (Hatwai1 and Lapwai) are very rural and should be comparable to the Parma site.

Data for this comparison purpose generally used replacement of values below the MRL with one-half of the MRL, with the exception of data from the Spokane study sites, for which the reported site means and 95% confidence intervals do not include discussion of below-detection-limit values. Nevertheless, only selected key species are compared: those which are generally found to contribute significantly to the total risk, and which are above detection limit in most samples; therefore, possible different treatment of non-detects at Spokane should not significantly affect the results in this study.

In addition to the regional comparison, the remote background values, discussed in Section 3.4 above, are also shown on the regional comparison graphs. Regional comparisons are discussed by species; however, only key species that typically contribute significant risk are shown.

Aldehyde Regional Comparisons. The acetaldehyde and formaldehyde regional comparisons are shown in Figure 3-19 and Figure 3-20, respectively. Similar patterns are present for both of these most-abundant aldehydes. Urban-dominated sites at St. Luke's and Bountiful, and most of the Lewiston/Nez Perce sites exhibit formaldehyde annual means in the range of 4 to 6 µg/m^3 for, while the acetaldehyde means approach 4 µg/m^3 at Bountiful and the Nez Perce sites, remaining around 2 µg/m^3 at the urban Treasure Valley sites (White Pine, Mountain View, and St. Luke's). These sites are all either in locations of enhanced photochemical activity downwind from significant urban emissions (St. Luke's, Bountiful) or are known to be influenced by significant wildfire activity during their respective study periods (St. Luke's and Lewiston/Nez Perce sites).

Within the region, the lowest levels of both aldehydes occur at NNU and Parma sites in the Treasure Valley, the Beacon Hill (Seattle) site, and the Spokane Health District site, all averaging approximately 1-2 µg/m^3 annually for both acetaldehyde and formaldehyde; however, remote background levels of aldehydes in some areas of North America (McCarthy et. al., 2006) are an order of magnitude lower (0.16 and 0.20 µg/m^3 for acetaldehyde and formaldehyde, respectively.)

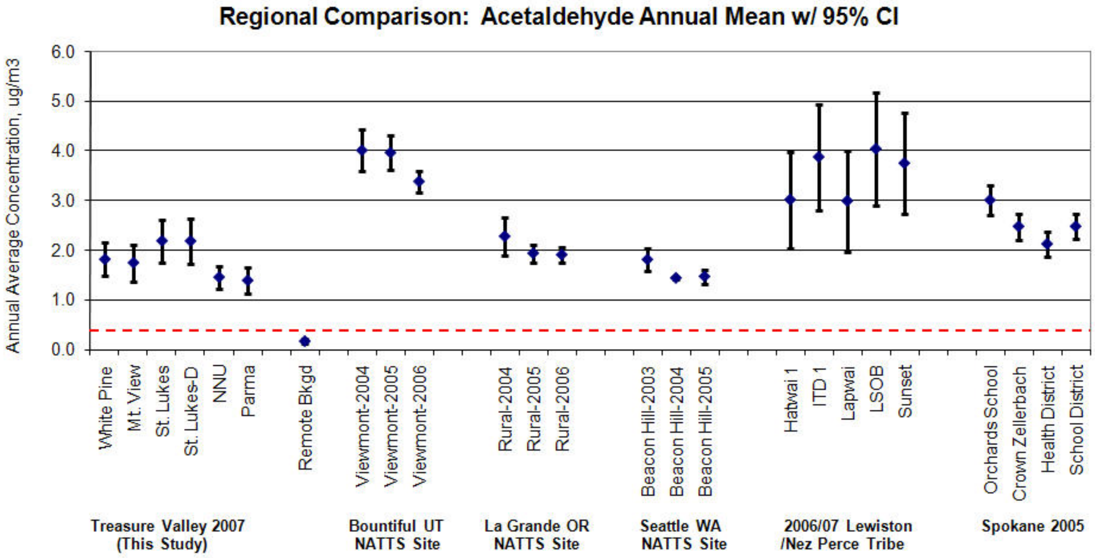

Figure 3-19. Regional comparison of Treasure Valley acetaldehyde annual mean concentrations to annual mean levels observed at other locations in the region. 95% Confidence Intervals are shown to reflect approximate uncertainty for each dataset (even though datasets may not be normally distributed). The dotted red line indicates the chronic health screening benchmark (see Section 5 and Appendix D).

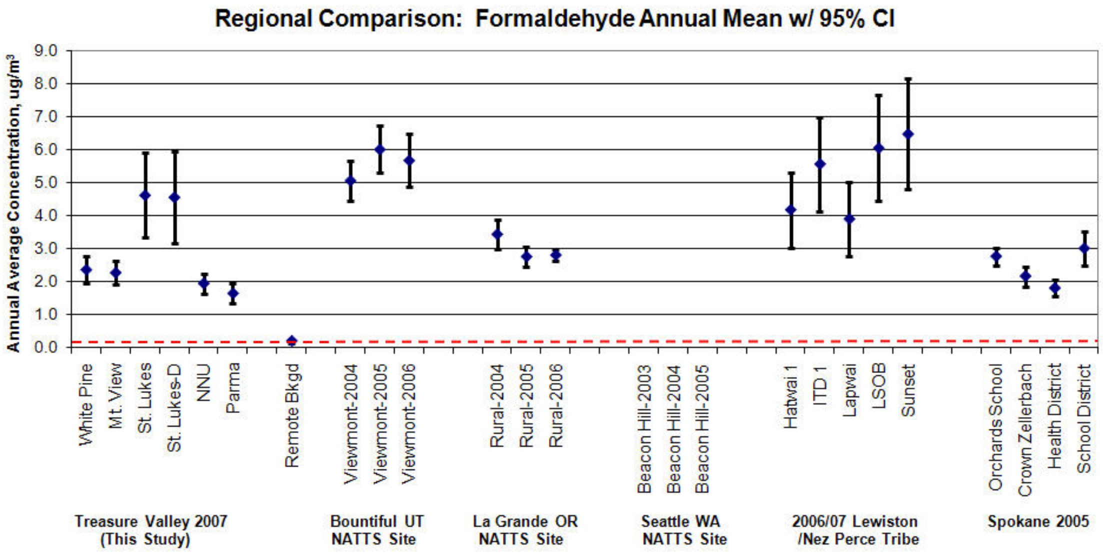

Figure 3-20. Regional comparison of Treasure Valley formaldehyde annual mean concentrations to annual mean levels observed at other locations in the region. 95% Confidence Intervals are shown to reflect approximate uncertainty for each dataset (even though datasets may not be normally distributed). The dotted red line indicates the chronic health screening benchmark (see Section 5 and Appendix D).

Arsenic Regional Comparison. Arsenic annual means are lowest at the Treasure Valley, La Grande, and at the Lewiston/Nez Perce sites, while levels at the Spokane Crown Zellerbach site, the Seattle Beacon Hill site, and the Bountiful site are significantly higher than in the Treasure Valley.

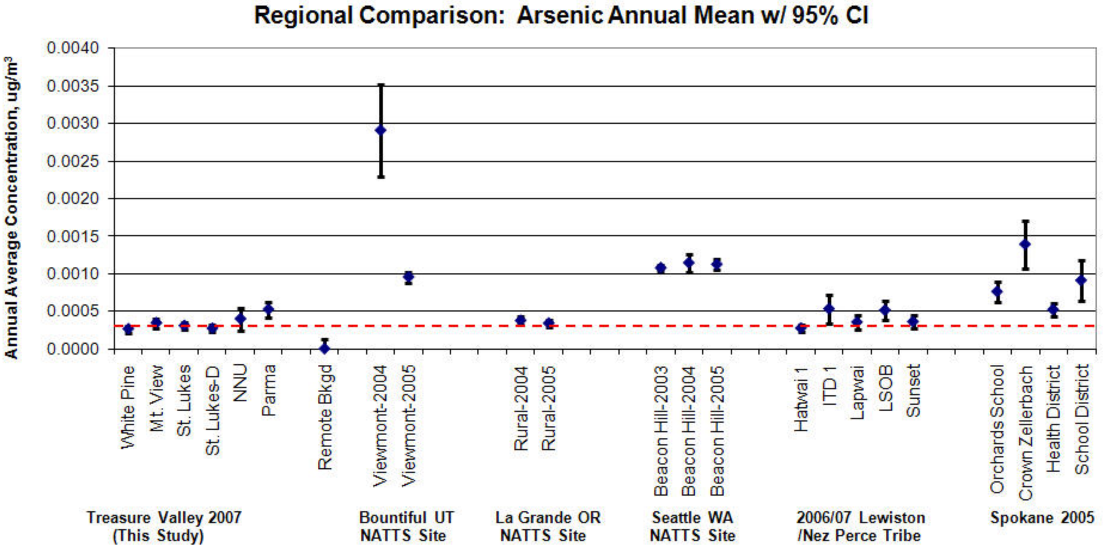

Figure 3-21. Regional comparison of Treasure Valley arsenic annual mean concentrations to annual mean levels observed at other locations in the region. 95% Confidence Intervals are shown to reflect approximate uncertainty for each dataset (even though

datasets may not be normally distributed). The dotted red line indicates the chronic health screening benchmark (see Section 5 and Appendix D).

Benzene Regional Comparison. Benzene concentrations at the urban Boise Mountain View site are above 1.5 µg/m^3, similar to those in Bountiful, Utah, and Lewiston, Idaho but somewhat higher than those in Seattle and Spokane. The mean benzene concentrations in the suburban/ rural locations from St. Luke's to Parma are all less than 1.0 µg/m^3, more typical of those at the La Grande rural site and all of the sites in Spokane.

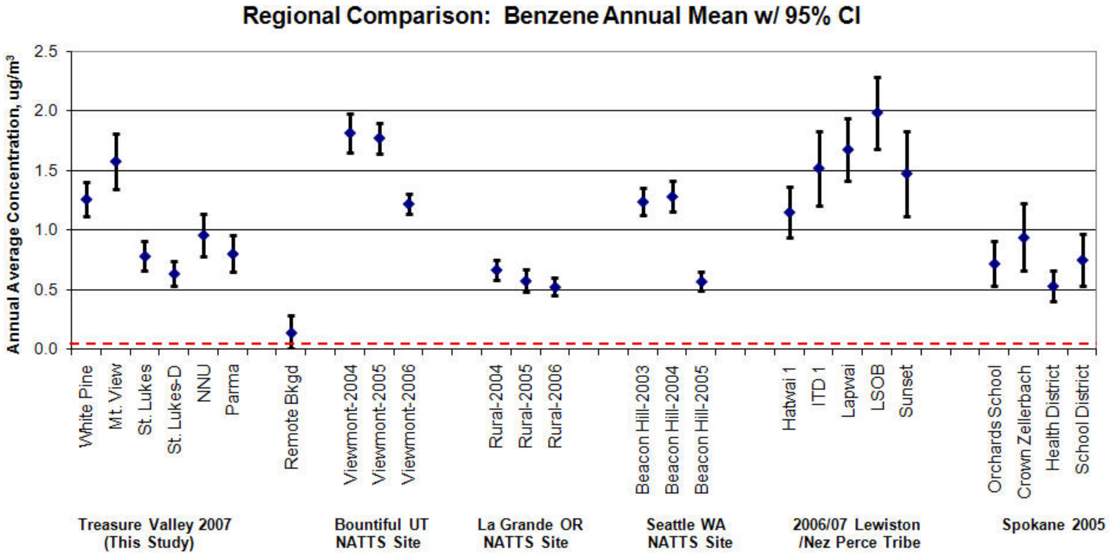

Figure 3-22. Regional comparison of Treasure Valley benzene annual mean concentrations to annual mean levels observed at other locations in the region. 95% Confidence Intervals are shown to reflect approximate uncertainty for each dataset (even though datasets may not be normally distributed). The dotted red line indicates the chronic health screening benchmark (see Section 5 and Appendix D).

3.6. *Trends Since 2003 at the NNU Site*

A range-finding, single-site air toxics monitoring project was conducted during the period 2003 through 2004 at the NNU site. This study included a VOC, metals/trace elements, and aldehyde analytes, along with semi-volatile air toxics. The NNU annual mean concentrations from the current (2007) study are compared to selected species from the earlier study in Figure 3-23. The mean concentrations in this study (2007) all appear to be lower than in the earlier two years (2003 and 2004), but this trend only appears to be statistically significant for acetaldehyde, formaldehyde, and ethyl benzene. Nevertheless, since population in Canyon County is increasing and since no significant mobile source control measures were in place in Canyon County from 2003 through 2007, these results suggest that the steady decline in new-car emission standards is resulting in a general decreasing trend in mobile-source and photochemically produced air toxics concentrations.

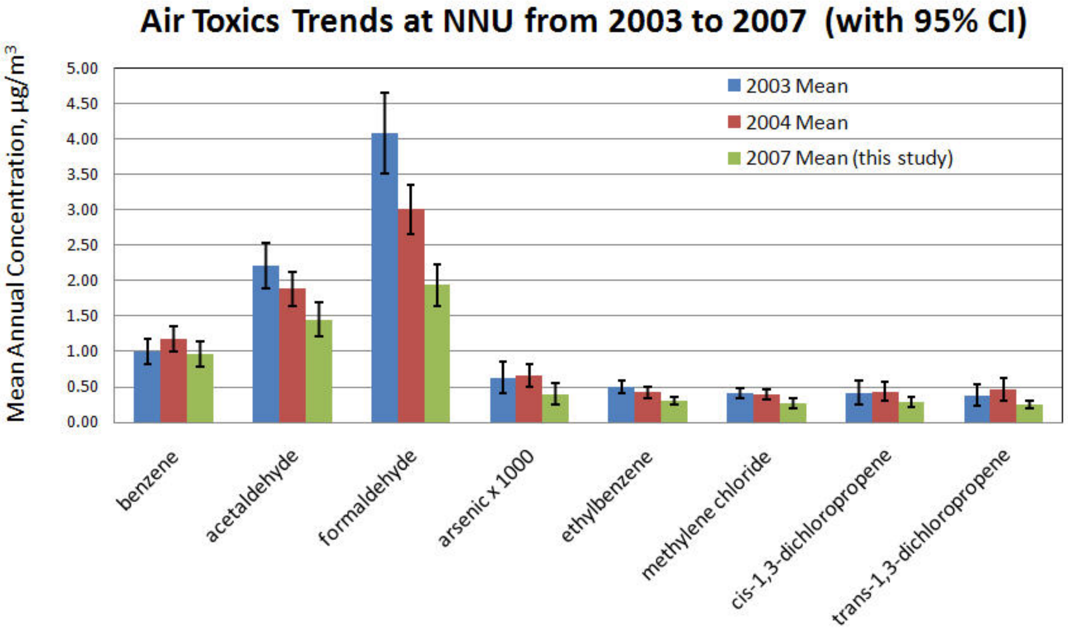

Figure 3-23. Comparison of selected VOC species concentrations observed at Northwest Nazarene University in this study (2007) versus 2003 - 2004. Annual mean concentrations with 95% confidence intervals are shown.

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4. Source-Receptor Relationships

Air toxic pollutants generally occur as trace components of common air pollutant emission streams such as motor vehicle combustion, fuel evaporation, heating and refrigeration processes, consumer product use, industrial production and agricultural activities. As trace components from many sources, it is often very difficult to identify the most important sources of such species and to determine which sources contribute to the human health risk. Nevertheless, one of the purposes of this study, and similar studies throughout the nation, is to identify sources of air toxics, determine if the associated health risk is acceptable and, if not, initiate awareness and actions that may result in lower risks. The purpose of this section is to identify sources of air toxics affecting the Treasure Valley. We begin with broad statistical approaches, and refine the focus to examine selected source categories and their potential contributions more directly.

4.1. Principal Component Analysis

Our initial efforts to identify potential categories of air toxics sources observed during this study involved limited principal component analysis (PCA). PCA is an exploratory tool involving a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. In this application, the PCA is hampered by having too many variables (species) and not enough samples (Osborne and Costello, 2004), a condition that can result in excessive error. Nevertheless, two PCA simulations were completed, which provided some information concerning the major factors that explain variability in air toxics concentrations in the Treasure Valley.

The initial PCA involved all the carbonyls (aldehydes and ketones), VOCs, and metals/trace elements measured during the HAPs study, along with the total PM_{10} mass concentration obtained with each metal/trace elements analysis. This analysis resulted in three primary factors or components, as shown in Table 4-1. The factors identified in this analysis include 1) mobile sources, identified by the strong contributions of aromatic BTEX species known to originate primarily from motor vehicle fuels and exhaust; 2) photochemical production, responsible for all the aldehyde analytes; and 3) wind erosion, in which PM_{10} is clustered together with the HAPs trace elements beryllium, cobalt, manganese, and selenium (while the arsenic and lead are weakly associated with the mobile source species in Factor 1).

A second PCA was conducted to refine the results of the first PCA by focusing on the HAPs metal/trace element species. For this purpose, the $PM_{2.5}$ speciation data from the co-located STN site at St. Luke’s were used together with the HAPs data. This included several major elemental species (iron, silicon, sulfur, and potassium), along with the other major organic and inorganic components of the $PM_{2.5}$ mass including ammonium, ionic sodium, nitrate, sulfate, organic carbon, and elemental carbon. In addition, to assure that the mobile source component was clearly identified in this PM analysis, benzene data from the HAPs VOC measurements were also included. This analysis was also reduced to a three-factor model, shown in Table 4-2. Subsequent factors beyond these three factors explained very little additional variation and were dropped from the analysis.

In the second PCA, the first factor, explaining nearly half of the variation in the data set, included both the wind erosion metal/trace elements identified previously, but also, of secondary importance, iron, potassium, and both organic and elemental carbon. Since potassium and both carbon species are identified with biomass burning, this factor can also be identified with the strong wildfire activity that occurred in June through September 2007. Residential wood combustion could also potentially be a contributor to this factor but it is not likely a significant factor since wood combustion impacts are not generally consistent with wind erosion events. The second factor includes all the common inorganic components of secondary aerosol (sulfur, ammonium, nitrate, and sulfate); however, it also includes cadmium as a strong contributor to this factor, and selenium as a weak contributor, a finding that suggests a source of these trace elements occurs on low-wind, stagnation days when secondary aerosol formation is dominant. This may include one or more industrial coal combustion sources and/or alternate sources of selenium and cadmium. The third factor identified in this analysis includes the mobile source emission “marker” benzene, along with arsenic and lead. This implies that mobile sources emissions are important sources of the arsenic and lead particulates in the valley. For lead, this is supported by the summer seasonal peaks for lead and arsenic at Mountain View (Figure 3-7) where the other mobile source species are also generally the highest. Finally, elemental carbon is weakly associated with Factor 3, presumably representing the diesel particulate matter (DPM) component of the mobile source category.

Table 4-1. Exploratory Principal Component Analysis #1: HAPs Study Analytes

	Factor 1	**Factor 2**	**Factor 3**
% of Variation Explained	33.8%	27.4%	17.5%
Strong Contributors	1,2,4 trimethylbenzene o-xylene m&p-xylene 2,2,4-trimethylpentane benzene cyclohexane toluene	formaldyhyde acetaldehyde propionaldehyde butyraldehyde butyraldehyde isovaleraldehyde valeraldehyde hexaldehyde	PM_{10} beryllium cobalt manganese selenium
Weak Contributors	PM_{10} arsenic lead n-heptane iso-valeraldehyde	carbon tetrachloride	
Probable Source Categories	mobile sources	photochemical production	wind erosion

Table 4-2. Exploratory Principal Component Analysis #2: HAPs Study Metal/trace elements and $PM_{2.5}$ species from the Speciation Trends Network (STN)

	Factor 1	**Factor 2**	**Factor 3**
% of Variation Explained	45.2%	37.3%	17.5%
Strong Contributors	beryllium cobalt manganese silicon	cadmium sulfur ammonium nitrate sulfate	benzene arsenic lead
Weak Contributors	iron selenium potassium elemental carbon organic carbon	selenium	elemental carbon
Probable Source Categories	wind erosion, biomass burning	secondary aerosol/ stagnation related	mobile sources

4.2. Positive Matrix Factorization

The EPA's Positive Matrix Factorization (PMF) receptor model was also used for toxic air pollutant source apportionment for the Treasure Valley. Due to their potential value for source apportionment, non-HAPs analytes including PM_{10} and $PM_{2.5}$ mass concentrations were included in the analysis. The sampling interval was every six days, resulting in about 58 samples for each site. Because there are too few samples from each individual site for PMF analysis, all samples were combined together to form a single data set. Because of this, the results are spatially averaged.

4.2.1. Positive Matrix Factorization Software (PMF)

Positive Matrix Factorization is a multivariable factor analysis tool that decomposes a matrix of speciated sample data into two matrices—factor contributions and factor profiles. The results are interpreted as to what source types are represented based on the measured profile information, meteorological conditions, and emission inventories. EPA's PMF software (Version 3.0) and user's guide were used in this analysis (EPA, 2008)

4.2.2. Data treatment

The data collection and preparation were described in Sections 1 and 2. To meet PMF analysis requirements, samples and species are removed from the analysis if the total of missing and below-detection-limit values is more than 90%. The species used in this analysis are listed in Table 4-3 and the species removed are listed in Table 4-4. A total of 366 samples with 35 species were used together for a single PMF analysis. It was necessary to combine data from all sites in a single analysis to obtain enough samples to meet guidelines for the analysis. Combining all samples from different sites together for a single PMF analysis challenges a basic assumption of the PMF analysis — that each site is impacted equally by the same sources as if they are from the same site. As a result, all spatial resolution is lost and the model results will not reflect the exact source contributions for any individual site, but rather the valley-wide source contributions averaged over all sites. In addition, this treatment may affect the attributions of some species to certain sources. However, the past studies indicated that the Treasure Valley airshed is usually well mixed and the major air toxics species (mobile source and photochemical) generally tend to affect all sites somewhat uniformly, so this treatment should not cause any serious bias in the source apportionment.

Missing data were replaced with species median values within the PMF software, and for each concentration reported as below the detectable limit, one-half of the MRL (Method Reporting Limit) value was substituted, in accordance with guidance (EPA, 2008).

A box plot is shown in Figure 4-1 for the species analyzed in the PMF analysis (however, missing data were not replaced by species median values for this chart). It can be seen that some data are very skewed, likely due to the large numbers of values substituted because reported values were below the detection limit.

Table 4-3. List of Species Used in the PMF Analysis

PM$_{10}$	butyraldehyde	methyl chloride (chloromethane)
arsenic	n-valeraldehyde	ethyl benzene
beryllium	isovaleraldehyde	dichloromethane
cadmium	hexanal	n-hexane
cobalt	benzaldehyde	toluene
lead	1,2-dimethyl benzene	1,2,4-trimethylbenzene
manganese	1,4&1,3-dimethylbenzene	2-hexanone
selenium	2,2,4-trimethylpentane	chloroethane
formaldehyde	benzene	cyclohexane
acetaldehyde	bromomethane	chlorodibromomethane
propionaldehyde	carbon tetrachloride	dichlorodifluoromethane

Table 4-4. List of Species Removed for the PMFAanalysis

Specie	Missing	Below Detection	Total %
chromium	11%	88%	99%
nickel	10%	88%	99%
crotonaldehyde	15%	81%	96%
o-tolualdehyde	16%	84%	99%
m-tolualdehyde	17%	79%	96%
p-tolualdehyde	18%	77%	95%
1,1,2,2-tetrachloroethylene	14%	85%	99%
1,2,4-trichlorobenzene	14%	85%	99%
p-dichlorobenzene	14%	85%	99%
methyl isobutyl ketone	14%	80%	95%
acrylonitrile	14%	80%	95%
carbon disulfide	14%	85%	99%
chlorobenzene	15%	83%	98%
chloroform	14%	85%	99%
cis-1,3-dichloropropene	15%	80%	95%
hexachloro-1,3-butadiene	14%	84%	99%
styrene	14%	84%	99%
trans-1,3-dichloropropene	14%	82%	96%

Specie	Missing	Below Detection	Total %
1,3,5-trimethylbenzene	14%	84%	98%
p-ethyltoluene	15%	84%	99%
trichlorotrifluoroethane	18%	72%	90%

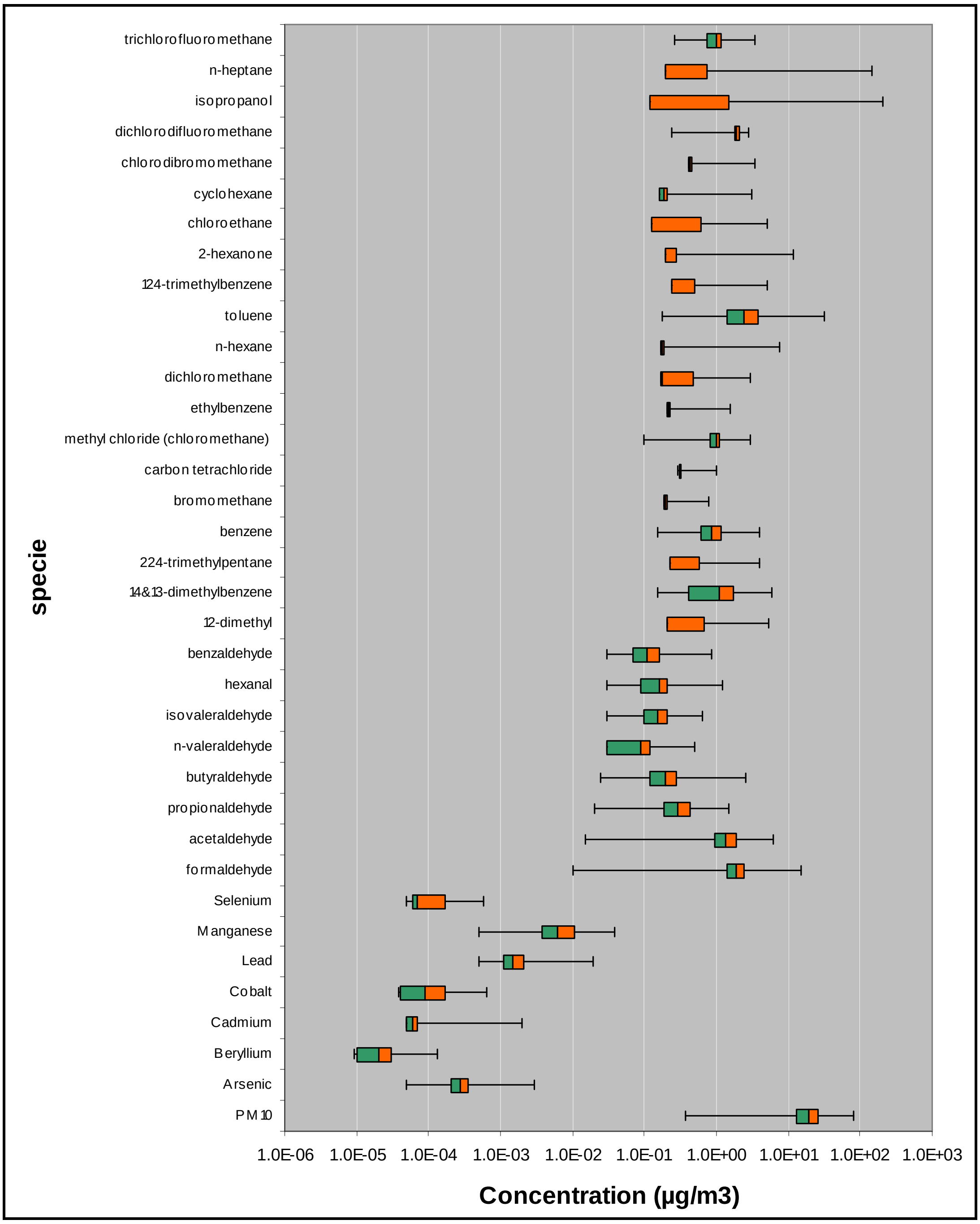


Figure 4-1. Boxplot of species included in PMF analysis.

4.2.3. PMF Analysis Results

Seven factors (source groups) of toxic pollutants were identified in the PMF analysis: photochemical reaction products, biomass burning, solvents, mobile sources, isopropanol, mixed sources associated with stagnation conditions, and geologic. The factor profiles are presented in Figure 4-2 through Figure 4-8. Each profile chart shows the concentrations (μg/m^3) of each species as blue bars on a logarithmic scale on the left hand y-axis. The right-hand y-axis depicts the percentage of each species that is attributed to that specific factor profile.

4.2.3.a. Factor Composition

Factor 1 is dominated by carbonyl species, the major constituents of which are formaldehyde, n-valeraldehyde, and hexenal, all with a magnitude of about 0.1 to 10 μg/m^3. Its profile is shown in Figure 4-2. Carbonyls are primarily the products of photochemical reactions or incomplete combustion. This factor is similar to PCA Factor 2 in Table 4-1.

Factor 2 is also dominated by carbonyls with major contributors being acetaldehyde, propionaldehyde, butyraldehyde, isovaleraldehyde, and benzaldehyde. The Factor 2 profile is shown in Figure 4-3. Some metal/trace elements and VOCs also contribute to this factor. This group is believed to be associated with biomass burning.

Factor 3 has only one major VOC contributor—chloroethane—and another relatively smaller contributor, cyclohexane, a solvent and constituent of hydrocarbon fuels. However, this group also includes small amounts of some HAPs, such as benzene, acetaldehyde, and bromomethane. The Factor 3 profile is termed “solvents” (Figure 4-4.)

Factor 4 contains several VOCs, with major contributors being 2,2,4-trimethylpentane and toluene, 1,2-dimethyl benzene, 1,4&1,3-dimethylbenzene, benzene, ethyl benzene, n-hexane, and 1,2,4-trimethylbenzene, all constituents associated with mobile sources. The Factor 4 profile is shown in Figure 4-5. This factor confirms PCA Factor 1 in Table 4-1.

Factor 5 is dominated by a single specie, isopropanol, a solvent of very low toxicity present in spring time at the White Pine site. The Factor 5 profile is shown in Figure 4-6.

Factor 6 includes most halogenated VOCs with larger contributions from bromomethane, carbon tetrachloride, dichlorodifluoromethane, methyl chloride (chloromethane), and chlorodibromomethane, representing solvents, pesticides, refrigerants, paint, and other chemicals used in industries and residential sites. The Factor 6 profile is shown in Figure 4-7. Because this group includes cadmium and selenium, but no aldehydes, and it peaks in the winter when ammonium, sulfate, nitrate, and organic carbon are typically highest, we believe it is associated with secondary aerosols and coal combustion emissions concentrated during winter stagnation periods. This is supported by Factor 2 identified in the PCA results shown in Table 4-2, in which cadmium and selenium are associated with the secondary aerosol species. Coal combustion is a typical source of sulfate, nitrate, and cadmium, and there are no other major sources of sulfate in the valley.

Factor 7 includes most metal/trace elements, which are important contributors to the PM_{10} mass. The major contributor to this group is geologic material (i.e. soils or dust).

The Factor 7 profile is shown in Figure 4-8. This factor is similar to PCA Factor 3 in Table 4-1.

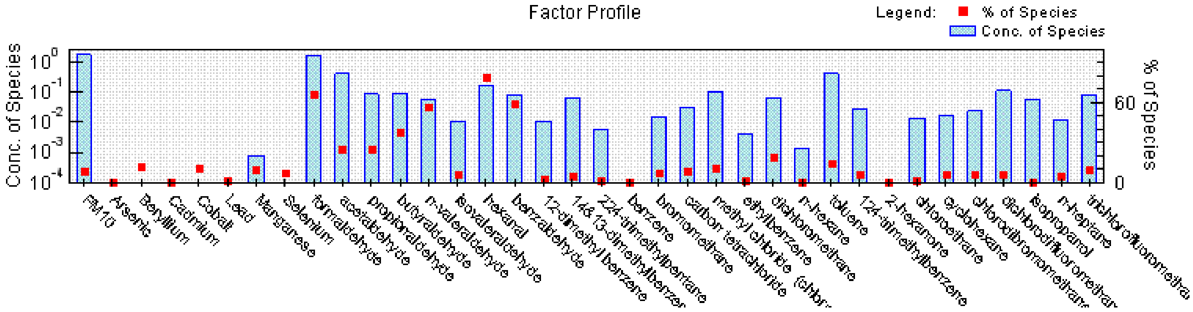


Figure 4-2. Factor 1, photochemical reaction products.

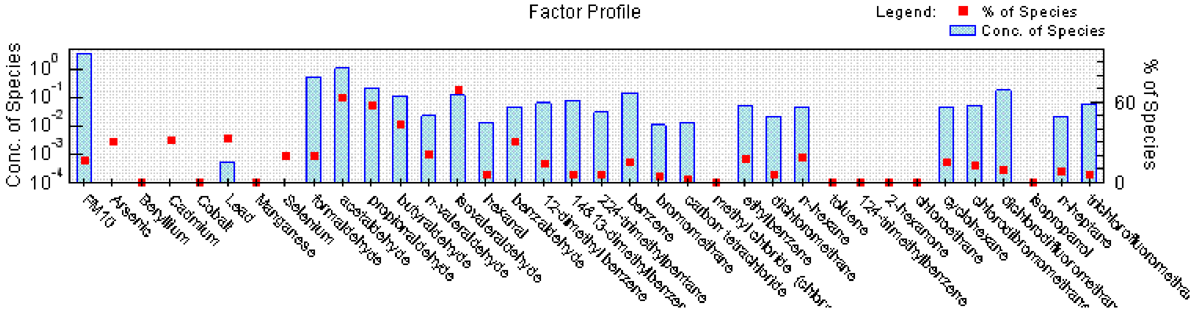


Figure 4-3. Factor 2, biomass burning.

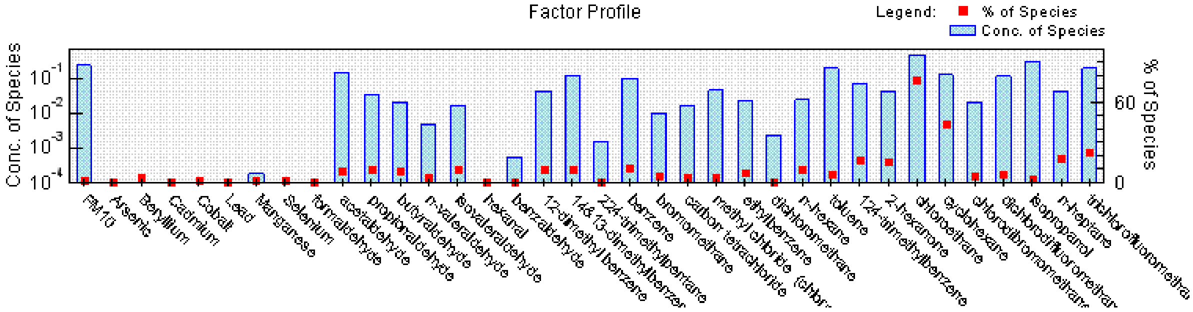


Figure 4-4. Factor 3, solvent group.

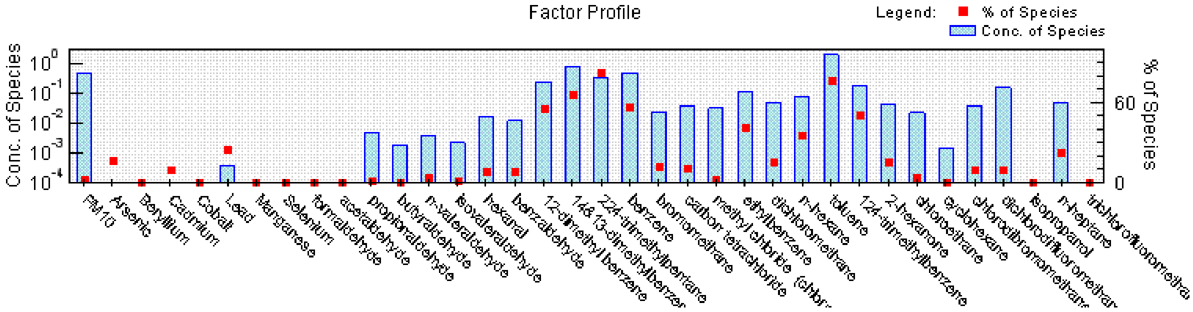


Figure 4-5. Factor 4, mobile emissions.

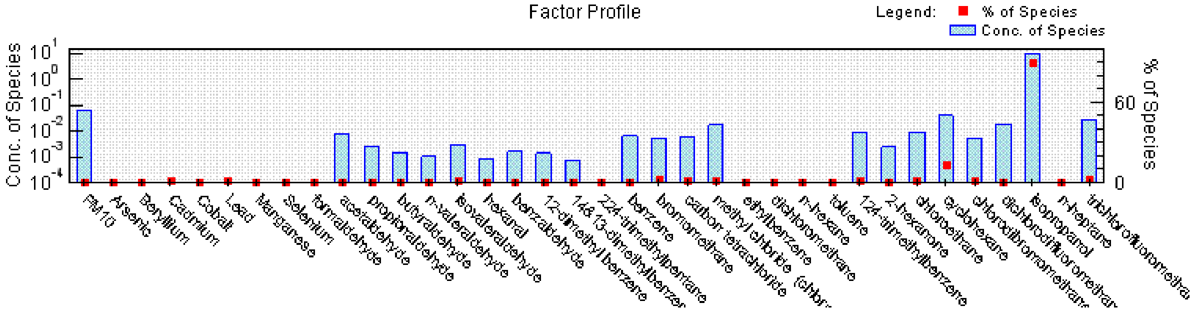


Figure 4-6. Factor 5, isopropanol.

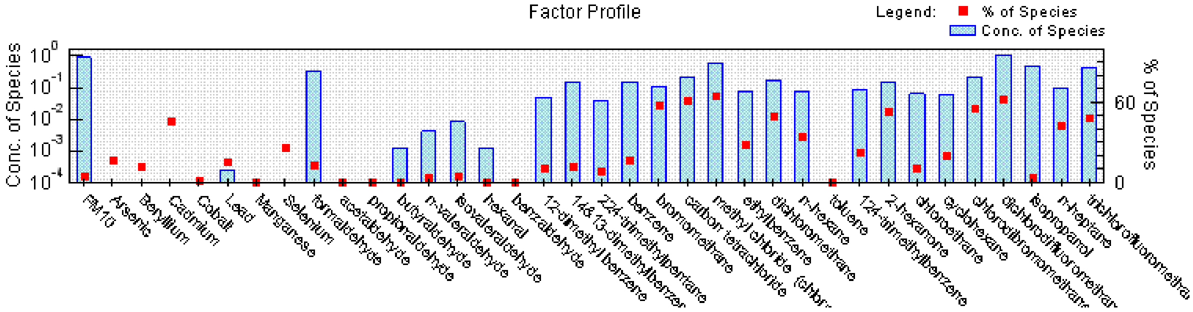


Figure 4-7. Factor 6, mixed sources concentrated by stagnation conditions.

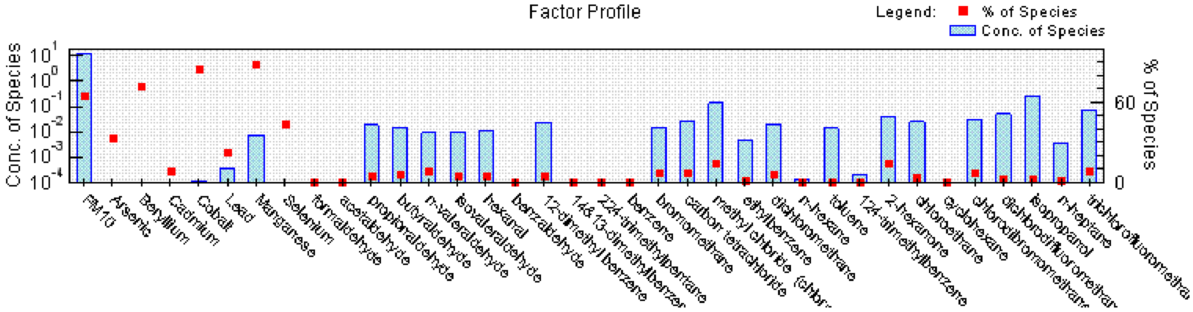


Figure 4-8. Factor 7, soil.

Table 4-5 summarizes the list of potential source groups identified in this analysis.

Table 4-5. Assumed Source Categories for PMF Factors

Factor	Source category
Factor 1	Photochemical
Factor 2	Biomass burning
Factor 3	Solvent group
Factor 4	Mobile emissions
Factor 5	Isopropanol
Factor 6	Mixed sources-stagnation enhanced
Factor 7	Geologic material

4.2.3.b. Factor Temporal Variation

The box plots in Figure 4-9 through Figure 4-22 show relative seasonal contributions ("Rel. Cont.") for each factor, followed by the relative contributions attributed to weekdays versus weekend days. Contributions are based on a relative scale so that, for example, if both the weekdays and weekend days contribute equally (per day) to a factor, then their relative contributions will both be 1.

Factor 1, the photochemical group, shows the highest contributions in summer, lowest in winter, reflecting the fact that the highest solar radiation is in summer and the lowest is in winter. Both the highest median and maximum were observed in summer. The weekday and weekend difference is insignificant as expected.

For Factor 2, the biomass burning category, the highest median occurred in fall, followed next by summer. The seasonal variation and positive correlation with organic carbon and elemental carbon (see next section) strongly suggests the active wildfires in summer and fall had significant contributions. It is interesting to note that the highest maximum values were recorded in the winter while the median in winter is lower. The major source of biomass burning in winter is residential wood combustion for heating, which is often one of the contributors to the winter episodes when PM standards are exceeded. It is not surprising that the PM concentrations can reach a high level during severe stagnation events (inversions) during the winter.

Factor 3, the solvent group, is highest in summer, followed by spring with similar median levels. The concentrations were higher in the east part of the valley. Although Figure 4-14 shows it is higher during weekends, the difference may not be statistically significant.

Factor 4, the mobile sources factor, is highest in spring time, and higher during weekdays as expected.

Factor 5, isopropanol, was measured mainly in spring, and no difference was observed for weekdays and weekends.

Factor 6, mixed sources-concentrated by stagnation conditions, was higher in winter, and lowest in summer. Weekend concentrations were higher than weekdays; however, this difference may not be statistically significant.

Factor 7, geologic material, was higher in summer and on weekdays. This is probably due to the drier conditions in summer and more dust-generating activities during the weekdays, including heavy construction and agricultural operations.

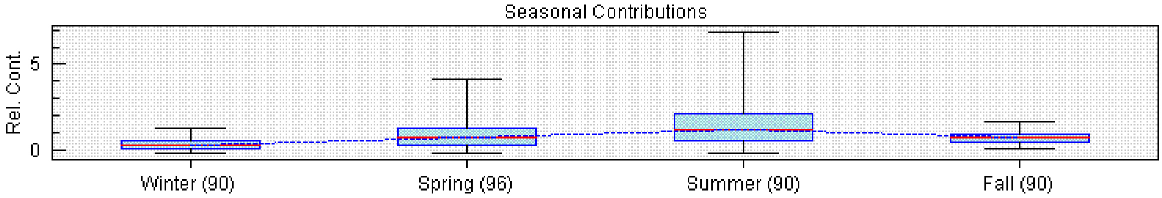


Figure 4-9. Seasonal contribution of Factor 1, photochemical production.

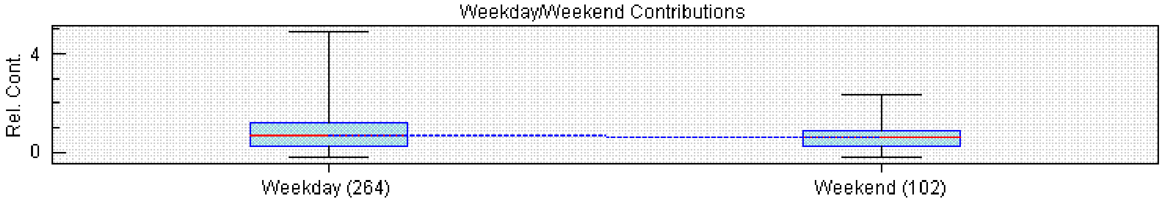


Figure 4-10. Week day and weekend difference for Factor 1, photochemical products.

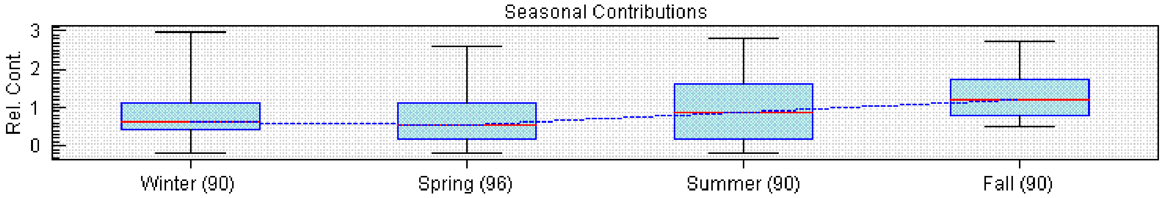


Figure 4-11. Seasonal contribution of Factor 2, biomass burning.

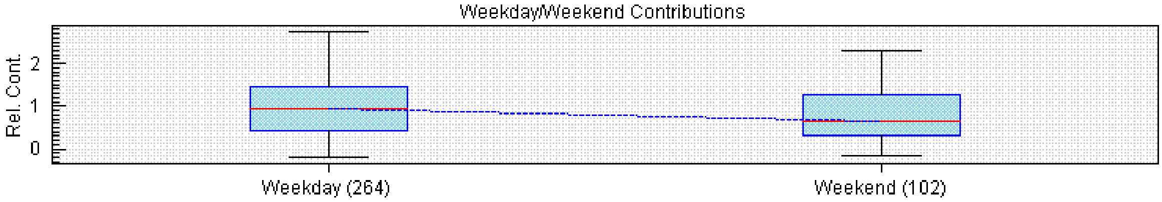


Figure 4-12. Weekday and weekend difference for Factor 2, biomass burning.

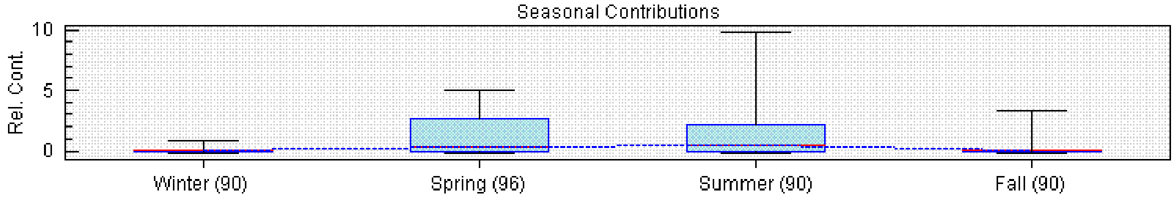


Figure 4-13. Seasonal contribution of Factor 3, solvent group.

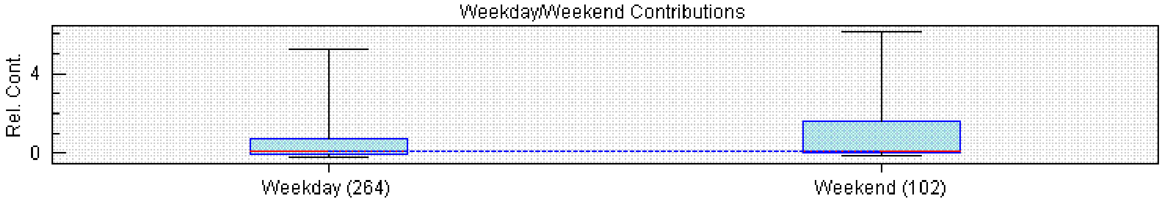


Figure 4-14. Weekday and weekend difference, for Factor 3, solvent group.

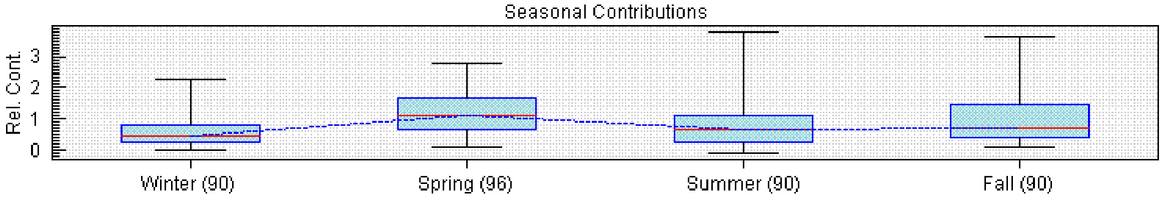


Figure 4-15. Seasonal contribution of Factor 4, mobile sources.

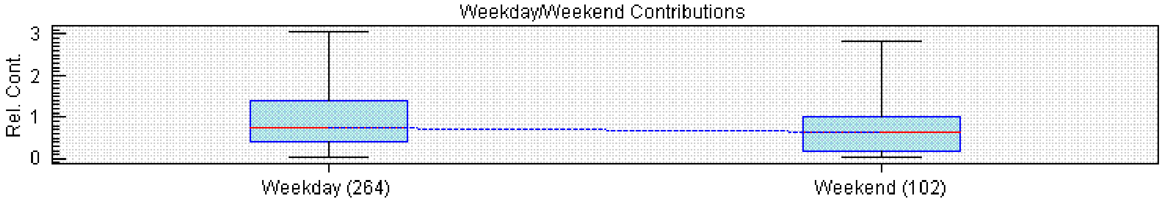


Figure 4-16. Weekday and weekend difference, for factor 4, mobile sources. The analysis suggests less mobile activities during weekends.

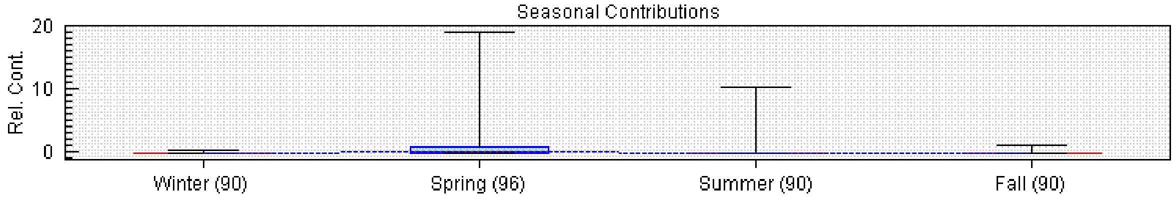


Figure 4-17. Seasonal contribution of Factor 5, isopropanol.

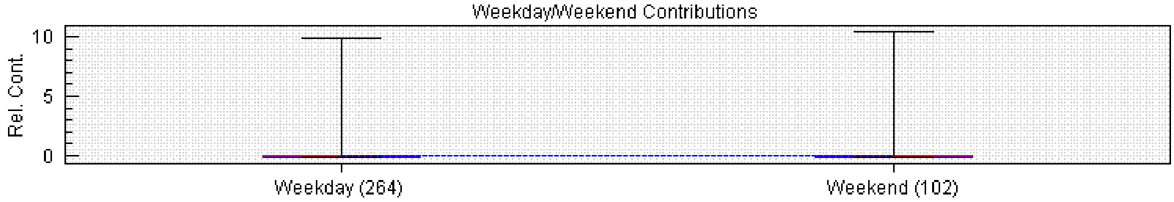


Figure 4-18. No difference for weekdays and weekends is noted for Factor 5, isopropanol.

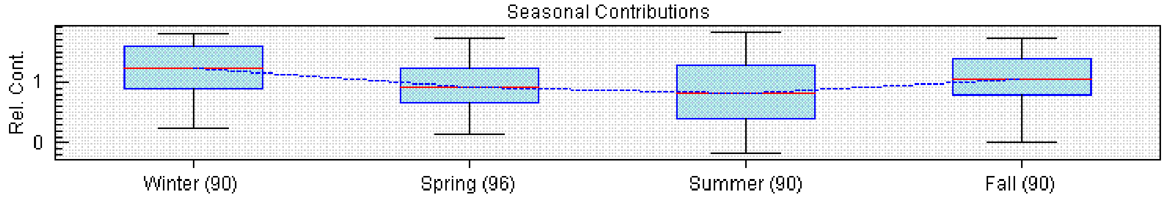


Figure 4-19. Seasonal contribution of Factor 6, mixed sources concentrated by stagnation conditions.

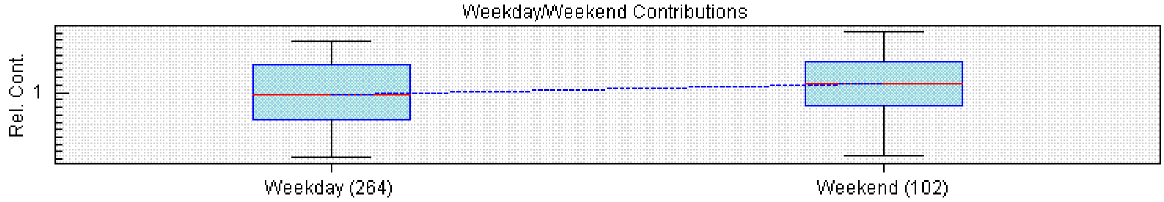


Figure 4-20. Weekday and weekend difference for Factor 6, mixed stagnation-enhanced sources. Slightly higher concentrations during weekends.

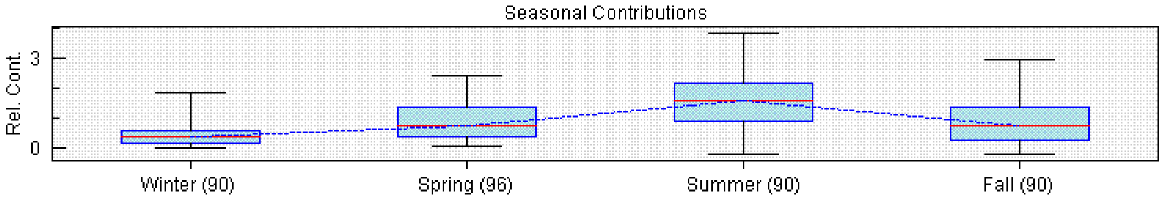


Figure 4-21. Seasonal contribution of Factor 7. Geologic material. Higher in summer due to drier conditions and wind-blown dust.

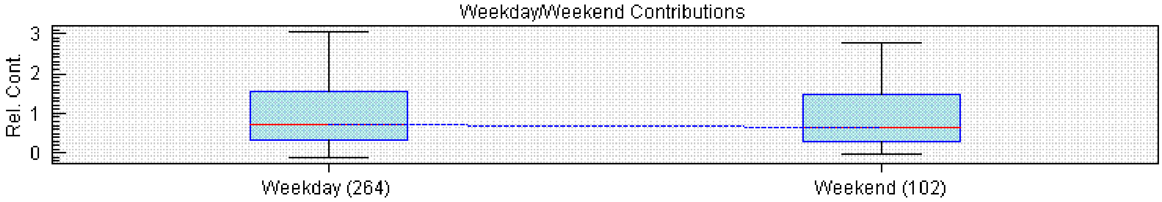


Figure 4-22. Difference between weekdays and weekends for Factor 7, geological material. Slightly lower concentrations during weekends, probably due to reduced traffic and other activities.

4.2.4. Source Contribution Summary for the HAPs

Source contributions to the HAP species that exceeded health screening benchmarks (Section 5) are shown in Table 4-6. The contribution percentages in this table refer to the specie attribution, summing to 100% for each species across all the source categories with which it is associated.

Table 4-6. Relative Contributions to Treasure Valley Concentrations of Nine Hazardous Air Pollutants from Each of Seven SourceCategories.

	Contribution from source group (%)						
Specie	**Factor 1 Photo-chemical**	**Factor 2 Biomass burning**	**Factor 3 Solvents**	**Factor 4 Mobile**	**Factor 5 Isopropanol**	**Factor 6 Mixed Sources/ Stagnation**	**Factor 7 Geologic**
acetaldehyde	25.7	64.6	9.2		0.5		
arsenic		31.5		17		16.6	33.9
benzene		15.4	10.8	56.7	0.7	16.4	
bromomethane	8	5.5	5.3	12.6	2.5	58.3	7.8
cadmium		32.3		10.4		46.6	9.1
carbon tetrachloride	9.2	3.5	4.6	11.3	1.7	64.8	7.9
ethyl benzene	1.5	18.5	7.8	41.6		28.9	1.6
formaldehyde	66.5	20.3				13.3	
manganese	9.5		2.1				88.4

4.2.5. Contributions From Wildfires

Based on the PMF analysis, biomass burning contributes two carbonyl HAP species; formaldehyde and acetaldehyde. The highest impact from biomass burning is during wildfires, as suggested in Figure 4-23, which shows the correlation among formaldehyde, acetaldehyde, organic carbon, and elemental carbon, which are the important indicators of biomass burning. The area was impacted frequently by wildfires in the summer and fall of 2007 and it is clear that wildfires are a major contributor to the increased level of formaldehyde and acetaldehyde.

It is noticeable that PMF Factor 1 (photochemical production) and Factor 2 (biomass burning) have similar profiles. This is understandable because of the close interaction between aldehydes, photochemistry, and wildfire enhancement of the photochemistry. To determine which profile is more representative for biomass burning, the concentration for Factor 1 and Factor 2 are plotted with the organic carbon concentration and potassium concentration in Figure 4-24. The Factor 2 time series is a better match with the organic carbon time series than that of Factor 1. High Factor 2 peaks were measured on several days with significant wildfire impact in Boise: July 5 (Fourth of July fireworks), July 11, July 23, August 16, September 3, and September 15. Organic carbon concentrations were relatively higher on most fire days, but were low August 16 and September 3. Organic carbon was measured only at the St. Luke’s site, and smoke may not have impacted that site on those days. Table 4-7 shows the correlation coefficients between Factor 1, Factor 2, and organic carbon. Factor 2 shows greater correlation with organic carbon than Factor 1. Based on these analyses, Factor 2 is more likely to represent biomass burning.

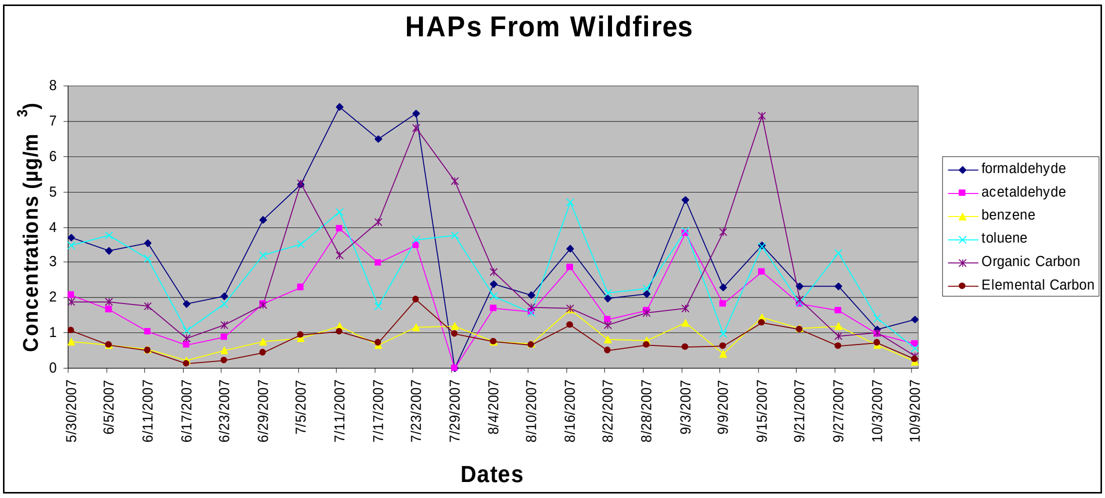


Figure 4-23. Correlation between some HAPs and fires (indicated by organic carbon and elemental carbon). Higher concentrations of organic carbon and elemental carbon during summer and fall were caused by wildfires. The HAPs concentrations are the average values of five sites in the valley. Organic carbon and elemental carbon were measured at the Saint Luke's site as part of the STN monitoring.

Table 4-7. Correlations Among Factor 1, Factor 2, and Organic Carbon

	Ave Factor 2	*Organic Carbon*	*Ave_Factor 1*
Ave Factor 2	1		
Organic Carbon	**0.49**	1	
Ave_Factor 1	0.31	0.29	1

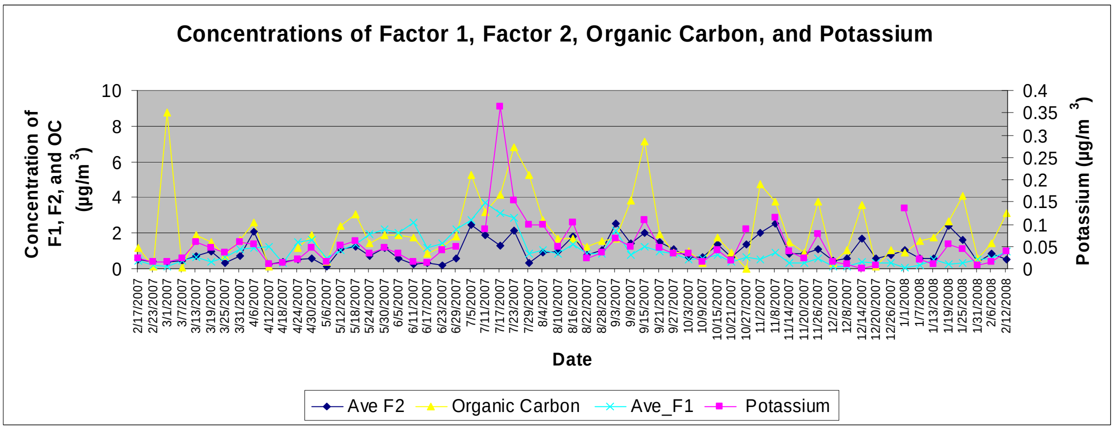


Figure 4-24. Concentrations of Factor 1, Factor 2, organic carbon, and potassium. Factor 2 has higher correlation with organic carbon and potassium, which are common tracer species for wildfires fires. Factor 2 and Factor 1 are average values of five sites; organic carbon and potassium concentrations were measured at the St. Luke's site only. Organic carbon and Factor 2 concentrations are higher on several wildfire days (July 11, July 23, August 16, September 3, and September 15).

4.2.6. Limitations of the PMF analysis

PMF modeling requires a relatively large data set, and good signal-noise ratio. There are typically about 58 samples for each site including some missing days, which is too few for PMF analysis. When all data from all five monitoring sites are combined together, the model is able to perform the source apportionment reasonably well. However, the spatial resolution is lost. A total of 23 species were removed from the data set due to the high rate of missing values and values below the detection limit. For most remaining species, the signal-noise ratios are low (less than 2). There are also uncertainties in the laboratory measurements that influence the statistical analysis. Finally, PMF does not separate the background and does not separate primary and secondary pollutants (such identifications are only analyst interpretations, e.g., identification of source 1 as photochemical products).

4.3. Source Category Discussion

The PCA and PMF statistical analyses served to identify general source categories influencing air toxics levels in the Treasure Valley, and are in general agreement on the major factors influencing air toxics variation in the valley: photochemical production, mobile sources, and wildfires. The PMF analysis also identified a mixed source grouping associated with stagnation events and wind erosion of soils, both of which were also identified in the PCA analyses. The second PCA analysis (PCA #2), which focused on fine particulate mass ($PM_{2.5}$), identified the secondary aerosol factor, which is associated in part with cadmium and selenium. Both methods also associated lead and arsenic primarily with mobile sources. Wind erosion explains most of the other metal/trace elements and the associated PM_{10} mass.

The seasonal/spatial charts presented in Section 3.2 corroborate these source categories and suggest additional sources. In this section, the source categories identified in the preceding sections by either statistical analysis or spatial/seasonal variation are discussed in more detail, and when possible, their relative contributions are estimated.

Factor 1: Photochemical Reaction Products: Formaldehyde, Acetaldehyde and Propionaldehyde

Photochemical reaction products are the aldehydes and ketones (collectively classified as carbonyls), formed during the free radical oxidation of hydrocarbons. Numerous additional carbonyl analytes were reported; however, only formaldehyde, acetaldehyde, and propionaldehyde are HAPs, and only the first two are discussed here because they are present in much higher concentration and dominate the aldehyde-related risk. The photochemical production of these compounds is associated with the formation of ozone and other oxidants, and we would expect them to vary spatially and temporally somewhat as ozone does. Accordingly, we see the highest formaldehyde and acetaldehyde levels during the summer ozone season (see Figure 3-9). Likewise, the diurnal variation of photochemically produced aldehydes (but not directly-emitted (primary) aldehydes) is expected to mimic the spatial-temporal patterns of ozone. Figure 4-25 shows the ozone diurnal variation at sites throughout the Treasure Valley, observed during the ozone precursor study in July and August 2007 (DRI, 2008). This figure for ozone is reproduced here because it is expected to reflect key features of the photochemically-produced aldehyde pattern: highest in the afternoon; highest at the eastern side of the valley where ozone is highest (White Pine and St. Luke's), then lower at NNU and lowest at Parma.

In addition to photochemical production, aldehydes and ketones are produced by combustion processes, wildfires, and possibly by additional solvent-related sources such as urea-formaldehyde foam used in construction or formalin used in medical/pathological procedures.

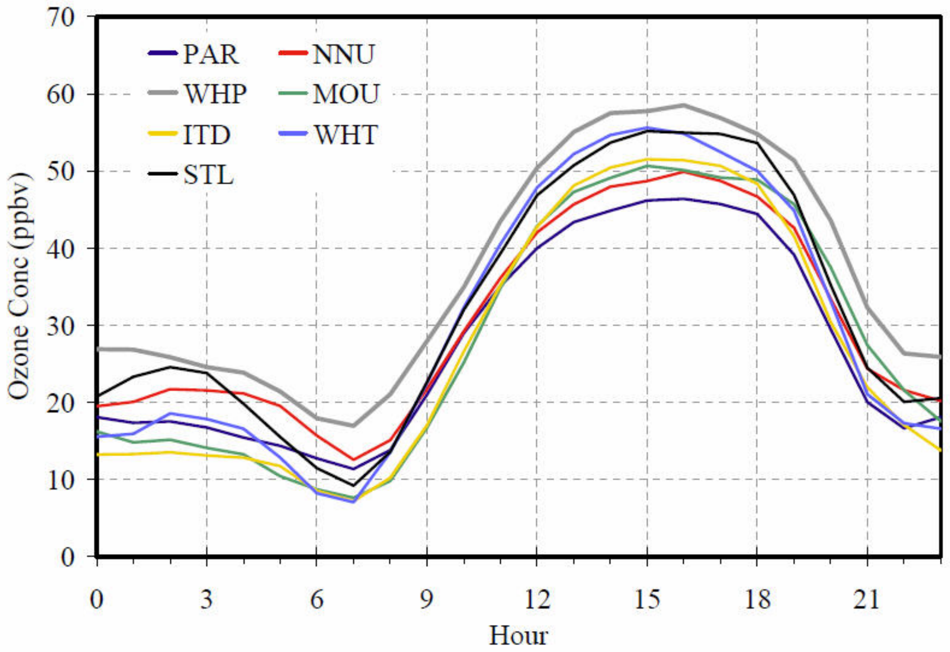


Figure 4-25. Ozone diurnal trends throughout the Treasure Valley. From 2007 ozone precursor study. (DRI, 2008). Photochemically- produced formaldehyde, acetaldehyde, and propionaldehyde are expected to vary similarly, increasing in the afternoon and increasing from west to east in the valley, as observed for ozone in this graph. (PAR–Parma; WHP–White Pine; ITD–Idaho Transportation Department; STL–St. Luke's Meridian; NNU–Northwestern Nazarene University; MOU–Mountain View; WHT–Whitney).

Since the aldehydes vary primarily with photochemical production, and wildfires simply enhance that production, all the aldehydes typically cluster along a single axis in a scatter plot of one aldehyde against another. When this type of plot is made for acetaldehyde and formaldehyde observations from this study, however, an unusual pattern arises. Most of the data from all sites cluster along a single axis, just below the 1:1 line (see Figure 4-26). However, in this data set, a separate axis with "excess" formaldehyde relative to acetaldehyde occurs. It occurs only at the St. Luke's site, but in both primary and duplicate samples at that site. Since distant wildfires would enhance aldehyde production at all sites, which isn't seen here, a third mechanism for formaldehyde formation detected at St. Luke's is suggested that is not present at any of the other sites. These "excess" formaldehyde observations occur on both smoky and non-smoky days so the wildfire enhancement operates independently on all sources of formaldehyde. One possible source of excess formaldehyde near St. Luke's may be urea-formaldehyde foam used in nearby construction, occurring just east of the site during the study, or nearby light industries. Another potential source might be pathological tissue preservation uses of formaldehyde solutions (formalin) that may be associated with nearby St. Luke's Hospital. In either case, this may be the formaldehyde component included in Factor 6, the "mixed sources" group in the PMF analysis.

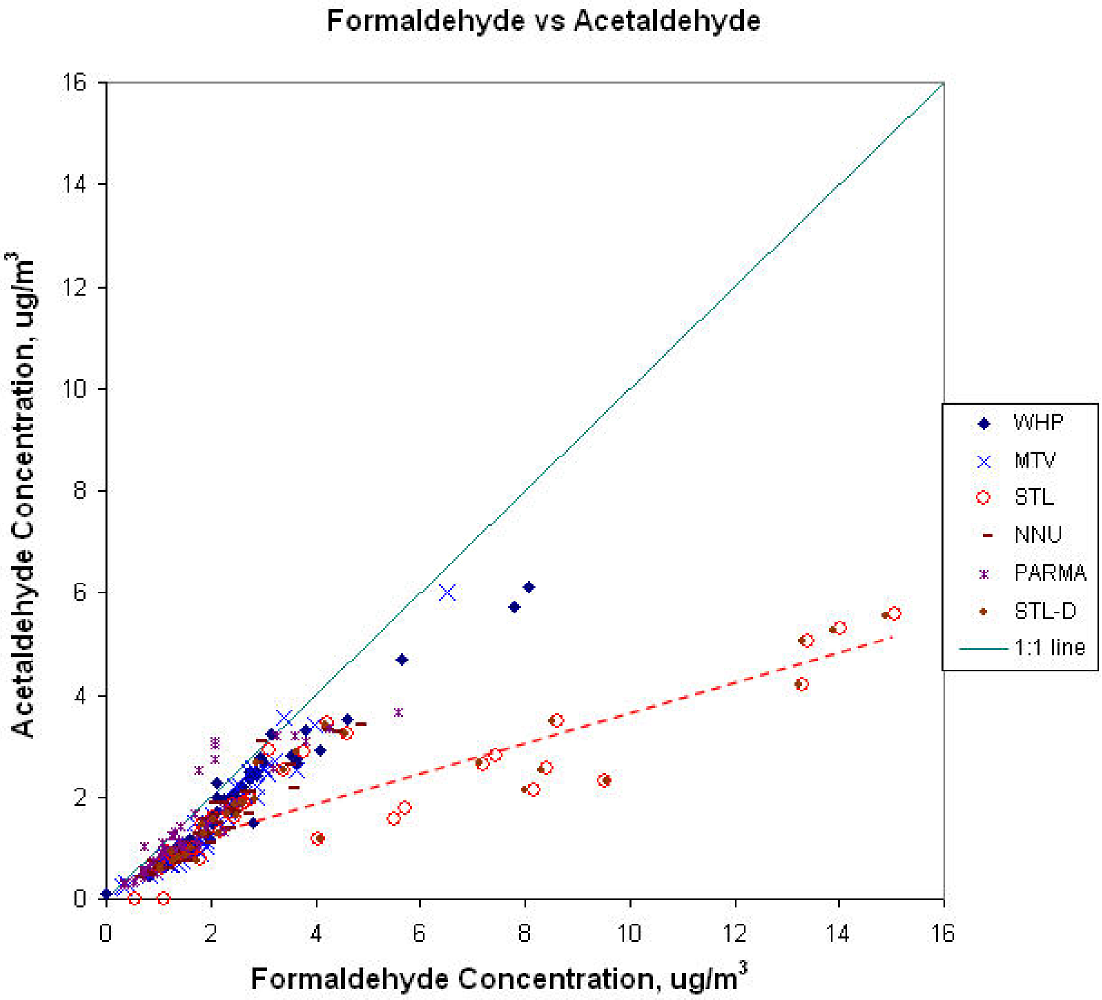


Figure 4-26. Acetaldehyde vs formaldehyde scatter plot for all sites. A separate axis is seen with “excess” formaldehyde compared to acetaldehyde, occurring only at the St. Luke’s site (but in both primary and duplicate samples). This suggests a third mechanism for formaldehyde formation that is not present at any of the other sites.

Factor 2: Biomass Burning/Wildfires

Biomass burning may include residential wood combustion, agricultural burning, and wildfires. Residential wood combustion, once a major contributor to wintertime PM_{10} stagnation episodes has declined significantly in the Treasure Valley as a contributor to the fine particulate pollution. Agricultural burning was banned during 2007 as result of litigation. However, the summer of 2007 was a very active wildfire year in the Northwest and intermountain regions.

Wildfires produce nitrogen oxides (NOx) and VOCs that enhance ozone production in downwind areas for hundreds of miles (Wotawa and Trainer, 2000). Wildfire emissions may involve direct aldehyde emissions or, more likely for more distant fires, oxidant precursor emissions of NOx and hydrocarbons that enhance the normal photochemical production process after reaching the Treasure Valley.

To explore the effects of wildfires on aldehyde production, the summer-season HAPs study sample days that had visible wildfire smoke in the vicinity were identified by satellite smoke analysis (NESDIS, 2009).

In addition, data from the Speciation Trends Network (STN) site at St. Lukes was used to obtain concentrations of $PM_{2.5}$, potassium, elemental carbon, and organic carbon, all known markers for biomass burning. Using the satellite smoke detections, the summer sampling days were separated into days with and days without wildfire influence as suggested by smoke in or near Boise on the sample day in question or the day immediately before it. The formaldehyde and acetaldehyde concentrations for the days on which smoke is present and the days when it is not are plotted for all sample sites in the top two graphs of Figure 4-27, along with a similar bar graph on the bottom showing the biomass burning indicators from the STN database.

First, it should be noted that, looking only at the smoke-free days, there appears to be a statistically significant difference, at the 95% confidence level, between Parma and the easternmost sites White Pine and St. Luke’s (MountainView data are incomplete for this period). We believe this represents the differences in aldehydes primarily of mobile and photochemical origin from the rural western to the urban eastern end of the valley. With respect to wildfires, there appears to be a statistically significant difference between the days with satellite-detected smoke and days with no smoke for each of the biomass burning indicators except elemental carbon, which appears to only be significant at a 90% confidence level (bottom graph, Figure 4-27). There also appears to be a significant “wildfire effect” at all sites for acetaldehyde and all sites except St. Luke’s for formaldehyde. It is important to note, however, that the wildfire or “smoke” days shown in Figure 4-27 occurred more often during the peak photochemical portion of the summer from mid-July to mid-August. The seasonal variation in aldehyde concentrations can be seen in Figure 4-28, which shows formaldehyde and acetaldehyde concentrations from this study (2007) along with the 2003-2004 data collected in an earlier study at NNU when wildfires were less prevalent. Clearly, the mid-July through mid-August aldehyde levels are naturally higher than early-summer and late-summer values.

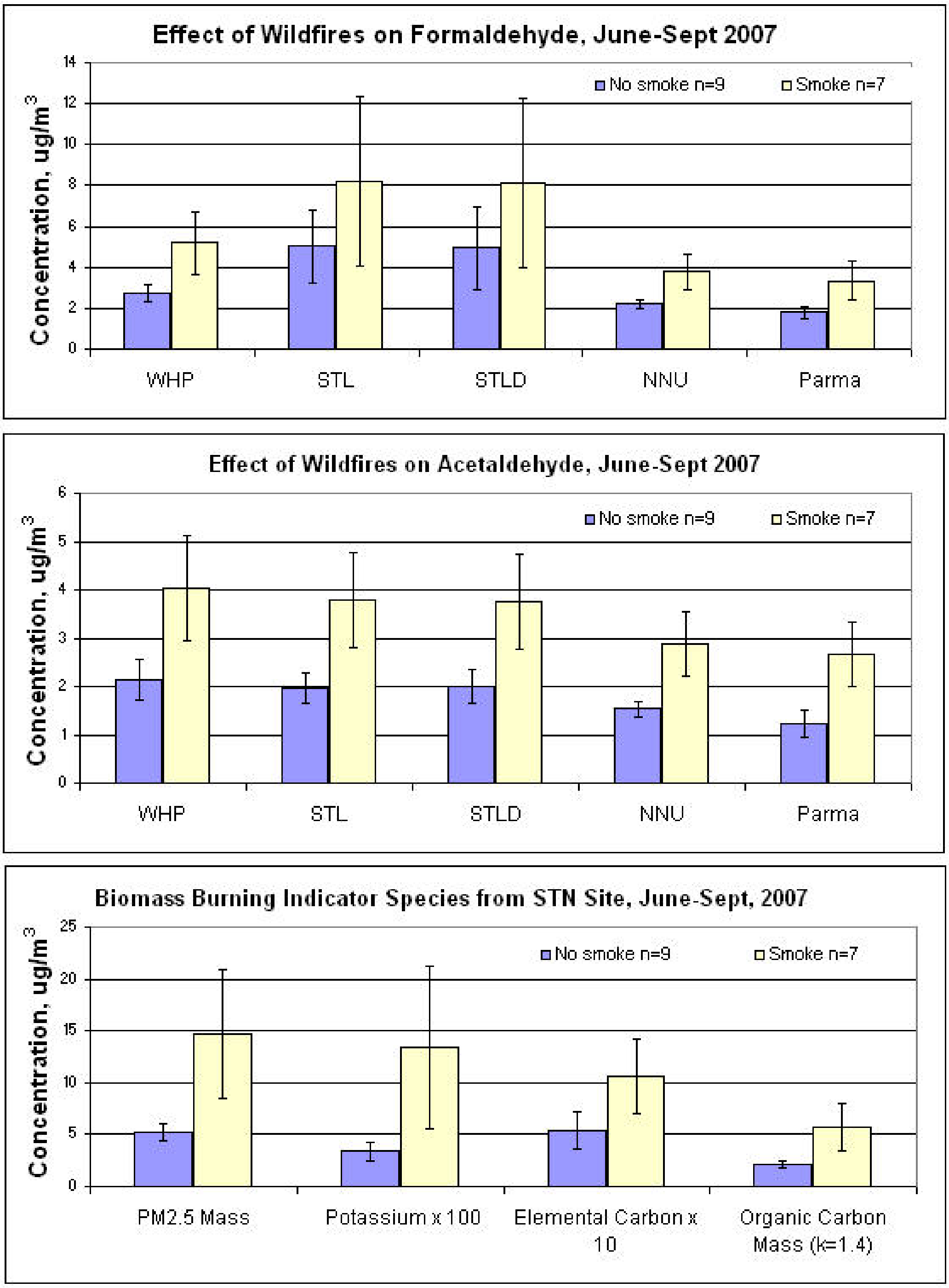
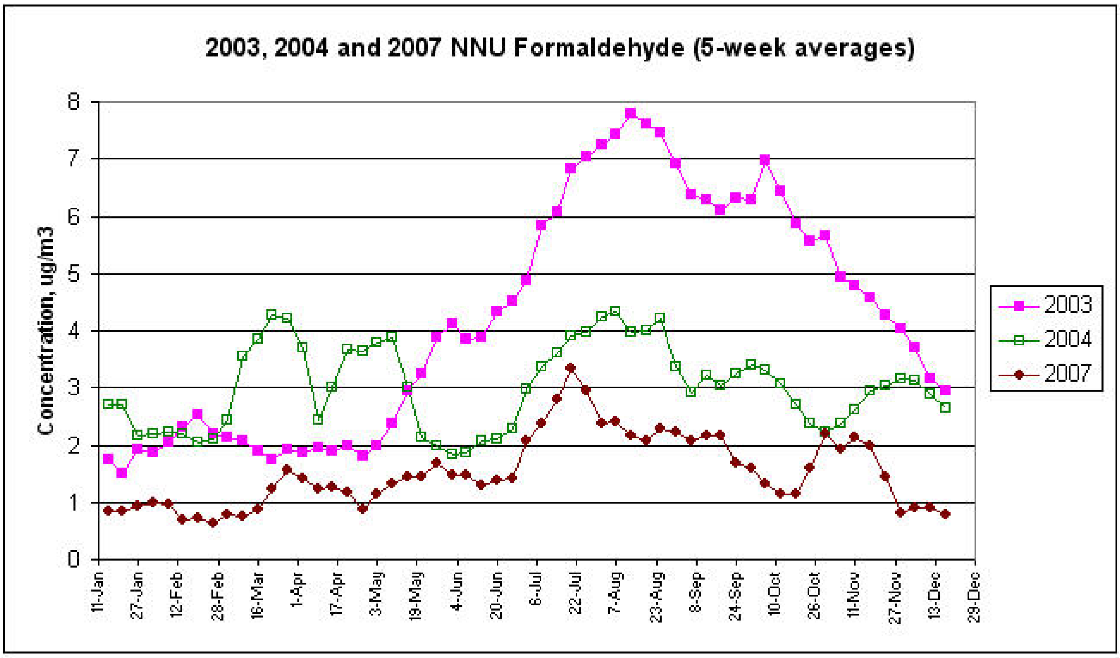


Figure 4-27. Effect of wildfires on aldehydes (top two) and known biomass burning indicators (bottom). Sample days that had wildfire smoke in the vicinity were identified by satellite smoke analysis; however, the biomass burning indicators corroborate the satellite-based determinations. This suggests a significant effect; however, the results are confounded by the temporal pattern in which aldehydes naturally peak during the time when many of the wildfires were active.



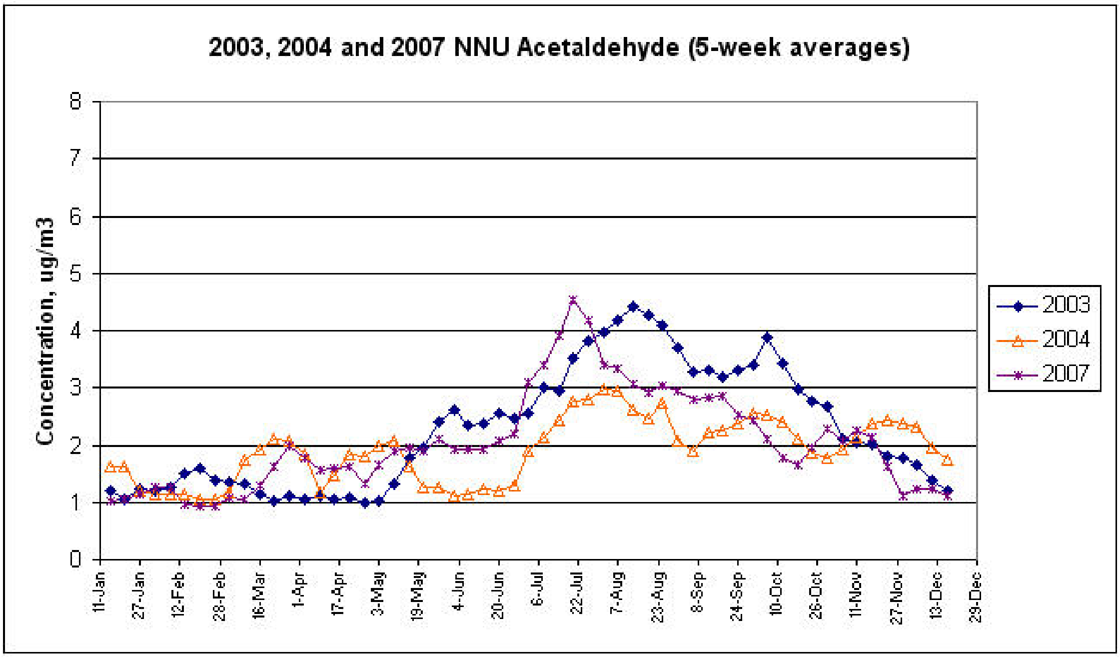
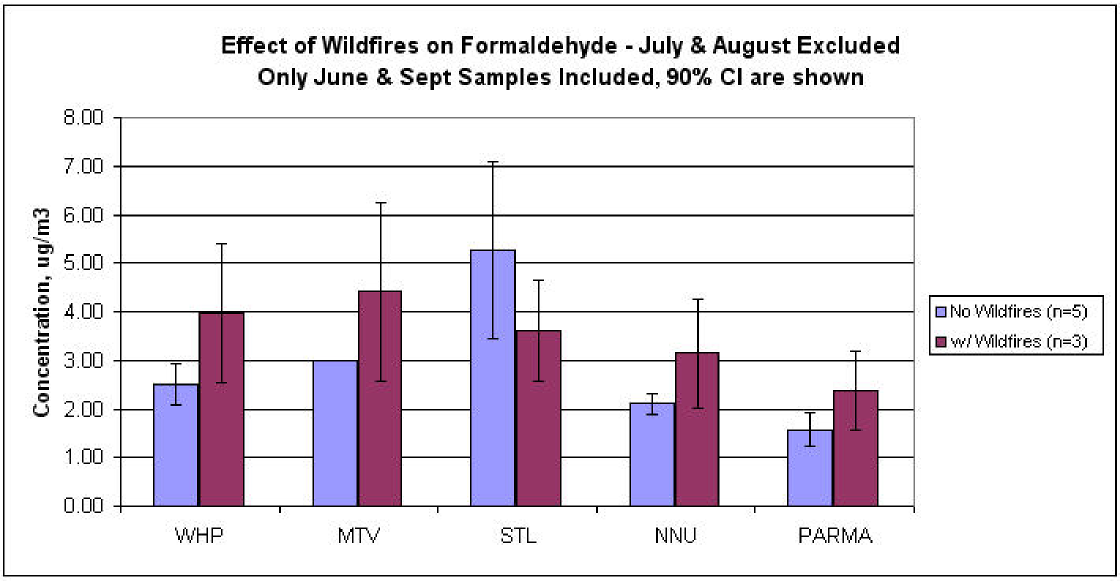


Figure 4-28. 2007 NNU aldehyde temporal patterns shown along with 2003 and 2004 data from NNU showing summertime period of peak photochemical activity.

In an effort to examine the wildfire influence without the coincident effect of the high mid-summer photochemical peak, the effect of wildfires on the aldehydes was re-examined using only the samples from June and September 2007. This revised analysis, shown in Figure 4-29 with confidence intervals relaxed to 90%, indicates that the mean concentrations on wildfire-impacted days generally appear to be higher than on the smoke-free days, but the difference is not significant at any of the sites. Thus, with this limited dataset, we cannot conclude that wildfires produced a significant increase in aldehyde levels. Formaldehyde at St. Luke's appears to be higher due to an unidentified source.



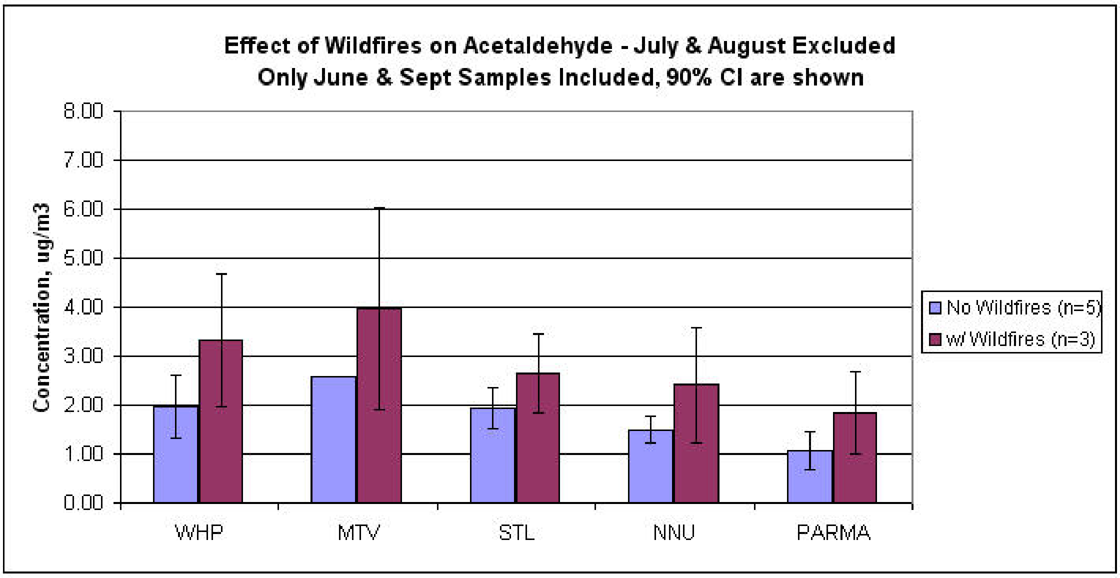


Figure 4-29. Re-analysis showing the effect of wildfires on aldehydes when the July and August period of peak photochemical activity is excluded from the analysis. Confidence intervals have been relaxed to 90%; however, no significant effect can be demonstrated.

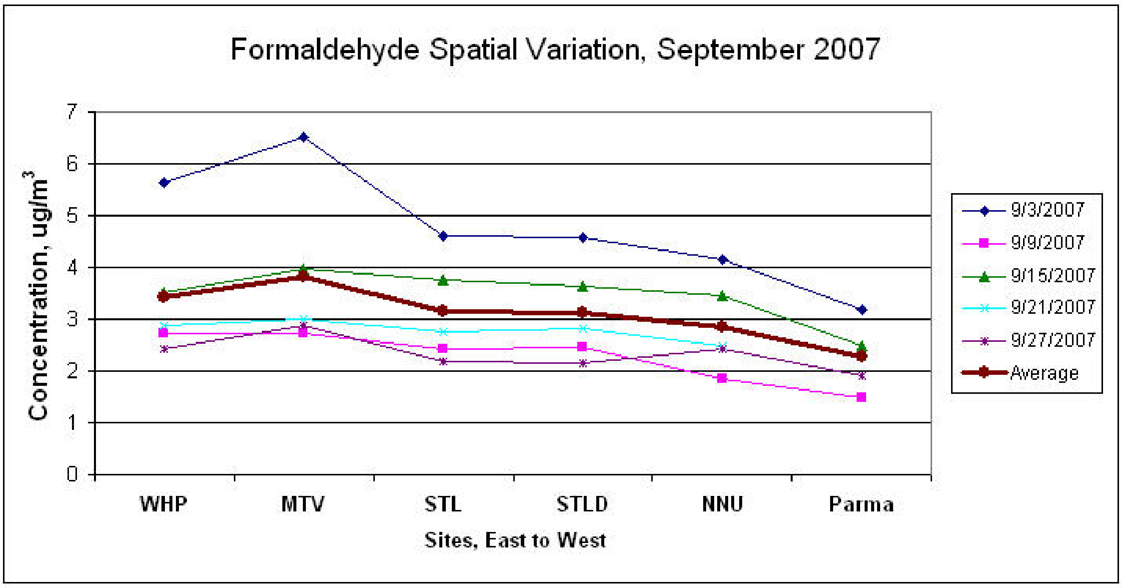
Factor 3: Solvent Group

Factor 3 in the PMF analysis primarily includes two VOC solvents/propellants: chloroethane and cyclohexane. Cyclohexane is a solvent, and a paint and varnish remover (Merck, 1996) while chloroethane (or ethyl chloride) has been used as a solvent, refrigerant, topical anesthetic, aerosol spray propellant, and blowing agent for foam packaging. Chloroethane is also a recreational inhalant or “huffer” drug sometimes referred to as “Duster.” Nevertheless, neither of these VOCs are HAPs and considering the low-parts-per-billion concentrations observed, additional analysis is not warranted.

Factor 4: Mobile Source Air Toxics

The PMF analysis identified a large number of VOCs, including known gasoline-related VOCs, the aromatic BTEX compounds (benzene, toluene, ethyl benzene, and xylenes), 2,2,4-trimethylpentane, and 1,2,4-trimethyl benzene, along with the metal/trace elements lead and arsenic. These compounds are clearly associated with mobile source/gasoline-related urban emissions. In most urban areas, mobile source exhaust and evaporation sources, are major components of air toxics risk.

The spatial and seasonal variation of the BTEX compounds and 2,2,4-trimethylpentane can be seen in Figure 3-10 and Figure 3-11, respectively, and a similar pattern is visible for lead and arsenic (Figure 3-7) during at least part of the year. The spatial-temporal pattern of the exhaust-related primary aldehydes is expected to be similar to the pattern of the BTEX compounds peaking at the Mountain View site; however, Mountain View aldehyde results were invalid during the summer period so this relationship is not clear in Figure 3-9. Although aldehyde data from the Mountain View site are incomplete during the summer, the contribution of on-road mobile exhaust aldehyde emissions, peaking at Mountain View, can be seen in September when the dominant photochemical activity has declined somewhat (Figure 4-30).



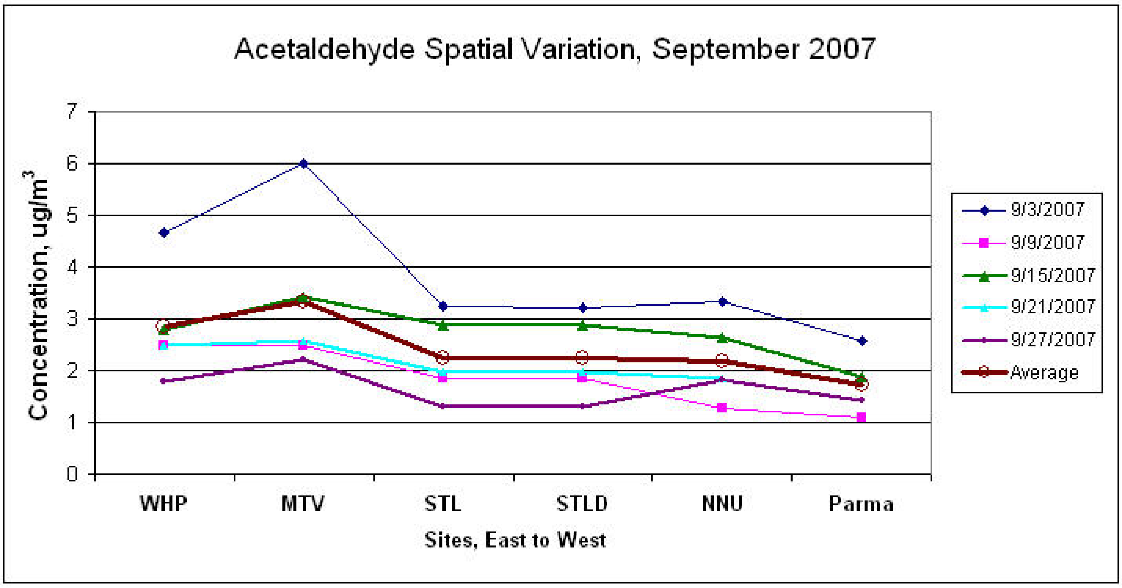


Figure 4-30. Formaldehyde and acetaldehyde in September 2007.   Higher levels are shown from west to east and peaking at Mountain View (MTV), similar to on-road mobile BTEX species. This pattern applies primarily to mobile-related aldehydes since photochemical activity is reduced by September.

Additional temporal characterization of the mobile source air toxics can be better understood by looking at continuous VOC monitoring over the July-August monitoring period of the 2007 ozone precursor study (DRI, 2008). The ozone precursor continuous VOC data at St. Luke's, when averaged over 24-hour periods and compared to the air toxics study VOC concentrations on the same days, were well-correlated (although the continuous data appears to be biased somewhat high). The period-averaged (July-September) diurnal VOC profiles for the St. Luke's site, shown in Figure 4-31, reveal a typical urban diurnal pattern: benzene, o-xylene, and ethyl benzene concentrations (along with other hydrocarbons) peak during the morning rush hour, become lower during the day due to enhanced dispersion and photochemical loss, then become higher again at night when the evening traffic emissions become trapped once again by stable night time air.

A similar plot of diurnal VOC variation is shown in Figure 4-32 for data from the monitoring site at the Idaho Transportation Department headquarters office on State Street, not far from the Mountain View Site (see Figure 1-1 for locations). Again, the pattern is higher at night than during the midday period; however, in this part of the city, emissions from the evening traffic in the downtown area become concentrated by stable air and pollutant levels remain elevated throughout the night. Mean continuous benzene concentrations at the ITD site during this summer period are approximately three times higher than the benzene mean concentrations at the St. Luke's site (note the scale is different in Figure 4-31 and Figure 4-32.) Since the ITD and Mountain View sites are both downwind of the urban core area during nighttime drainage conditions, this finding corroborates the finding of this study that this area of Boise experiences the greatest mobile source impacts as a result of their relationship to the downtown area and major arterials approaching it during evening and morning drainage conditions.

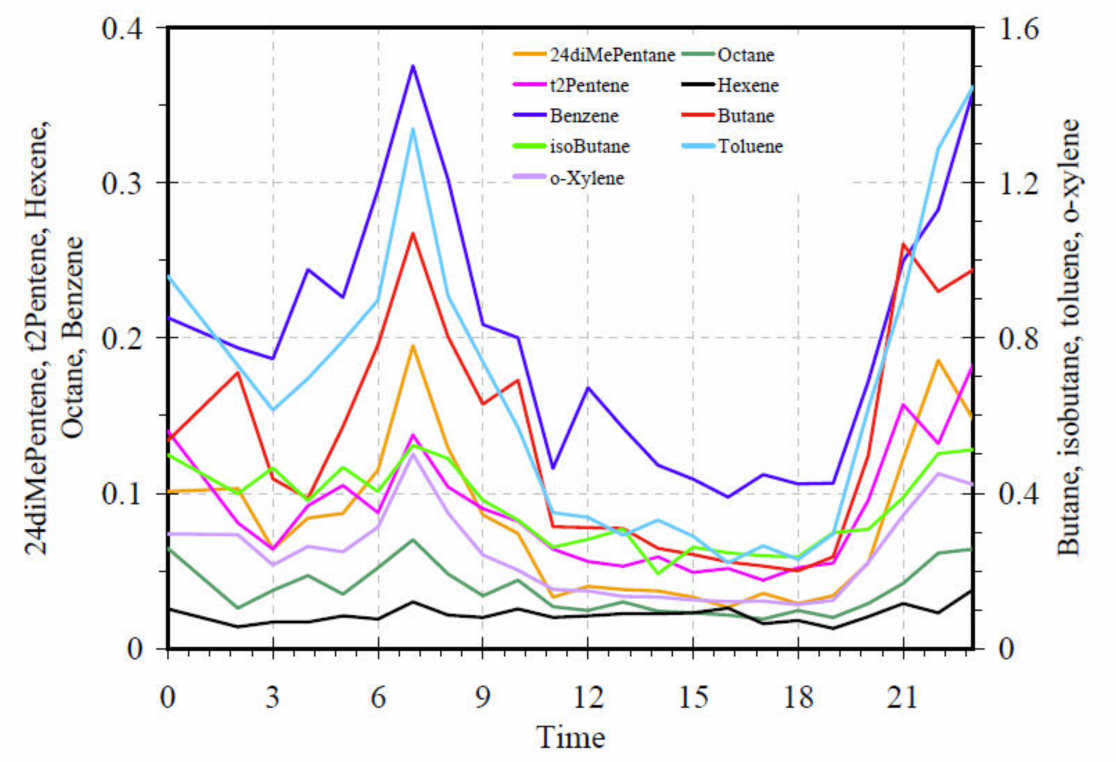


Figure 4-31. Diurnal Variation in VOCs at the St. Luke's site, averaged over the July-September period of 2007. From the Treasure Valley ozone precursor study. (DRI, 2008). Levels are highest during the morning rush hour and evening but lower overnight and at midday.

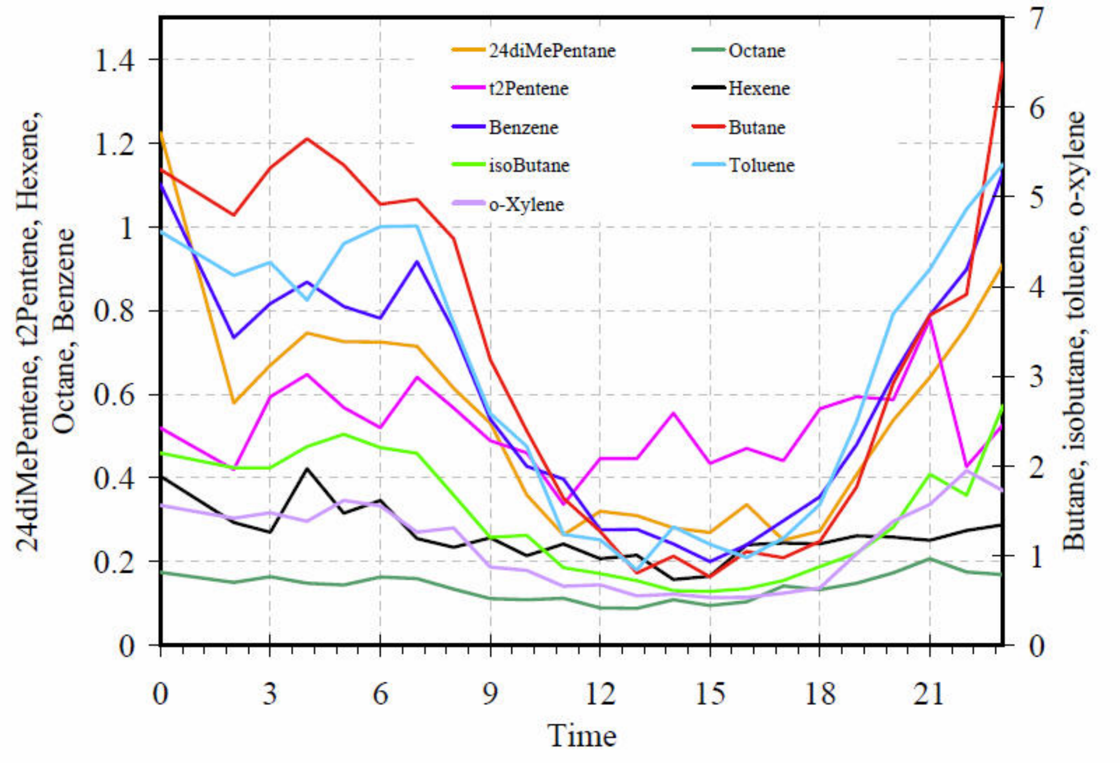


Figure 4-32. Diurnal Variation in VOCs at the ITD site, near Mountain View and northwest of the Boise downtown area. Units are all in parts per billion by volume (ppbv) averaged over the July-September period of 2007 as part of the Treasure Valley ozone precursor study (DRI, 2008). Average concentrations of benzene, toluene, ethyl benzene, and o-xylene HAPs species and other mobile source hydrocarbons are higher here than at St. Luke's (Figure 4-31), due in part to high night-time levels (note different scale).

Factor 5: Isopropanol

During the spring and summer of 2007, unusually elevated isopropanol (isopropyl, or "rubbing" alcohol) was observed at the White Pine site, with somewhat lower levels observed at St. Luke's.

Unfortunately, the isopropanol data quality is poor (132% RPD). In addition, isopropanol is of low toxicity, is not a HAP, and is of low photochemical reactivity. Thus, for these reasons and in view of the unusual seasonal pattern (spring and summer, primarily at a single site — White Pine), additional analysis is not warranted.

Factor 6: Mixed Sources/Stagnation Conditions – halogenated solvents and refrigerants, cadmium, arsenic, selenium.

This group of species includes the halogenated compounds bromomethane, carbon tetrachloride, methyl chloride, methylene chloride, the refrigerants dichlorodifluoromethane and trichlorofluoromethane, and three PM_{10} HAP species: cadmium, arsenic, and selenium. Smaller amounts of hexane, heptane, and 2-hexanone are also included.

Specific sources of these VOC compounds have not been identified other than general urban activity. They appear to factor together seasonally in the winter and they generally exclude aldehydes, except for a small fraction of the formaldehyde, believed to originate from a non-photochemical and non-motor vehicle source (such as urethane foam or formalin solvent). We believe this is also related to the PCA factor involving cadmium, selenium, and secondary aerosol species sulfate, nitrate and ammonium, which are probably related, in part, to industrial coal combustion. The secondary aerosol PCA factor is also greatest during winter stagnation periods. Since cadmium and selenium are associated with the VOC species in Factor 6 and the secondary aerosol factor in the second PCA analysis, this factor is termed “mixed sources, stagnation related”. It should also be noted that although the PCA secondary aerosol factor is based on $PM_{2.5}$ samples at the St. Luke’s STN site, the cadmium measured in this study is in the PM_{10} fraction and may be a mixture of fine mode cadmium ($PM_{2.5}$) and coarse mode cadmium (2.5-10 micrometers in size).

Carbon tetrachloride has been largely phased out of use; however, it is persistent in the environment and occurs at a very constant globally uniform concentration of about 0.62 $\mu g/m^3$ (McCarthy, et. al. 2006). While carbon tetrachloride was detected in a number of samples, the detections (and the expected global average) are just at the MRL for this study, so there is no clear pattern and the annual average concentration appears to be lower than the global background level, primarily as a result of substituting one-half of the MRL for missing values. For the purposes of estimating risk, therefore, it may be concluded that Treasure Valley sources do not add to carbon tetrachloride concentrations and carbon tetrachloride may be assumed to be approximately equivalent to the global background value at all sites.

The PM_{10} particulate species cadmium, selenium, and arsenic show very strong increasing trends toward the western sites, especially in the spring (Figure 3-7 and Figure 3-8) although it is important to remember that all three of these species are present at concentrations below the 25th percentile of annual means nationwide (see Figure 3-15 and Figure 3-16.) Three potential source explanations have been considered to explain these patterns; however, there is not sufficient information to positively identify any sources or their relative contributions. The sources suspected of producing the increasing western gradient for these particulate species are a) industrial coal combustion, b) cement kilns in Durkee, Oregon, and c) fertilizer application and/or tilling of fertilizer-enriched soils in agricultural areas.

To explore sources of these metal/trace elements and the cause of the increasing western gradient further, the springtime species concentrations at Parma were divided by the average springtime total PM_{10} mass determined as part of the Method IO-3.5 determination, to see how concentrated the metal/trace elements are in the PM_{10} material sampled. These results are shown in Table 4-8, along with typical concentrations for soils in the region.

In each case, the concentrations of these species in the PM_{10} captured on filters in Parma are greater than what is typical for soils in the region. Thus, it appears that while wind erosion of typical soils alone cannot explain the concentrations observed in the PM_{10} mass, and since other typical urban sources of these metal/trace elements are not present at Parma, there must be another source or sources of these species with an increasing gradient toward the west that contributes to these levels.

Industrial coal combustion sources near Nampa, Idaho, could potentially serve to increase the content of these species in the PM_{10} mass, but this is not likely a dominant source of these gradient-related metal/trace elements because they are highest in Parma rather than NNU (although coal combustion may contribute during winter stagnation, separate from the gradient-related springtime patterns as reflected in PMF Factor 6).

A source to the west of Parma would explain the east-west gradient, so the cement plant in Durkee, Oregon, is also another possibility. The Durkee plant, however, is 92 km away from Parma and this is probably too far to have this level of impact and to show this steep a gradient, in the Treasure Valley.

Finally, several types of fertilizer contain elevated levels of these elements (WSDA, 2009) so it is plausible that some of the cadmium, arsenic, and selenium may originate either directly from fertilizer handling and application, or from tilling and wind erosion of fertilizer-enriched soils in the heavily agricultural area around Parma and to a lesser extent, Nampa. In addition, selenium is also a dietary supplement for beef and dairy cattle, so dust from animal waste trampling and handling may also be a contributor of selenium in the agricultural areas of the valley. This potential source is consistent with the fact that the selenium east-to-west gradient appears in all four seasons while the cadmium, arsenic, and manganese gradients appear primarily in the spring when tilling and fertilizing may be most active.

Table 4-8. Metal/trace element Concentrations in PM_{10} at Parma

Material	**Cadmium Concentration, mg/kg**	**Selenium Concentration, mg/kg**	**Arsenic Concentration, mg/kg**
Typical soils in region	< 1.0[(a)]	0.1 to 2.0 range, 0.5 typical[(b)]	6.4[(c)]
Spring PM_{10} dust measured at Parma	3.3	8.6	21.0

Notes:

(a) Based on geometric means of 88 samples collected from northwestern, south-central, and southeastern Oregon (Holmgren et. al., 1993) and 55 samples collected in Idaho counties north and east of Canyon County, with concentrations ranging from 0.20 to 0.78 mg/kg (Holmgren, 1985).

(b) Common ranges and typical levels of trace elements in cultivated surface soils, (Berrow and Burridge, 1980; OSWER, 2003)

(c) Values represent Oregon (Boerngen and Shackette, 1981)

Factor 7: Soil/Wind erosion

The PM_{10} metals manganese, beryllium, cobalt, and some portion of the trace elements selenium and arsenic co-occur without any significant VOCs. This subgroup of the PM_{10} mass probably results from wind erosion of soils. As reflected in Figure 3-7 and Figure 3-8, these species are highest in concentration during the windy and dry seasons (spring and summer), and there is a slight increasing trend toward St. Luke's and the western, more rural end of the valley where more bare soils are present. Construction was occurring within 500 m of St. Luke's during the spring and summer of 2007 and may have contributed to this source factor.

Additional source category not identified by PMF analysis: Acrylonitrile

Acrylonitrile was only sparsely detected at Parma, and even less at White Pine, during the spring and summer of 2007, so the data quality assessment assigned a low level of confidence to the acrylonitrile long-term averages. In addition, acrylonitrile was excluded from the PMF analysis due to the sparse detections.

A definitive source of acrylonitrile has not been identified. The only common characteristics noted for these two sites is proximity to light industrial/painting activity and to water/wastewater treatment plants—the Parma air monitoring sampler is at the city wastewater lagoons and the White Pine monitoring site is approximately 2 km south of the City of Boise water treatment plant. Acrylonitrile can off-gas from acrylic latex paint, ABS pipe, and acrylamide flocculant used in water treatment processes, but none of these were reported to be present near the sampler in Parma during this period. Nevertheless, it is possible that unknown wastewaters containing trace acrylonitrile may have entered the wastewater lagoons during this period and then dissipated over time, explaining its occurrence at Parma primarily in the spring and summer. Light industrial activity that includes automotive or industrial painting is another possible source near both the Parma and White Pine sites.

Additional source category not identified by PMF analysis: 1,3-dichloropropene

The *cis*- and *trans*- isomers of 1,3-dichloropropene (1,3-DCP) were also only sparsely detected and were not amenable to inclusion in the PMF analysis. Both 1,3-DCP isomers (*cis*- and *trans*-) appear at Parma in late October and in early November, and to a much smaller extent at Nampa during that time period, and also apprear at Parma briefly in the spring. Refer to the seasonal-spatial plot in Figure 3-6 and the more detailed time series plots below in Figure 4-33 (NNU: Nampa) and Figure 4-34 (Parma). Figure 4-33 includes NNU data from the limited 2003-2004 air toxics monitoring study, and shows that there appears to be a slight decreasing trend in 1,3-DCP levels at NNU; however, it occurs very regularly every fall for several weeks.

1,3-DCP is a common soil fumigant that has replaced methyl bromide in recent years in the Treasure Valley for control of potato, sugar beet, and onion nematodes. It is typically used after the fall harvest, although some application appears to occur in the spring just prior to planting. 1,3-DCP is a fumigant widely used in other parts of the country, including the Central Valley of California where significant monitoring and regulatory control has occurred (Lee et. al., 2002). While it may be applied using spray methods on the surface for some crops, it is typically shank-injected in this region, at least 12 inches below the surface, and controlled by soil sealing. Approximately 177.5 pounds per acre are reported to have been used in Idaho potato crop applications in 2005 (NASS, 2008). Soil sealing traps the fumigant by first disking (i.e. cultivating soil with a disk harrow) the top few inches of soil, then roller-compacting it to minimize diffusion. Regulations require it to be applied by licensed individuals with the specialized shank-injection and rolling equipment, and there is a mandatory 100-foot buffer zone between any application site and the nearest point of public access (R. Gabehart, Idaho State Department of Agriculture, personal communication). Measured 1,3-DCP emission fluxes peak approximately 1-2 days after shank injection, then decrease exponentially over the following two weeks, resulting in typical total loss rates of 11-25% according to the manufacturer (Cryer et. al., 2003).

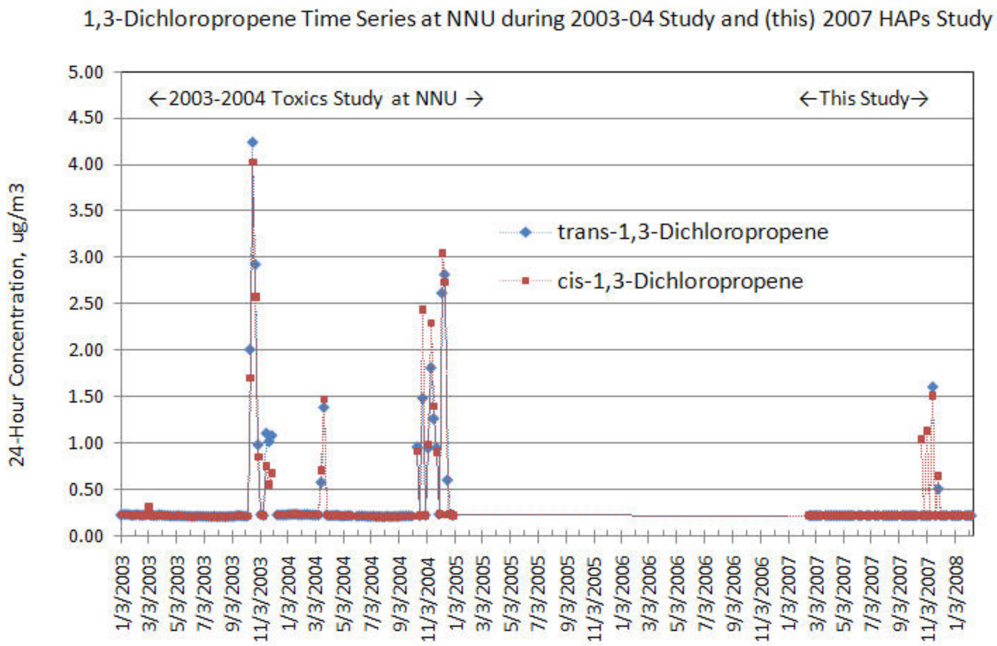


Figure 4-33. 1,3-Dichloropropene time series at NNU in Nampa, including data from 2003-2004 and this study (2007).

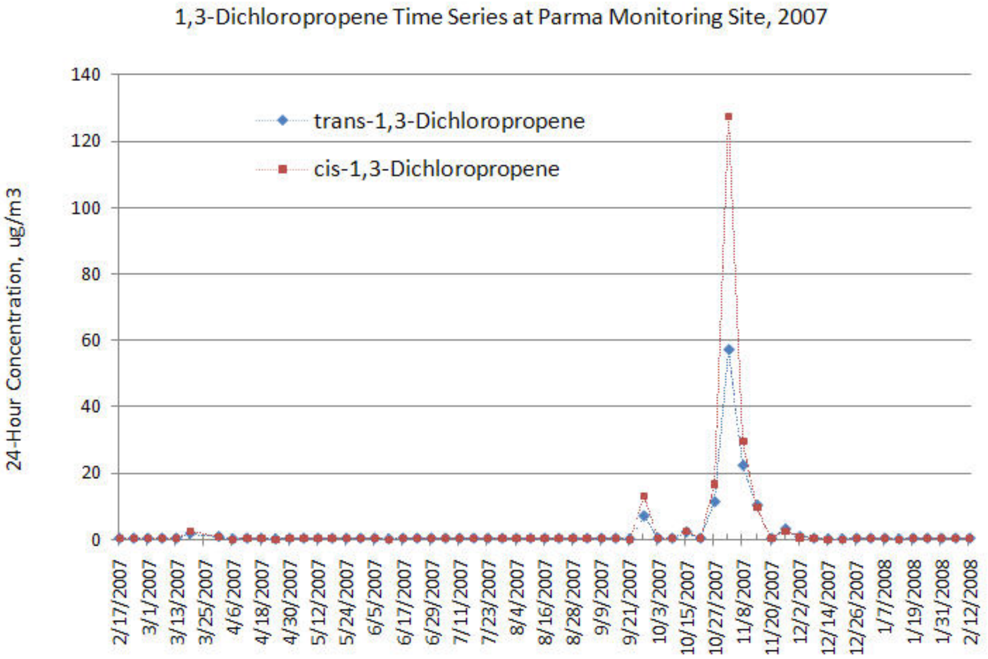


Figure 4-34. 1,3-Dichloropropene time series at Parma, 2007.

The 24-hour averaged 1,3-DCP concentrations at Parma reached 184.5 µg/m^3 (total *cis*- and *trans*- isomers) on November 2, 2007, and were somewhat lower in the samples taken 6 days earlier and 6 days later (27 and 51 µg/m^3, respectively). It should be noted that the highest values, on November 2, 2007, were flagged as "estimated values" by the ODEQ Lab because they exceeded the calibration range of the laboratory analysis; however, they are retained here because 1) the calibration is linear and not expected to deviate significantly just beyond the last calibration point, and 2) they occurred during the peak application season when expected, and 3) replacing them with blanks would be non-conservative and underestimate the actual exposure. The annual average for total 1,3-DCP isomers at Parma is 5.3 µg/m^3 (using one-half of the MRL in place of non-detects). More relevant to sub-chronic risk evaluations, the 4-week average at Parma from October 27, 2007, through November 14, 2007, is 71 µg/m^3 total 1,3-DCP. Since there are no potato, sugar beet, or onion fields in the immediate vicinity of the Parma sample site (for at least 1-2 km), these concentration levels are not near-field, but may represent any areas within 1-2 km of treated fields. Concentrations are expected to increase closer to the application area.

The 1,3-DCP observations at Nampa (NNU) are relatively consistent over the three years of 1,3-DCP detections, with a slight declining trend in the three fall periods when it was detected. The 24-hour peak of total 1,3-DCP at Nampa typically ranged from 4 to 8 µg/m^3 in 2003 and 2004 and was only 3.1 µg/m^3 in 2007. For the purposes of sub-chronic health risk evaluation, the peak 4-week averages at NNU in 2003, 2004, and 2007 were 4.8, 3.4, and 1.3 µg/m^3, total 1,3-DCP, respectively, while the annual mean concentrations at NNU in those three years were 0.85, 0.95 and 0.53 µg/m^3, respectively. The Nampa site at NNU is surrounded by approximately 5-6 km of predominantly urban/residential land use and the nearest potato, sugar beet, or onion fields of any significance appear to be at least 5-6 km from the monitoring site. Therefore, since these levels represent potential exposures located at least 5 km from any application areas and most rural residents in the valley live closer to fields than that, it appears that these 24-hour, weekly, and annual concentrations at NNU should be considered lower exposure limits for most of the agricultural (western) end of the Treasure Valley. The 1,3-DCP levels in the more populated urban areas of Meridian and Boise all have 1,3-DCP concentrations that are generally below the detection limit of this study (0.43 µg/m^3 for each isomer).

As discussed in Section 3.3 the 1,3-DCP annual means at Parma appear to be higher than any reported in the national database. This is probably more a reflection of the mostly-urban/industrial focus of air toxics monitoring nationwide than of unusually high levels of 1,3-DCP in the Treasure Valley. Extensive community monitoring in California indicates that total 1,3-DCP concentrations have been observed ranging up to 135-160 µg/m^3 for 24 hours in California, while 15-day averaged community levels can reach 22-42 µg/m^3 (Lee et. al., 2002), all near the same range of values as discussed above for Parma. In addition, discussions with EPA (personal communication, Jeff Dawson, Office of Pesticide Programs, Health Effects Division) indicate that the values observed at Parma for 1,3-DCP are not unusual for agricultural areas where the pesticide is used.

It should be noted that 1,3-DCP formulations used in this region, are widely used, registered pesticides (EPA, 1998), requiring the application to be performed by certified applicators who are properly trained, and using proper control techniques. The Idaho State Department of Agriculture monitors 1,3-DCP use and promotes responsible application through Fumigation Management Plans (Spencer, 2009). These rankings in comparison to the national database do <u>not</u> in any way suggest that there is unacceptable risk. A conservative, preliminary risk-based screening is presented in Section 5. A more comprehensive risk evaluation is then planned for any species identified in the screening analysis as warranting such evaluation.

5. Risk Analysis Screening

A key purpose of this study was to help characterize health risk associated with air toxics present in the Treasure Valley. Toward this end, a preliminary risk-based screening analysis was performed on this data set in accordance with the protocols outlined in the EPA guidance document, “A Preliminary Risk-Based Screening Approach (PRBSA) for Air Toxics Monitoring Data Sets” (U.S. EPA, 2006). One component of the recommended analysis is to compare the maximum measured concentrations against a health benchmark or screening value. The maximum monitored value is used as a “conservative surrogate” for actual long-term exposure. Since this technique is simple and very conservative, it will help determine which compounds are most likely to be risk-drivers and should be investigated further. A next step in this analysis will be a Health Consultation by the Bureau of Community and Environmental Health of the Idaho Division of Health.

As part of the risk screening, both chronic and acute exposures will be assessed. In this context, a chronic exposure is continuous or multiple exposures that occur over an extended period of time or a significant fraction of a person’s lifetime (U.S. EPA, 2006). A chronic exposure could lead to both carcinogenic and non-carcinogenic health effects. For carcinogens, the exposure is assumed to occur 24 hours a day, every day, for a lifetime (70 years). An acute exposure is one or multiple exposures occurring within a short time frame relative to the lifetime of a person (approximately 24 hours for humans) (U.S. EPA, 2006). Thus, a chronic benchmark concentration is a chemical concentration below which there is not expected to be any adverse health effect for long-term (up to lifetime) exposures. An acute benchmark concentration is a concentration below which there is not expected to be any adverse health effects associated with an acute exposure. If a benchmark concentration is exceeded, it *does not indicate that there will be deleterious health effects* associated with exposure at that concentration. Health benchmarks are very conservative and have numerous safety factors associated with them. If a contaminant concentration does not exceed a benchmark it is generally accepted that the contaminant does not pose a human health risk. If a contaminant does exceed a health benchmark, it should be investigated further to determine if there a human health risk.

5.1. Risk Analysis Methods

A first step in a risk analysis is to screen all of the compounds to determine those compounds that may contribute to human health risk. For this process, measured concentrations are compared to existing screening health benchmarks or concentrations below which one would not expect to observe an adverse health effect. The chronic screening benchmarks (concentrations for screening chronic health effects or cancer) used were the newly developed acceptable source impact level (ASIL) values established by the Washington State Department of Ecology (Washington Ecology) (Guilfoil, 2008; Washington State Department of Ecology, 2009). These ASIL values were used because they were based on screening health values from the three primary sources of these values: the U.S. Environmental Protection Agency (EPA), the California Office of

Environmental Health Hazard Assessment (OEHHA), and the Agency for Toxic Substances and Disease Registry (ATSDR: U.S. Department of Health and Human Services). For the contaminants of concern in this study, the ASILs provided only chronic exposure screening values. As specified in the Preliminary Risk-Based Screening Approach (PRBSA), if a carcinogenic or chronic screening value is exceeded, the measured concentration was then compared to an acute screening health value. Since the Washington Ecology ASILs do not list both a chronic and an acute screening value, a list of acute screening values from EPA was used (EPA, 2006). Note: Since chronic screening values in general do not exceed acute screening values, comparison to acute screening values was made only for a compound that exceeded a chronic screening value.

In Appendix D, the tables show the maximum detected concentration for each HAP species in µg/m^3, and the chronic and (if applicable) acute screening values. (Non-HAP compounds [not shown] were also compared to any existing health screening benchmarks and none of their respective health benchmarks was exceeded). These tables also indicate by color the species that exceeded the chronic and/or acute screening value. The chronic carcinogenic screening values are based on a 1 in a million risk level. The chronic non-carcinogenic screening values are based on 1/10 of the listed benchmark concentration, following the PRBSA. This extra factor of 10 provides the most conservative initial screening approach.

5.2. Risk Analysis Results

For the following contaminants, the maximum measured values (or in some cases, one-half the MRL, see Appendices C and D for details) exceeded the chronic screening values for all five locations:

- acetaldehyde
- acrylonitrile
- arsenic
- benzene
- bromomethane
- cadmium
- carbon tetrachloride
- chromium
- chloroform
- chlorodibromomethane
- p-dichlorobenzene
- cis and trans 1,3-dichloropropene
- ethyl benzene
- formaldehyde
- hexachloro-1,3-butadiene
- manganese
- 1,1,2,2-tetrachloroethylene

One compound exceeded the chronic the screening value for four locations: methylene chloride

None of the maximum concentrations of any of these compounds exceeded acute screening values.

Based on the data quality analysis in Section 2, the confidence in measured levels of some of the above pollutants is low and therefore more detailed analysis is not warranted. Any pollutants that had an overall level of confidence designation of "low" (see Table 2-3) were not recommended for additional analysis. These compounds include chromium, 1,1,2,2-tetrachloroethylene, p-dichlorobenzene, acrylonitrile, carbon tetrachloride, bromomethane, chloroform, hexachloro-1,3-butadiene, and chlorodibromomethane. This does not mean that these species do not contribute to hazard or risk, just that the data collected is not of sufficient quality to adequately assess their contribution to human health risk. Other sources, such as EPA's National-Scale Air Toxics Assessment (NATA) (EPA, 2009a) could be used to help determine whether there may be any health concerns related to these species.

After removing the compounds measured with a low confidence level from further consideration as described above, the following species are the remaining contaminants of concern:

- acetaldehyde
- arsenic
- benzene
- cadmium
- (*cis*- and *trans*-)1,3-dichloropropene
- ethyl benzene
- formaldehyde
- manganese
- methylene chloride

All but one of these compounds are considered carcinogens. The International Agency for Research on Cancer (IARC) carcinogenic rating for each of these species is shown in Table 5-1 below. (IARC, 2009). The EPA Integrated Risk Information System (IRIS) database lists carcinogenic risk factors for all compounds considered carcinogens by the IARC except for ethyl benzene (EPA, 2009d). The carcinogenic risk factor used in this analysis comes from OEHHA. The only compound not considered a carcinogen by either IARC or EPA is manganese.

Table 5-1. International Agency for Research on Cancer (IARC) Carcinogenic Ratings.

Air Toxic Compound	**IARC[a]**
acetaldehyde	2B
arsenic	1
benzene	1

Air Toxic Compound	**IARC[a]**
cadmium	1
dichloropropene	2B
ethyl benzene	2B
formaldehyde	1
manganese[b]	--
methylene chloride	2B

a. IARC rating scheme:
Group 1: The agent is *carcinogenic to humans*.
Group 2A: The agent is *probably carcinogenic to humans*.
Group 2B: The agent is *possibly carcinogenic to humans*.
Group 3: The agent is *not classifiable as to its carcinogenicity to humans*.
Group 4: The agent is *probably not carcinogenic to humans*.

b. No rating is given for manganese because it is not considered a carcinogen by either IARC or EPA.

For the non-carcinogen manganese, a hazard quotient can be calculated. A hazard quotient is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected. If the hazard quotient is calculated to be 1 or less than 1, then no adverse health effects are expected as a result of exposure. If the hazard quotient is greater than 1, then adverse health effects are possible. Performing this calculation on the mean concentrations for manganese yields the following hazard quotients for each site shown in Table 5-2. Since the hazard quotient is less than one, our measurements indicate that manganese should not pose a health risk for the Treasure Valley.

Table 5-2. Hazard Quotients for Manganese

Site	**Manganese**
White Pine	0.17
Mountain View	0.19
St. Luke's	0.24
NNU (Nampa)	0.21
Parma	0.25

For carcinogens, a cancer risk can be calculated, usually expressed as "x risk in a million." A calculated risk less than 1 in a million is usually considered negligible and is not considered to pose a serious health risk. Risks greater than 1 in a million should be the subject of greater analysis.

Table 5-3 contains the carcinogenic "risk-drivers" at each monitoring site based on this preliminary screening analysis. Only those compounds with a possible carcinogenic risk greater than 1 in a million are included in the table. There are some contaminants that are ubiquitous risk drivers throughout the Treasure Valley. These are benzene, formaldehyde, acetaldehyde, ethyl benzene, and arsenic. One compound is observed less frequently: dichloropropene (NNU and Parma).

Table 5-3. Carcinogenic Risk Drivers Based on Preliminary Screening

White Pine	Mountain View	St. Luke's	NNU	Parma
benzene	benzene	formaldehyde	benzene	dichloropropene
formaldehyde	formaldehyde	benzene	formaldehyde	benzene
acetaldehyde	acetaldehyde	acetaldehyde	dichloropropene	formaldehyde
	ethyl benzene	arsenic	acetaldehyde	acetaldehyde
	arsenic		arsenic	arsenic

Future work will include an ATSDR Health Consultation by the Bureau of Community and Environmental Health of the Idaho Division of Health. An ATSDR Health Consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as intensifying environmental sampling; restricting site access; or removing the contaminated material. In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; monitoring biological indicators to assess exposure; and providing health education for health care providers and community members.

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6. Model-Monitor Comparisons

6.1. Purpose of Model-Monitor Comparisons

In an effort to provide greater spatial characterization of the air toxics in the Treasure Valley for use in the planned Health Consultation and presentation of results to the community, the 2007 HAPs measurements were compared with two different models that were readily available. The objective of this exercise was to evaluate whether the model-monitor agreement was of sufficient quality to support use of the modeled spatial surfaces or maps to approximate the air toxics concentrations at areas of the valley outside the immediate vicinity of the 5 monitoring sties.

6.2. Comparison with 2007 CMAQ Ozone Modeling

The first model-monitor comparison evaluated the relationship between air toxics measurements in this study and model results from the CMAQ photochemical/transport model (Community Multi-scale Air Quality model) using data from a 2007 summer ozone modeling period. The CMAQ model of the 2007 summer period was developed originally to evaluate ozone and was not specifically set up to model air toxics. However, this implementation of the CMAQ model has high spatial resolution in the valley (4-km grid cell size) and it incorporates meteorology, chemistry, emissions, topography, and land use data across the regional domain. The air toxics species modeled (formaldehyde, acetaldehyde, and model-lumped mechanism species ARO1 (the sum of benzene, ethyl benzene, and toluene) were extracted from the grid cells in which the air toxics monitoring sites were located. The summer 2007 episode model period was July 2 through August 8. The average concentration during the model period was compared to the average concentrations of the ambient data measured during the corresponding sampling dates from this study, which were July 5, 11, 17, 23, 29, and August 4.

6.3. Comparison with NATA 2002 Modeling Study

The second model comparison evaluated the relationship between air toxics measurements in this study and corresponding values from the 2002 National-Scale Air Toxics Assessment (NATA). The NATA model is an ongoing effort by the U.S. EPA to estimate air toxics at a national scale. The emissions sources used in the model are general and use annual data (EPA, 2009a). The modeled concentrations of HAPs species from the NATA study (1,3-dichloropropene, 2,2,4-trimethylpentane, acetaldehyde, acrilonitrile, arsenic, benzene, beryllium, cadmium, carbon tetrachloride, chlorobenzene, cobalt, ethyl benzene, formaldehyde, hexane, lead, manganese, methylene chloride, propionaldehyde, selenium, and toluene) were extracted from the database for each census tract in which an air toxics monitoring site for this study was located. In order to perform a similar comparison as with the CMAQ model, the benzene, ethyl benzene, and toluene species were combined to create an ARO1 “lumped” model species group.

6.4. Model-Monitor Comparisons

To evaluate whether the agreement between modeled and monitored concentrations is within a factor of two, an approach suggested by Hafner and O'Brien (2006) was used, in which model-monitor agreements within a factor-of-two are identified.

6.4.1. CMAQ Model-Monitor Agreement

Results of the model-to-monitor comparison for the CMAQ model are shown in Figure 6-1. The lighter-shaded box on the chart indicates the area of agreement within a factor of two (0.5 – 2.0).

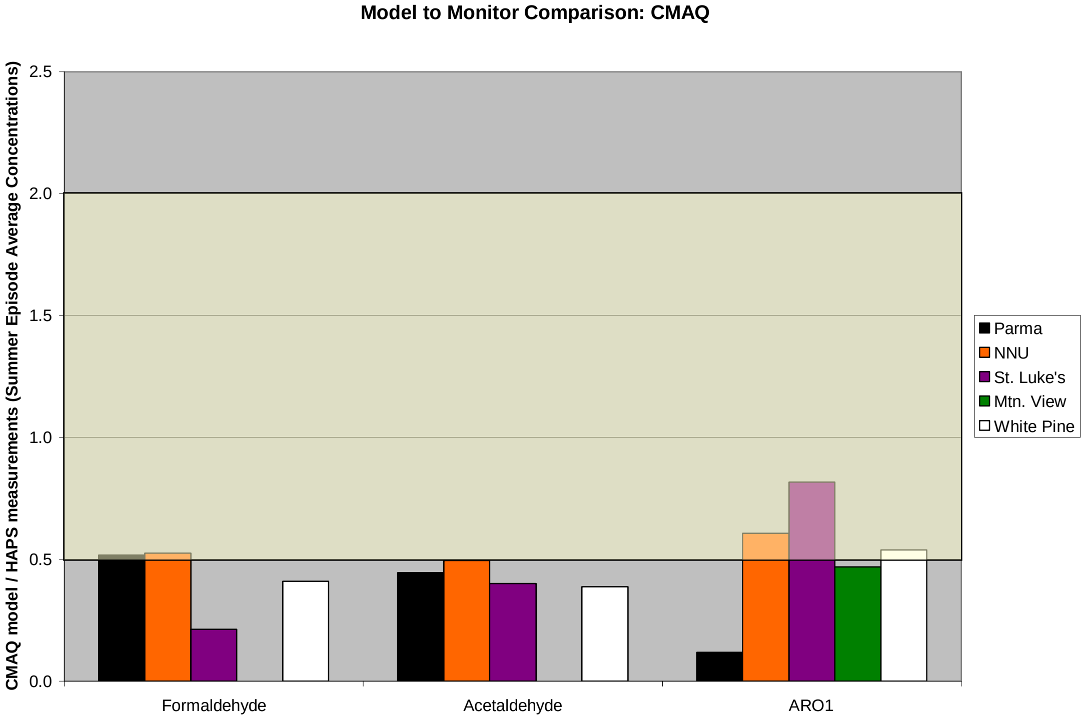

Figure 6-1. Comparison of CMAQ-modeled values for species formaldeyhyde, acetaldehyde, and ARO1 (benzene, toluene, ethyl benzene) to HAPs (this study) observed values. All species were biased approximately 50% low.

The CMAQ model agrees within a factor of two at no sites for acetaldehyde, two sites (Parma and NNU) for formaldehyde, and three sites (NNU, St. Luke's, and White Pine) for ARO1. The CMAQ model underestimates concentrations at all sites for all species.

6.4.2. NATA Model-Monitor Agreement

Results of the model-to-monitor comparison for the NATA model are shown in Figure 6-2. The lighter-shaded box on the chart indicates the area of agreement within a factor of two (0.5 – 2.0). The NATA species plotted are the contaminants of concern identified in Section 5 of this document, plus the lumped model species group ARO1 and toluene, which is a component of ARO1 (along with benzene and ethyl benzene).

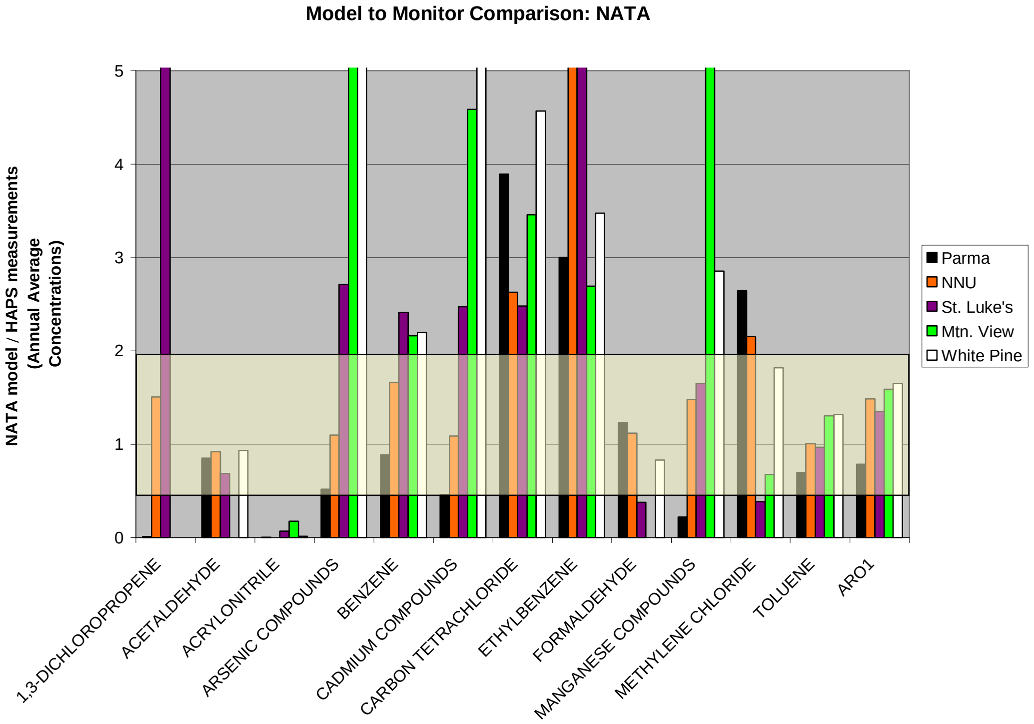

Figure 6-2. Comparison of NATA model results to HAPs observations for those species. Modeled values for acetaldehyde, benzene, formaldehyde, toluene and the lumped species group ARO1 are generally within the range of 50% to 200% of the observed values, while the metal/metalloid compounds arsenic, cadmium, and manganese are severely over-predicted by NATA in the urban areas.

In general, NATA appears to overpredict concentrations for many compounds. The NATA-modeled values do agree within a factor of two with the monitor values at all sites for acetaldehyde, ARO1, and toluene. For all sites except St. Luke's, where an excess source is suspected, they agree for formaldehyde. Arsenic, cadmium, and manganese NATA predictions are generally near or within 50 to 200% of the observations in the rural areas, but are severely overpredicted in the urban areas (> 5x). Species with poor model-to-monitor agreement, such as dichloropropene, acrylonitrile, carbon tetrachloride, and ethyl benzene, are species with high percentages of monitored concentrations below the detection limit resulting in annual means generally judged to represent long-term concentrations with low confidence (see Table 2-2 and Table 2-3).

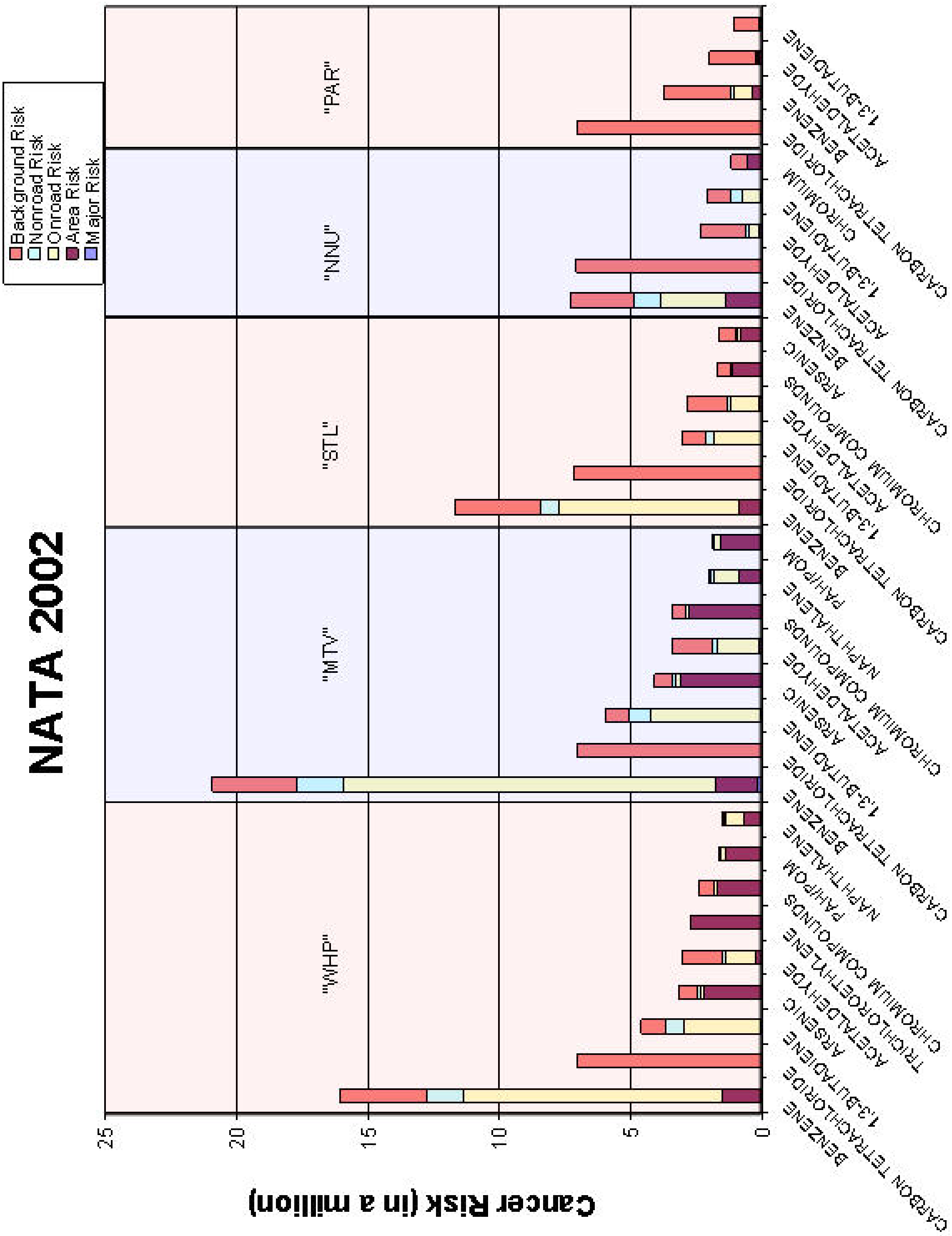

Figure 6-3. Cancer risk predicted by NATA 2002 in the five census tracts containing the monitoring locations used in this study. Only those compounds predicted to have greater than a 1 in a million cancer risk are shown. Each census tract is identified by its monitoring site (WHP – White Pine; MTV – Mountain View; STL – St. Luke's; NNU – Northwest Nazarene University; PAR – Parma).

The NATA model appears to provide a reasonable agreement with the annual mean concentrations for key species observed in this study that represent much of the chronic health risk – on-road mobile air toxics and aldehydes. In this context, additional information from the 2002 NATA model may be helpful in characterizing the relative source contributions to the modeled risk at the locations monitored in this study.

Figure 6-3 shows the cancer risk for the census tracts that contained the five air toxics monitoring locations from this study. In the Treasure Valley (as well as nationally), benzene is predicted to be the highest risk-driver by NATA. In fact, the 2002 NATA results predict benzene will be the risk-driver for 4 out 5 of the census tracts. This is consistent with our modeling data, which also indicates the importance of benzene to risk. The next most significant risk-driver predicted by NATA is carbon tetrachloride, which is a background pollutant and similar cancer risk from it is seen across the U.S. Since the measured concentration is near our detection limit, the data quality for carbon tetrachloride is low; therefore, its risk was not evaluated in this study. There are two additional pollutants identified in NATA that were also identified in this study as risk-drivers: acetaldehyde and arsenic. The rest of the toxic air pollutants identified in NATA as risk drivers are: 1,3-butadiene, trichloroethylene, chromium, polycyclic aromatic hydrocarbons/polycyclic organic matter (PAH/POM), and naphthalene. In this study, these compounds either were not sampled for or were present in concentrations below the detection limits.

Our preliminary risk based screening analysis of the species observed in this study did identify three compounds that are not shown in Figure 6-3: formaldehyde, 1,3-dichloropropene, and ethyl benzene. See Table 5-3. Formaldehyde was identified as a contributor to cancer risk in our screening analysis. The reason that it does not appear in NATA as a cancer risk-driver is that EPA has adopted a different risk factor for use in NATA that is **not** the value used in the EPA IRIS database. EPA is currently updating the IRIS file for formaldehyde and future NATA assessments will hopefully reflect the most recent toxicological information. The second compound identified in our study but not the 2002 NATA is the soil fumigant 1,3-dichloropropene. It appears that the emission inventory used in NATA does not accurately reflect the use of pesticides in agricultural areas, presumably due to the complexity of crop and agricultural patterns nationwide that could not be captured at the level of detail present in NATA. The last compound that this study identified as a potential risk contributor, that was not identified by the 2002 NATA, is ethyl benzene. Ethyl benzene does not have an EPA inhalation unit risk and therefore is not considered to be a carcinogen. The carcinogenic risk factor used in this study comes from California's OEHHA.

In addition to cancer risk, the NATA model also calculates hazard quotients for non-carcinogens for inhalation and neurological health impacts. As discussed in section 5, hazard quotients greater than 1 indicate possible health impacts. None of the hazard quotients for neurological health effects are greater than 1 in the census tracts considered. The only compound with a hazard quotient greater than 1 for inhalation health effects in the census tracts considered was acrolein. Acrolein concentrations were not measured in this study.

Another useful component of the NATA model is that it tracks the modeled source contributions to a pollutant's concentration and therefore risk. The source category bins that NATA uses are 1) background (the contributions to outdoor air toxics concentrations resulting from natural sources, persistence in the environment of emissions from years past, and long-range transport from distant sources), 2) non-road (mobile sources not found on roads and highways, such as airplanes, trains, lawn mowers, construction vehicles, and farm machinery), 3) on-road (vehicles found on roads and highways, such as cars, trucks, and buses), 4) area (sources that generally have smaller emissions on an individual basis than "major sources" and are often too small or ubiquitous in nature to be inventoried as individual sources), and 5) major sources (large sources defined by the Clean Air Act as those stationary facilities that emit or have the potential to emit 10 tons of any one toxic air pollutant or 25 tons of more than one toxic air pollutant per year) (EPA, 2009a). Figure 6-3 shows that NATA predicts essentially no "major source" contribution to cancer risk in the Treasure Valley. The largest source categories contributing to risk are mobile sources, background, and area sources.

Another compound for which the cancer risk was not addressed in this study or in NATA is from diesel exhaust PM emissions. For NATA, data are not sufficient to develop a quantitative estimate of the carcinogenic potency for this pollutant (EPA, 2009a). However, EPA has concluded that diesel exhaust is among the substances that may pose the greatest health risk. OEHHA has developed a risk factor, and if the carcinogenic risk factor developed by OEHHA is used with predicted NATA diesel PM concentrations, diesel PM would be predicted to have cancer risk five times greater than that of benzene.

Finally, as suggested by the persistence of wildfire smoke during the summer of 2007, and its correlation with organic and elemental carbon at the St. Lukes STN site, some additional risk is likely contributed by the wildfire-caused smoke and combustion-related species that were neither measured during this study nor included in the NATA model.

6.4.3. Monitor-Model Agreement Conclusions

The CMAQ model of the summer ozone season compares poorly to the measured concentrations of formaldehyde and acetaldehyde species; however, CMAQ correlates reasonably well from rural to urban sites for ARO1 species benzene, toluene, and ethyl benzene, tending to underestimate average summer concentrations at all sites.

The NATA model correlates negatively with the measured ambient concentrations for formaldehyde and poorly for acetaldehyde, although all site annual averages were similar and were within a factor-of-two. NATA correlates rather well for ARO1 species benzene, toluene, and ethyl benzene and all sites are predicted within a factor-of-two for ARO1 with slight over-predictions at all sites except Parma, where NATA under-predicts slightly.

The NATA model appears to be in better agreement with the monitor data and may therefore be a better choice for use in creating estimated concentration surfaces or maps of the spatial distribution of key air toxics. NATA tends to overestimate (overestimation is one goal of the NATA (EPA, 2009a), while CMAQ tends to underestimate.

6.4.4. Future Work Using the Model Comparison Results

Future work is recommended in fitting modeled spatial surfaces to the data from the five Treasure Valley HAPs study monitoring locations to obtain the best estimate of a spatial distribution that can be utilized to inform a planned health risk evaluation and to explain spatial variation of air toxics concentrations to the public.

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7. Summary of Findings for Key Species

Summaries of findings from this study for 12 key species are on the following pages. The summaries include a data summary and review of data quality for each species, highlights from comparisons of air toxic levels observed in the Treasure Valley with levels reported for other locations in the region and with national averages. Finally, the conclusion from our preliminary risk-based screening analysis for each air toxic are included. The regional sites represent different types of settings that range from urban to rural, as described in section1.1 and briefly summarized here:

Spokane, Washington – multi-site 2005 study with urban and suburban locations.

Lewiston, Idaho (urban) and rural Nez Perce tribal lands in central Idaho – multi-site 2006-2007 study

Beacon Hill (Seattle), Washington – urban NATTS monitoring site, 2003 - 2005

Bountiful, Utah – suburban NATTS monitoring site, 2004-2006

La Grande, Oregon – rural NATTS monitoring site, 2004 - 2006

7.1. Benzene

Benzene is a trace constituent of gasoline and other fuels. In the Treasure Valley airshed mobile source emissions and fuel distribution are the primary sources of benzene.

Benzene was detected in 91% of all successful samples and sampling was 82% complete, with a 16% average relative percent difference (RPD) between co-located samples; thus, there is an overall high level of confidence that the benzene annual mean concentrations reported in this study are suitable for characterizing long-term exposure. A summary of statistics for benzene concentrations measured in this study is provided in Table 7-1.

Benzene concentrations are highest in the summer and fall, presumably due to increased fuel evaporation and strong surface inversions at night. The annual and seasonal long-term averages are highest at the Mountain View site and decrease outside the urban core. The background benzene levels at Parma contribute approximately 50% of the benzene at Mountain View, while valley wide sources, mostly mobile, contribute the other half. Other aromatic air toxic species, toluene, xylenes, and ethyl benzene are all distributed spatially and temporal in patterns very similar to benzene.

The mean annual benzene concentration for all sites in the Treasure Valley is very close to the median value in the 2003-2005 national database (EPA, 2009b), while the annual mean concentration at Mountain View, the highest observed in this study, lies between the 75th and 95th percentile nationally. Regionally, the mean annual benzene concentration at Mountain View is close to the highest values in the region (1.5-2.0 μg/m^3), which occur in Bountiful, Utah, just north of Salt Lake City, and Lewiston, Idaho while the mean annual benzene concentration from St. Luke's to Parma is generally about 0.8 to 1.0 μg/m^3, similar to the values observed in Spokane and rural La Grande, Oregon.

Statistical receptor modeling, including principal component analysis (PCA) and positive matrix factorization (PMF) analyses, both confirm that mobile sources are the predominant source of benzene in the Treasure Valley.

Maximum benzene concentrations are above the chronic health screening benchmark (0.0345 μg/m^3) at all sites, indicating that additional risk analysis is appropriate. Among the compounds analyzed in this study, benzene is among the highest contributors to cancer risk at all sites.

Table 7-1. Summary of Benzene Concentration Statistics (μg/m^3)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	1.26	1.33	3.1	0.53	0.31	54	54
Mt. View	1.58	1.43	3.77	0.85	0.31	52	50
St. Luke's	0.78	0.67	1.92	0.43	0.31	46	40
NNU	0.96	0.81	2.78	0.63	0.31	49	45
Parma	0.8	0.78	4.03	0.54	0.31	50	46

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.2. Formaldehyde

Formaldehyde is the smallest aldehyde molecule, formed primarily during free-radical oxidation of VOCs in combustion and photochemical processes. It is also released during urea-formaldehyde foam curing and from formalin, a water solution of formaldehyde used for tissue preservation. A summary of formaldehyde statistics is in Table 7-2.

Formaldehyde sampling resulted in a sample completness rate of 70%; however, it was detected in over 99% of the samples and the precision was very high (2.3%). Thus, the overall confidence in obtaining a representative annual average for this species is high.

Formaldehyde concentrations are typically highest in the summer and lowest in the winter, reflecting the effect of photochemical production, sometimes enhanced by plumes from regional wildfires. Formaldehyde is also one of the mobile source air toxics, which tend to peak at the Mountain View site like the other mobile emissions, or at St. Luke's, possibly due to another, unknown, source category influencing that site only. Potential sources of excess formaldehyde at St. Luke's include urea-formaldehyde foam use in nearby construction or formalin uses in pathology tissue preservation at the nearby hospital.

The valley-wide annual mean formaldehyde concentration is very close to the median annual concentration nationwide; however, the highest annual mean, observed at the St.Luke's site, lies between the 75th and 95th percentile concentrations in the 2003-2005 national distribution (EPA, 2009b). The St. Luke's annual mean concentration is comparable to those at the Bountiful, Utah sites and the rural, but potentially wildfire-impacted, sites in Lewiston, Idaho. The lowest annual mean formaldehyde concentration in this study, at the Parma site, would be within the lowest quartile nationally (5th-25th percentile) and lower than at any other sites in the region except the Spokane Health District site.

Valley-wide urban sources, mostly mobile-related, tend to increase formaldehyde as much as 64% in the urban area as compared to the background site at Parma. On the seven summer days of study sampling when the Treasure Valley was smoky, however, formaldehyde was enhanced another 39 to 46% relative to non-smoky days. This may have resulted from direct formaldehyde emissions and/or from local photochemical action on oxidation precursors that originated in regional wildfires.

Maximum formaldehyde concentrations are above the chronic health screening benchmark (0.167 $\mu g/m^3$) at all sites, indicating that additional risk analysis is appropriate. Among the species analyzed in this study, formaldehyde is one of the highest contributors to cancer risk at all sites.

Table 7-2. Summary of Formaldehyde Concentration Statistics ($\mu g/m^3$)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	2.36	2.08	8.06	1.53	0.02	54	53
Mt. View	2.27	2.03	6.52	1.10	0.02	35	35
St. Luke's	4.61	2.71	15.06	4.05	0.02	38	38
NNU	1.94	1.76	4.77	1.04	0.02	48	48
Parma	1.64	1.43	5.58	1.07	0.02	49	48

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.3. Acetaldehyde

Acetaldehyde is the next largest aldehyde molecule after formaldehyde, formed primarily during free-radical oxidation of hydrocarbons as a result of combustion and photochemical processes. A summary of acetaldehyde concentration statistics is provided in Table 7-3.

Acetaldehyde sampling was 70% complete; however, it was detected in 99.6 % of the samples and the precision was very high (0.9 % average RPD). Thus, the overall confidence in obtaining a representative annual average for this species is high.

Acetaldehyde concentrations are typically highest in the summer and lowest in the winter, reflecting the effect of photochemical production, just one of the factors related to aldehyde production in urban areas. Acetaldehyde is also one of the mobile source toxic emission species with concentrations that peak in the urban core and become lower in the rural western Treasure Valley.

The valley-wide annual mean acetaldehyde concentration is slightly greater than the 2003-2005 median concentration nationwide; however, concentrations at all Treasure Valley sites are lower than the 75th percentile annual mean nationally (EPA, 2009b). The lowest mean acetaldehyde concentrations, at NNU and Parma, are lower than any other sites in the region except La Grande. The highest mean concentration, at St. Luke's, is statistically lower than the mean annual concentrations observed at the Bountiful, Utah site, and the urban Lewiston sites and are generally similar to the levels observed at the Spokane sites.

Acetaldehyde is associated with mobile sources and photochemical production; however, like formaldehyde, the summertime photochemical production appears to be enhanced by regional wildfires by 54 to 56% at Parma and St. Luke's, respectively. In the absence of wildfires, local urban sources, largely mobile-related, appear to increase the summertime acetaldehyde levels in the urban area by 37% in comparison to the valley background levels at Parma.

Maximum acetaldehyde concentrations are above the chronic health screening benchmark (0.37 $\mu g/m^3$) at all sites, indicating that additional risk analysis is appropriate. Among the compounds analyzed in this study, acetaldehyde is among the highest contributors to cancer risk at all sites.

Table 7-3. Summary of Acetaldehyde Concentration Statistics ($\mu g/m^3$)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	1.81	1.51	6.12	1.26	0.03	54	54
Mt. View	1.74	1.58	6.01	1.12	0.03	35	35
St. Luke's	2.18	1.85	5.59	1.31	0.03	36	36
NNU	1.45	1.29	3.42	0.85	0.03	49	49
Parma	1.38	1.09	3.66	0.94	0.03	50	49

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.4. Arsenic

Arsenic is an inorganic metalloid element used in wood preservation and insecticides, and is released into the air as a trace contaminant in fossil fuels, mobile emissions, volcanic releases, geologic sources and mineral products. A summary of statistics for arsenic concentrations measured in this study is provided in Table 7-4.

Arsenic data quality was very high in this study, with a good completness rate (77%), high detectability (7% non-detects at a 0.0001 μg/m^3 MRL), and high precision (9.9% average RPD).

Arsenic concentrations have a strong east-to-west gradient, peaking at Parma in the spring and fall, however, mobile source arsenic appears to dominate in the summer and winter when arsenic concentrations peak at Mountain View and NNU.

The arsenic annual mean for all sites in the Treasure Valley is 0.00035 μg/m^3, with the highest annual mean located at Parma (0.00053 μg/m^3) and the lowest at White Pine (0.00027 μg/m^3). These levels straddle the 5th percentile annual arsenic concentration in the 2003-2005 national database (0.00041 μg/m^3), and are well below the national median concentration (0.0019 μg/m^3); however, it should be noted that the vast majority of air toxics monitoring sites nationwide (EPA, 2009b) are in urban and industrial locations.

The highest mean arsenic concentration in the Treasure Valley, at Parma (0.00053 μg/m^3), is equal to the lowest mean concentration observed in Spokane (at the Health District site). All the Treasure Valley annual arsenic concentrations are lower than those at the Bountiful, Utah, and Beacon Hill (Seattle, Washington) NATTS sites, and are comparable to those at the La Grande, Oregon, and Lewiston/Nez Perce Tribal sites.

The PCA and PMF receptor modeling analyses both suggest arsenic in the Treasure Valley is closely associated with mobile emissions, biomass burning, and geologic/wind erosion, and is weakly identified with a “mixed sources” stagnation-related group that was identified in the PMF analysis. Coal combustion, cement kilns, or fertilizer application and tilling of fertilizer-enriched soils, may contribute also, resulting in the east-to-west gradient seen between White Pine and Parma.

Maximum arsenic concentrations are above the chronic health screening benchmark at all sites (0.000303 μg/m^3), indicating that additional risk analysis is appropriate.

Table 7-4. Summary of Arsenic Concentration Statistics (μg/m^3)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.00027	0.00024	0.00107	0.00016	0.00010	51	49
Mt. View	0.00034	0.00029	0.00125	0.00023	0.00010	45	42
St. Luke's	0.00031	0.00026	0.00104	0.00019	0.00010	50	48
NNU	0.00040	0.00029	0.00289	0.00051	0.00010	46	42
Parma	0.00053	0.00046	0.00145	0.00035	0.00010	42	41

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.5. Lead

Lead is a heavy metal contaminant still associated with some motor vehicle fuels, even though "leaded gasoline" has been largely phased out. Lead air emissions may also result from combustion of solid waste, oil, and coal, and from metal/mineral refining.

A summary of statistics for observed lead concentrations is provided in Table 7-5.

In this study, PM_{10} quartz filter samples were analyzed for lead. The data quality for lead is good based on a high degree of completeness (79%), good detectability (only 25% non-detects at 0.001 $\mu g/m^3$ MRL), and a moderate level of precision (18% average RPD) based on 20% co-located samples.

Spatial-temporal trends suggest no significant seasonal variation, however mean seasonal concentrations are highest at Mountain View in the summer and winter, and Parma in the spring and fall.

The combined annual mean concentration of PM_{10} lead in the Treasure Valley for all sites is 0.0018 $\mu g/m^3$ and the highest single site mean annual mean lead concentration is at Mountain View (0.00222 $\mu g/m^3$), followed closely by Parma (0.00216 $\mu g/m^3$). Lead concentrations at all Treasure Valley sites are lower than the 5th percentile annual concentration in the 2003-2005 national database (EPA, 2009b). The lowest annual average in the Treasure Valley (0.0014$\mu g/m^3$ at NNU) is close to the mean annual concentration observed in La Grande.

Receptor modeling analyses, using PCA and PMF methods, suggest an association between PM_{10} lead concentrations and mobile sources, although there are also weak correlations between lead and geologic sources/wind erosion, biomass burning, and a "mixed sources" group identified in the PMF analysis that appears to associate with stagnation events.

Maximum lead concentrations did not exceed a chronic health screening benchmark for any sites (0.0833 $\mu g/m^3$), so additional risk analysis is not necessary.

Table 7-5. Summary of Lead Concentration Statistics ($\mu g/m^3$)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.00172	0.00140	0.01520	0.00208	0.00100	52	38
Mt. View	0.00222	0.00175	0.01920	0.00279	0.00100	46	36
St. Luke's	0.00189	0.00170	0.00800	0.00130	0.00100	50	41
NNU	0.00142	0.00130	0.00360	0.00088	0.00100	50	32
Parma	0.00216	0.00160	0.01290	0.00221	0.00100	45	34

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.6. Cadmium

Cadmium is a toxic heavy metal compound usually found as a trace contaminant in fossil fuels such as oil and coal, municipal sewage, and phosphate fertilizers. Smoking is also a source of cadmium exposure. A summary of statistics for cadmium concentrations measured in this study is provided in Table 7-6.

Cadmium was measured in PM_{10} samples for this study, however the cadmium data quality (confidence in characterizing long-term concentrations) was judged to be only moderate. Although the degree of data completeness was high for cadmium (84%), the detectability was poor (24% detected), and the precision was also moderate (18.1% average RPD). Due to the poor detectability, the concentration averages may be somewhat biased (by the replacement of each non-detect with one-half of the MRL.)

Cadmium seasonal and spatial variation in the Treasure Valley is very similar to that of arsenic, with strong gradients increasing toward Parma in the spring and fall, but peak levels at Mountain View in the summer and winter.

The highest annual mean cadmium level in the Treasure Valley, observed at both Parma and Mountain View, is equivalent to the 5th percentile annual mean in the 2003-2005 national database (EPA, 2009b), thus Treasure Valley cadmium levels are unusually low.

Regionally, the annual mean cadmium level at Parma is lower than the concentrations measured at the Bountiful, Utah NATTS site and all of the Spokane sites except the Health District site, where the annual mean concentration is equal to the Parma annual mean concentration.

The PCA receptor modeling analysis associates cadmium most strongly with the $PM_{2.5}$ secondary aerosol components sulfate, nitrate, and ammonium. The PMF analysis associates cadmium with biomass burning, mobile sources, geologic sources, and the group identified in the PMF analysis as “mixed sources/stagnation conditions.” This last category may be the same as the secondary aerosol group identified in the PCA analysis, as selenium is also associated with both groups. Finally, the east-west cadmium gradient in the spring, peaking at Parma, may also be associated with fertilizer application and/or tilling of fertilizer-enriched soils.

Maximum cadmium concentrations are above the chronic health screening benchmark at all sites (0.000238 $\mu g/m^3$), indicating that additional risk analysis is appropriate.

Table 7-6. Summary of Cadmium Concentration Statistics ($\mu g/m^3$)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.00008	0.00005	0.00097	0.00013	0.00010	54	8
Mt. View	0.00012	0.00005	0.00200	0.00029	0.00010	49	11
St. Luke's	0.00009	0.00005	0.00043	0.00008	0.00010	51	14
NNU	0.00009	0.00005	0.00045	0.00008	0.00010	51	14
Parma	0.00012	0.00005	0.00056	0.00011	0.00010	54	23

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.7. cis- and trans-1,3 Dichloropropene (1,3-DCP)

The isomers *cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene occur together (1,3-DCP) in the soil fumigant Telone-II, commonly used on potato, sugar beet, and onion fields in the Treasure Valley to control nematodes. A summary of statistics for 1,3-DCP concentrations measured in this study is provided in Table 7-7.

The data set for 1,3-DCP is 85.5% complete; however, probably due to the short agricultural application season, it only occurred above the detection limit in 5.4% and 3.8% of the samples, for the *cis*- and *trans*- isomers respectively. Since 1,3-DCP was only detected once at St. Luke's where the co-located sampler was operated, there are no precision estimates available.

The annual mean concentrations of 1,3-DCP at Parma are the highest in the nation, based on the archived national database over the years 2002-2006 (EPA, 2009c), and the Nampa values for this study and for the 2003-2004 NNU study are in the top ten nationally. The national database highest annual concentrations are 1.36 $\mu g/m^3$ *trans*-1,3-DCP and 1.16 $\mu g/m^3$ *cis*-1,3-DCP, while the values at Parma were 2.33 $\mu g/m^3$ and 3.98 $\mu g/m^3$, *trans*- and *cis*-1,3-DCP, respectively. Similar levels were observed in California (Lee et. al.,2002).

For the purposes of any sub-chronic analysis it should be remembered that 1,3-DCP applications primarily occur for only 4-6 weeks in the Fall. The highest 4-week average concentrations at NNU range from 1 to 5 $\mu g/m^3$ (2003, 2004, 2007) while the highest 4-week average total 1,3-DCP concentration at Parma was 71 $\mu g/m^3$. Since potato, sugar beet, and onion fields do not occur within 1-2 km of the Parma site or within 5-6 km of the Nampa site, these are clearly not near-field levels, but rather, they likely represent the range of concentrations experienced by most of the rural residents of the Treasure Valley who live within 1-6 km from fields were this chemical is applied. Persons living closer than 1-2 km from a field where 1,3-DCP is applied may experience higher levels for a few days following application.

1,3-DCP was only detected seasonally at three locations, mostly at Nampa and Parma. However, the annual means, based on these sparse detections are nevertheless above the chronic health screening benchmark (0.0625 $\mu g/m^3$), and at concentrations high enough to warrant additional risk analysis.

Table 7-7. Summary of 1,3-Dichloropropene Concentration Statistics ($\mu g/m^3$)

Isomer	Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
cis-1,3-DCP	St. Luke's	0.22	0.22	0.5	0.04	0.43	47	1
cis-1,3-DCP	NNU	0.28	0.22	1.51	0.25	0.43	51	4
cis-1,3-DCP	Parma	3.98	0.22	127.4	17.81	0.43	54	11
trans-1,3-DCP	NNU	0.25	0.22	1.6	0.2	0.43	51	2
trans-1,3-DCP	Parma	2.33	0.22	57.11	8.42	0.43	54	10

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.8. Manganese

Manganese is a naturally occurring metal that commonly occurs in soils, coal and coal combustion, and mineral products. A summary of statistics for Manganese concentrations measured in this study is provided in Table 7-8.

Manganese sampling during this study was 75.7% complete, and 93.5% of the samples had concentrations above the detection limit of 0.001 μg/m^3. Co-located sampling at St. Luke's indicates that the overall level of precision in the sampling and analysis process was good (10.5% average RPD), and our overall level of confidence in long-term manganese mean concentrations is high.

Manganese mean concentrations are generally highest in the spring and summer and tend to be lowest at White Pine on the eastern side of the valley and highest at Parma on the western, rural side.

Manganese concentrations at all Treasure Valley sites are within the 3rd quartile (50-75th percentile) of the 2003-2005 national distribution (EPA, 2009b).

Maximum manganese concentrations are above the chronic health screening benchmark at all sites (0.004 μg/m^3), indicating that additional risk analysis is appropriate.

Table 7-8. Summary of Manganese Concentration Statistics (μg/m^3)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.00673	0.00510	0.01980	0.00506	0.00100	50	47
Mt. View	0.00748	0.00650	0.02690	0.00586	0.00100	45	43
St. Luke's	0.00958	0.00880	0.03830	0.00745	0.00100	47	45
NNU	0.00843	0.00615	0.02950	0.00693	0.00100	46	44
Parma	0.01000	0.00535	0.03310	0.00940	0.00100	42	39

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.9. *Methyl Chloride*

Methyl chloride (or chloromethane), formerly a widely-used refrigerant, was once also used in production of lead-based gasoline additives. Methyl chloride is also used to extract greases, oils and resins; as a propellant and blowing agent in polystyrene foam production; and as a local anesthetic. A summary of statistics for methyl chloride concentrations measured in this study is provided in Table 7-9.

Methyl chloride sampling during this study was 79.8% complete, and more than 96% of the valid samples had concentrations above the MRL (0.20 µg/m^3.) The precision was also good (9.3% average RPD), so the overall level of confidence in the long-term mean methyl chloride concentrations reported here is at the highest level.

Methyl chloride does not show a strong seasonal variation nor a consistent site-to-site variation except for peak seasonal values at the St. Luke's site in spring and fall.

The remote background concentration reported by McCarthy, et. al. (2006) is 1.2 µg/m^3. The annual mean concentration at St. Lukes is very close to this value; however, at all the other sites, the concentrations are about 20 to 30% lower. This probably reflects the relatively non-urban nature of the Treasure Valley, and the fact that McCarthy's "remote background" values probably become "out of date" within a few years, especially for materials that are largely banned or phased out of use such as methyl chloride. The Treasure Valley methyl chloride concentrations are mostly near the 25th percentile of the 2003-2005 national database range (EPA, 2009b), and the St. Luke's site annual mean concentration is near the median value nationally.

The regional data is sparse for methyl chloride; however, the Treasure Valley annual means appear to reflect the La Grande, Oregon range of values (0.84 to 1.08 µg/m^3), reinforcing the conclusion that the remote background value of McCarthy (1.2 µg/m^3)is not a good measure of "remote" in the western United States. The methyl chloride annual means at Bountiful, Utah (1.22 – 1.36 µg/m^3) are typically higher than those at St. Lukes which are the highest Treasure Valley.

Maximum methyl chloride concentrations at all sites are below the chronic health screening benchmark (9 µg/m^3).

Table 7-9. Summary of Methyl Chloride Concentration Statistics (µg/m^3)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.92	0.88	1.9	0.36	0.2	54	53
Mt. View	1.01	1.02	2.98	0.37	0.2	53	52
St. Luke's	1.21	1.27	1.82	0.34	0.2	41	40
NNU	0.88	0.87	1.22	0.15	0.2	50	50
Parma	0.91	0.82	2.47	0.45	0.2	49	47

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.10.Methylene Chloride

Methylene chloride, (or dichloromethane) is a common solvent, paint stripper, and degreaser. It has also found use as a blowing agent for polyurethane foams, as an aerosol propellant, and as a plastic welding adhesive. A summary of statistics for methylene chloride concentrations measured in this study is provided in Table 7-10.

Methylene chloride data capture was good during this study (81.1%); however, it was only detected 44% of the time at an MRL of 0.33 $\mu g/m^3$. The precision based on co-located samples at St. Luke's was 23% average RPD. As a result, the overall confidence in using the annual means reported here for chronic risk analysis is only moderate.

Methylene chloride annual mean concentrations are highest at St. Luke's, perhaps reflecting potential solvent use at the hospital and/or other uses such as paint stripper or plastic welding in the light industrial and construction areas near the St. Luke's site.

The remote background methylene chloride concentration reported by McCarthy et. al (2006) is 0.09 $\mu g/m^3$, much lower than the values reported here.

Nationally (2003-2005 database summary [EPA, 2009b]), the 25th percentile mean concentration is 0.24 $\mu g/m^3$, the median annual average concentration is 0.40, and the 75th percentile concentration is 0.87, so all the values observed in the Treasure Valley are generally within the interquartile range (25th-75th percentile) of the national data, with Parma just marginally below the 25th percentile.

Regional statistics are sporadic; however, the Parma annual mean is just below the La Grande, Oregon annual mean concentration of 0.25 $\mu g/m^3$ reflecting a consistent rural background level in this region.

Maximum methylene chloride concentrations exceeded the chronic health screening value (1 $\mu g/m^3$) for every site except for Parma, indicating that additional risk analysis is appropriate.

Table 7-10. Summary of Methylene Chloride Concentration Statistics ($\mu g/m^3$)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.29	0.17	1.18	0.22	0.33	55	17
Mt. View	0.55	0.43	2.98	0.51	0.33	51	30
St. Luke's	0.64	0.56	2	0.46	0.33	45	33
NNU	0.27	0.17	1.52	0.25	0.33	48	12
Parma	0.22	0.17	0.82	0.14	0.33	51	9

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.11. Ethyl Benzene

Ethyl benzene is an aromatic compound commonly associated with petroleum fuels, specifically the BTEX group (benzene, toluene, ethyl benzene, and xylenes). As such, it is primarily a mobile source air toxic compound. A summary of statistics for ethyl benzene concentrations measured in this study is provided in Table 7-11.

The ethyl benzene sampling completeness rate was good (81.7%); however, it was only detected in 22.7% of the samples at an MRL of 0.42 μg/m^3. Nevertheless, the precision was very good (4.2% average RPD at the St. Luke's co-located sample site). As a result of the relatively low detection rate, the overall level of confidence in use of the annual mean concentrations for evaluating chronic risk was judged to be moderate.

Ethyl benzene mean annual concentrations are highest at the Mountain View site and lowest at the Parma site, similar to other compounds that are largely mobile source air toxics.

In comparison to the 2003-2005 national database summary statistics (EPA, 2009b), the ethyl benzene annual means at Parma are just below the 25th percentile, while the highest values, at Mountain View, are between the median (0.42 μg/m^3) and the 75th percentile (0.63 μg/m^3).

Regional data is sporadic for ethyl benzene; however, the highest values are similar to the annual means at Bountiful, Utah, which range from 0.44 to 0.54 μg/m^3 between 2004 and 2006.

Maximum benzene concentrations are above the chronic health screening factor (0.4 μg/m^3) at all sites, indicating that additional risk analysis is appropriate.

Table 7-11. Summary of Ethyl Benzene Concentration Statistics (μg/m^3)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.37	0.21	1.31	0.26	0.42	54	18
Mt. View	0.5	0.21	1.54	0.39	0.42	53	22
St. Luke's	0.26	0.21	0.74	0.14	0.42	43	7
NNU	0.31	0.21	1	0.21	0.42	49	10
Parma	0.23	0.21	0.8	0.1	0.42	54	4

a. MRL – minimum reporting limit
b. count – number of samples
c. detects – number of samples with detections reported

7.12.Carbon Tetrachloride

Carbon tetrachloride was identified as an ozone-depleting substance in the stratosphere and has therefore been largely phased out of production and use globally. It is also very persistent, with a long photochemical life and as a result, carbon tetrachloride is globally present with very little variation. McCarthy et. al. (2006) report the North American remote concentration to be 0.623 +/- 0.0075 $\mu g/m^3$; however, minimum reporting levels (MRLs) in this study were just at this level, so detectability is a problem, and the means and medians computed for carbon tetrachloride samples are really more a reflection of the number of non-detects rather than the real concentrations. Therefore, the mean annual carbon tetrachloride concentration, for the purpose of estimating total air toxics risk, should be considered to be the remote North American average, 0.623 $\mu g/m^3$ at all sites.

A summary of statistics for carbon tetrachloride concentrations measured in this study is provided in Table 7-12, however, as discussed above, these data should not be used.

The carbon tetrachloride values detected here (and the global average) exceed the chronic health screening benchmark (0.0238 $\mu g/m^3$).

Table 7-12. Summary of Carbon Tetrachloride Concentration Statistics ($\mu g/m^3$)

Site	Mean	Median	Max	Standard Deviation	MRL[a]	Count[b]	Detects[c]
White Pine	0.39[d]	0.3[d]	0.9	0.2	0.6	57	9
Mt. View	0.4[d]	0.3[d]	0.88	0.21	0.6	53	12
St. Luke's	0.45[d]	0.3[d]	0.88	0.22	0.6	46	15
NNU	0.44[d]	0.3[d]	0.9	0.23	0.6	51	15
Parma	0.4	0.3[d]	0.99	0.2	0.6	54	11

a. MRL – minimum reporting limit

b. count – number of samples

c. detects – number of samples with detections reported

d. Carbon Tetrachloride mean and median values are not representative due to the large number of non-detects. The global average of approximately 0.6 2µg/m3 should be used for all sites.

7.13. Acrylonitrile

Acrylonitrile is a monomer used in the production of acrylic fibers, styrene-acrylonitrile resins, nitrile rubbers, and latex materials. It has also been associated with cigarette smoking and, in prior years, as a pesticide often applied with carbon tetrachloride, although this use has been phased out. Acrylamide polymer used in wastewater treatment has also been found to contain residual levels of acrylonitrile monomer ranging from 1 to 100 mg/kg (IARC 1986).

Acrylonitrile data quality is low, due to the small number of detections (6.1%) and its unusual pattern, occurring primarily at Parma (12 detections), and to a lesser extent at White Pine (5 detections). There was only one detection at the St. Lukes co-location site, so precision data are not available. In view of these problems and the unusual seasonal pattern of occurrence, there was not sufficient confidence in annual mean concentrations to justify discussing acrylonitrile in the preliminary risk-based screening analysis.

A summary of statistics for acrylonitrile concentrations measured in this study is provided in Table 7-13. Acrylonitrile occurred primarily at the Parma site in the spring and summer, and to a lesser extent at the White Pine site during the same seasons. Wastewater treatment plants within proximity to these two sites are a potential source of the acrylonitrile but automotive and light industrial painting activities have also been identified near both sites, so the identification of sources is inconclusive.

The overall Treasure Valley annual mean acrylonitrile concentration is very close to the median of the distribution of annual mean concentrations nationwide, and the highest annual average in the valley, 0.31 μg/m^3, is very close to the 75th percentile of annual means in the national database (EPA, 2009b).

Acrylonitrile is not discussed in the preliminary risk based screening analysis due to the data quality issues discussed above, and the resulting low level of confidence in annual averages obtained in this study. Nevertheless, the annual mean concentration at the Parma site, if assumed to be valid, would exceed the chronic screening benchmark (0.00345 μg/m^3).

Table 7-13. Summary of Acrylonitrile Concentration Statistics (μg/m^3)

Site	**Mean**	**Median**	**Max**	**Standard Deviation**	**MRL**	**Count**	**Detects**
White Pine	0.14	0.1	0.71	0.12	0.21	57	5
Mt. View	0.11	0.1	0.26	0.02	0.21	53	1
St. Luke's	0.11	0.1	0.49	0.06	0.21	47	1
Parma	0.31	0.1	1.91	0.41	0.21	54	12

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Appendix A. Analyte Species Identification

Table A-1 Analyte Species Identification

HAP Status	Chemical Class	Database Species Names	Alternate Names	PMF Species Names	CAS Nos. (Chemical Abstract Registry)	Atomic /Mole-cular Weight
HAP	Metalloid	Arsenic		Arsenic	7440-38-2	74.9
HAP	Metals	Beryllium		Beryllium	7440-41-7	9.0
HAP	Metals	Cadmium		Cadmium	7440-43-9	112.4
HAP	Metals	Chromium		Chromium	7440-47-3	52.0
HAP	Metals	Cobalt		Cobalt	7440-48-4	58.9
HAP	Metals	Lead		Lead	7439-92-1	207.2
HAP	Metals	Manganese		Manganese	7439-96-5	54.9
HAP	Metals	Nickel		Nickel	7440-01-0	58.7
HAP	non-metal	Selenium		Selenium	7782-49-2	78.9
HAP	Carbonyls	formaldehyde		formaldehyde	C50-00-0	30.03
HAP	Carbonyls	acetaldehyde		acetaldehyde	C75-07-0	44.05
HAP	Carbonyls	propionaldehyde		propionaldehyde	C123-38-6	58.08
non-HAP	Carbonyls	crotonaldehyde		crotonaldehyde	C4170-30-3	70.09
non-HAP	Carbonyls	butyraldehyde		butyraldehyde	C123-72-8	72.11
non-HAP	Carbonyls	n-valeraldehyde	n-pentanal	n-valeraldehyde	C110-62-3	86.13
non-HAP	Carbonyls	isovaleraldehyde	3-methylbutanal	isovaleraldehyde	C590-86-3	86.13
non-HAP	Carbonyls	hexanal	hexaldehyde	hexanal	C66-25-1	100.16
non-HAP	Carbonyls	benzaldehyde		benzaldehyde	C100-52-7	106.12
non-HAP	Carbonyls	o-tolualdehyde		o-tolualdehyde	C529-20-4	120.15
non-HAP	Carbonyls	m-tolualdehyde		m-tolualdehyde	C620-23-5	120.15
non-HAP	Carbonyls	p-tolualdehyde		p-tolualdehyde	C104-87-0	120.15
non-HAP	Carbonyls	acetone		acetone	C67-64-1	58.08
non-HAP	Carbonyls	methyl ethyl ketone (MEK)	2-butanone	methylethyl ketone	C108-10-1	100.16

Table A-1 Analyte Species Identification (continued)

HAP Status	Chemical Class	Database Species Names	Alternate Names	PMF Species Names	CAS Nos. (Chemical Abstract Registry)	Atomic /Molecular Weight
HAP	VOCs	1,1,2,2-tetrachloroethylene	perchloroethylene	1122-tetrachloroethylene	C127-18-4	165.83
HAP	VOCs	1,2,4-trichlorobenzene		124-trichlorobenzene	C120-82-1	181.45
HAP	VOCs	o-xylene	1,2-dimethyl benzene	12-dimethyl benzene	C95-47-6	106.17
HAP	VOCs	m,p-xylenes	1,4/1,3-dimethyl benzene	14&13-dimethylbenzene	C108-38-3/ C108-42-3	106.17
HAP	VOCs	p-dichlorobenzene	1,4-dichlorobenzene	p-dichlorobenzene	C106-46-7	147.00
HAP	VOCs	2,2,4-trimethylpentane		224-trimethylpentane	C540-84-1	114.23
HAP	VOCs	methyl isobutyl ketone (MEK)	2-butanone	methyl isobutyl ketone	C108-10-1	100.16
HAP	VOCs	acrylonitrile		acrylonitrile	C107-13-1	53.06
HAP	VOCs	benzene		benzene	C71-43-2	78.11
HAP	VOCs	bromomethane	methyl bromide	bromomethane	C74-83-9	94.94
HAP	VOCs	carbon disulfide		carbon disulfide	C75-15-0	76.14
HAP	VOCs	carbon tetrachloride		carbon tetrachloride	C56-23-5	153.82
HAP	VOCs	chlorobenzene		chlorobenzene	C108-90-7	112.56
HAP	VOCs	chloroform		chloroform	C67-66-3	119.38
HAP	VOCs	methyl chloride		methyl chloride	C74-87-3	50.49
HAP	VOCs	*cis*-1,3-dichloropropene		*cis*-13-dichloropropene	C10061-01-5	110.97
HAP	VOCs	ethyl benzene		ethyl benzene	C100-41-4	106.17
HAP	VOCs	hexachloro-1,3-butadiene		hexachloro-13-butadiene	C-87-68-3	260.76
HAP	VOCs	methylene chloride	dichloromethane	dichloromethane	C75-09-2	84.93
HAP	VOCs	n-hexane		n-hexane	C110-54-3	86.18
HAP	VOCs	styrene		styrene	C100-42-5	104.15
HAP	VOCs	toluene		toluene	C108-88-3	92.14
HAP	VOCs	*trans*-1,3-dichloropropene		*trans*-13-dichloropropene	C10061-02-6	110.97
HAP	VOCs	1,2,4-trimethylbenzene		124-trimethylbenzene	C95-63-6	120.19
HAP	VOCs	1,3,5-trimethylbenzene		135-trimethylbenzene	C108-67-8	120.19

Table A-1 Analyte Species Identification (continued)						
HAP Status	**Chemical Class**	**Database Species Names**	**Alternate Names**	**PMF Species Names**	**CAS Nos. (Chemical Abstract Registry)**	**Atomic /Molecular Weight**
non-HAP	VOCs	2-hexanone		2-hexanone	C591-78-6	100.16
non-HAP	VOCs	p-ethyltoluene	1,4-ethyltoluene	p-ethyltoluene	C622-96-8	120.19
non-HAP	VOCs	chloroethane	ethyl chloride	chloroethane	C-75-00-3	64.51
non-HAP	VOCs	cyclohexane	cyclohexane	cyclohexane	C110-82-7	84.16
non-HAP	VOCs	chlorodibromomethane	dibromochloromethane	Chlorodibromo-methane	C124-48-1	208.28
non-HAP	VOCs	dichlorodifluoromethane	Refrigerant F-12	Dichlorodifluoro-methane	C75-71-8	120.91
non-HAP	VOCs	isopropyl alcohol	isopropanol	isopropanol	C67-63-0	60.10
non-HAP	VOCs	n-heptane		n-heptane	C142-82-5	100.20
non-HAP	VOCs	trichlorofluoromethane		trichlorofluoromethane	C75-69-4	137.37
non-HAP	VOCs	trichlorotrifluoroethane	Refrigerant F-113	trichlorotrifluoroethane	C76-13-1	187.38

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Appendix B. Quality Assurance Results

Final Data Validation Notes

1. The final data validation for the Treasure Valley Air Toxics database involved a number of revisions after Oregon DEQ Lab completed their validation and loaded the database into AQS. These changes are based on time series analysis, scatter plots, and other methods of data exploration. Non-HAPs are included in the complete database as well as HAPs because non-HAPS may contain source information.

2. Three different versions of the dataset were developed with different indicators for missing values and non-detects (below the MRL or Minimum Reporting Level). This included a file with commas removed and all species in $\mu g/m^3$, along with a matching uncertainty file for PMF analysis.

3. All species have been converted to common units ($\mu g/m^3$) at local temperature and pressure. Site-specific temperatures and pressures on each site each sample day were used for the VOC correction from ppbv to $\mu g/m^3$, according to the formula:

   $\mu g/m^3$ = ppbv x MWT / (22.414 x (T/273.15) x (760/Pbar))

4. Acetone, methyl ethyl ketone (MEK), and tetrahydrofuran have been omitted for these reasons: 1) due to probable contamination in monitoring trailers; 2) they are also common laboratory contaminants; 3) there are inconsistencies between method TO-15 and TO-11 analyses of the same carbonyls (acetone and MEK); 4) because they are all of relatively low toxicity; and 5)because they are not classified as Hazardous Air Pollutants.

5. Data prepared for PMF analysis: Uncertainty file and Matching Concentration file, all in $\mu g/m^3$. Uncertainties are based on the absolute percent differences of the St. Luke's primary and co-located samples x 100.

6. All QA-flagged samples (flagged by the ODEQ Lab) were omitted from the final data set with the exception of several formaldehyde samples from St. Luke's and White Pine, and two 1,3 dichloropropene samples from Parma, all of which exceeded the calibration range in the laboratory analysis. These values were included because: 1) the calibration curves are reasonably linear even at the upper end so these should be reasonable estimates, and 2) the highest values of these pollutants are important components of the risk and deleting them would underestimate risk. The samples included on this basis are listed below.

   - White Pine -- formaldehyde on 7/11/2007: 8.06 $\mu g/m^3$
   - St. Luke's -- formaldehyde on 7/5, 7/11, 7/17 and 7/23/2007 (13.4, 14.03, 13.3 and 15.06 $\mu g/m^3$)
   - Parma -- two 1,3 dichloropropene isomers on 11/2/2007: 29 ppbv or 127.4 $\mu g/m^3$ *cis*-1,3-dichloropropene, and 13 ppbv or 57.1 $\mu g/m^3$ *trans*-1,3-dichloropropene.

7. Species names are provided without commas in the worksheet for PMF input. In addition, several common names have been in use throughout laboratory and data analysis. Alternative names, CAS identifying numbers, and molecular weights are shown in the table in Appendix A.

Final Data Validation Notes

8. 5-19-2009 The following dates were corrected in the working database:

   line 49 12/2/2008 to 12/2/2007 @ WHP, line 77 5/18/2004 to 5/18/2007@ MTV, line 173 12/14/ 2008 @ STL, line 190 3/25/2000 to 3/25/2007 @ NNU, line 232 12/2/2008 to 12/2/2007 @ NNU, and line 356 12/14/2008 to 12/14/2007 @ STL-D

9 Butyraldehyde on 1/25/2008 was voided as an unrealistic value – far too high for wintertime and for butyraldehyde in general.

10. Aldehyde/carbonyl values from the Mountain View site for the period 5/24/2007 through 8/28/2007 were voided due to massive leak (-433% difference) found in sampler during audit on 8/28/2007. All values during this period were also extremely low, reflecting loss of flow into the DNPH cartridge due to the leak.

11. Formaldehyde at the St. Luke's-Duplicate site on 3/19/2007 and 3/25/2007 are too low (0.11µg/m^3) compared to other sites and compared to STL-Primary sample. Voided.

Appendix C. Descriptive Statistics

Table C-1. Data from the White Pine Monitoring Site

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
Arsenic	2.65E-04	2.40E-04	1.07E-03	1.64E-04	1.00E-04	51	49
Beryllium	1.06E-05	5.00E-06	1.10E-04	1.52E-05	1.00E-05	53	18
Cadmium	8.30E-05	5.00E-05	9.70E-04	1.34E-04	1.00E-04	54	8
Chromium	1.66E-03	1.60E-03	4.90E-03	4.45E-04	3.20E-03	55	1
Cobalt	9.63E-05	8.10E-05	2.79E-04	6.93E-05	7.50E-05	51	27
Lead	1.72E-03	1.40E-03	1.52E-02	2.08E-03	1.00E-03	52	38
Manganese	6.73E-03	5.10E-03	1.98E-02	5.06E-03	1.00E-03	50	47
Selenium	8.13E-05	6.00E-05	2.70E-04	5.09E-05	1.20E-04	55	10
formaldehyde	2.36	2.08	8.06	1.53	0.02	54	53
acetaldehyde	1.81	1.51	6.12	1.26	0.03	54	54
propionaldehyde	0.40	0.35	1.40	0.28	0.04	54	53
crotonaldehyde	0.03	0.03	0.07	0.01	0.05	58	2
butyraldehyde	0.30	0.21	2.50	0.36	0.05	54	53
n-valeraldehyde	0.12	0.11	0.36	0.08	0.06	51	40
isovaleraldehyde	0.20	0.16	0.52	0.11	0.06	53	52
hexanal	0.22	0.21	0.68	0.14	0.06	48	45
benzaldehyde	0.16	0.15	0.48	0.12	0.06	50	42
m-tolualdehyde	0.04	0.04	0.43	0.05	0.07	57	3
1,2-dimethyl benzene	0.51	0.47	1.48	0.35	0.42	56	29
1,4/1,3-dimethylbenzene	1.49	1.55	4.64	0.90	0.83	54	39
2,2,4-trimethylpentane	0.41	0.22	2.31	0.43	0.45	54	11
methyl isobutyl ketone	0.24	0.20	2.01	0.26	0.39	57	2
acrylonitrile	0.14	0.10	0.71	0.12	0.21	57	5
benzene	1.26	1.33	3.10	0.53	0.31	54	54
bromomethane	0.22	0.19	0.56	0.10	0.37	57	6
carbon tetrachloride	0.39	0.30	0.90	0.20	0.60	57	9
chlorobenzene	0.27	0.22	0.80	0.14	0.44	57	6
chloroform	0.26	0.23	1.83	0.21	0.47	57	1

	Mean, (μg/m^3)	**Median (μg/m^3)**	**Max (μg/m^3)**	**Standard Deviation (μg/m^3)**	**MRL (μg/m^3)**	**Count**	**Detects**
methyl chloride	0.92	0.88	1.90	0.36	0.20	54	53
ethyl benzene	0.37	0.21	1.31	0.26	0.42	54	18
hexachloro-1,3-butadiene	0.54	0.51	2.02	0.20	1.02	57	1
methylene chloride	0.29	0.17	1.18	0.22	0.33	55	17
n-hexane	1.22	0.17	7.65	1.87	0.34	54	22
styrene	0.21	0.20	0.73	0.07	0.41	57	1
toluene	3.33	3.20	12.08	2.08	0.36	55	52
1,2,4-trimethylbenzene	0.63	0.24	5.11	0.74	0.47	56	24
1,3,5-trimethylbenzene	0.25	0.24	0.84	0.09	0.47	57	2
2-hexanone	0.75	0.20	4.29	0.94	0.39	56	18
p-ethyltoluene	0.49	0.47	1.38	0.12	0.94	57	1
chloroethane	1.97	1.83	5.04	1.61	0.25	53	43
cyclohexane	0.99	0.77	3.07	0.83	0.33	56	39
chlorodibromomethane	0.46	0.41	3.39	0.39	0.82	57	1
dichlorodifluoromethane	1.92	1.92	2.59	0.41	0.47	51	50
isopropyl alcohol	63.6	34.1	205.8	69.1	0.24	55	51
n-heptane	44.2	36.2	145.4	40.9	0.39	54	54
trichlorofluoromethane	1.69	1.50	3.46	0.94	0.54	52	48
trichlorotrifluoroethane	0.42	0.37	1.18	0.21	0.73	56	4

Table C-2 Data from the Mountain View Monitoring Site

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
Arsenic	3.44E-04	2.90E-04	1.25E-03	2.26E-04	1.00E-04	45	42
Beryllium	9.49E-06	5.00E-06	3.70E-05	7.01E-06	1.00E-05	45	18
Cadmium	1.18E-04	5.00E-05	2.00E-03	2.85E-04	1.00E-04	49	11
Chromium	1.67E-03	1.60E-03	5.30E-03	5.18E-04	3.20E-03	51	1
Cobalt	1.15E-04	1.00E-04	3.80E-04	8.68E-05	7.50E-05	45	27
Lead	2.22E-03	1.75E-03	1.92E-02	2.79E-03	1.00E-03	46	36
Manganese	7.48E-03	6.50E-03	2.69E-02	5.86E-03	1.00E-03	45	43
Selenium	9.44E-05	6.00E-05	3.50E-04	6.83E-05	1.20E-04	48	12
formaldehyde	2.27	2.03	6.52	1.10	0.02	35	35
acetaldehyde	1.74	1.58	6.01	1.12	0.03	35	35
propionaldehyde	0.40	0.36	1.45	0.26	0.04	36	36
crotonaldehyde	0.03	0.03	0.07	0.01	0.05	39	1
butyraldehyde	0.24	0.22	0.91	0.16	0.05	36	36
n-valeraldehyde	0.10	0.10	0.40	0.08	0.06	33	24
isovaleraldehyde	0.20	0.21	0.63	0.11	0.06	36	36
hexanal	0.18	0.17	0.76	0.14	0.06	33	28
benzaldehyde	0.16	0.16	0.42	0.10	0.06	34	29
m-tolualdehyde	0.04	0.04	0.04	0.00	0.07	39	0
p-tolualdehyde	0.04	0.04	0.09	0.01	0.07	35	1
1,1,2,2-tetrachloroethylene	0.35	0.32	1.46	0.16	0.65	53	1
1,2,4-trichlorobenzene	1.43	1.42	1.88	0.06	2.84	53	1
1,2-dimethyl benzene	0.81	0.78	1.97	0.46	0.42	53	40
1,4/1,3-dimethylbenzene	2.26	2.14	5.92	1.38	0.83	53	41
2,2,4-trimethylpentane	1.11	0.91	3.95	0.82	0.45	53	42
methyl isobutyl ketone	0.26	0.20	1.14	0.20	0.39	53	5

	Mean, (μg/m^3)	**Median (μg/m^3)**	**Max (μg/m^3)**	**Standard Deviation (μg/m^3)**	**MRL (μg/m^3)**	**Count**	**Detects**
acrylonitrile	0.11	0.10	0.26	0.02	0.21	53	1
benzene	1.58	1.43	3.77	0.85	0.31	52	50
bromomethane	0.21	0.19	0.63	0.08	0.37	53	4
carbon tetrachloride	0.41	0.30	0.88	0.21	0.60	53	12
methyl chloride	1.01	1.02	2.98	0.37	0.20	53	52
ethyl benzene	0.50	0.21	1.54	0.39	0.42	53	22
methylene chloride	0.55	0.43	2.98	0.51	0.33	51	30
n-hexane	0.44	0.17	2.95	0.57	0.34	53	13
styrene	0.21	0.20	0.50	0.04	0.41	53	1
toluene	4.64	4.21	12.56	3.07	0.36	53	52
1,2,4-trimethylbenzene	0.77	0.63	2.50	0.62	0.47	53	28
1,3,5-trimethylbenzene	0.27	0.24	0.94	0.14	0.47	53	3
2-hexanone	0.95	0.20	11.89	1.72	0.39	53	21
chloroethane	0.88	0.86	2.42	0.74	0.25	53	33
cyclohexane	0.27	0.16	1.00	0.21	0.33	53	13
dichlorodifluoromethane	1.90	1.93	2.76	0.40	0.47	53	52
isopropyl alcohol	0.80	0.12	6.39	1.18	0.24	53	22
n-heptane	0.64	0.71	1.73	0.44	0.39	52	30
trichlorofluoromethane	0.87	1.01	1.46	0.36	0.54	50	40
trichlorotrifluoroethane	0.47	0.37	1.19	0.26	0.73	52	8

Table C-3 Data from the St. Luke’s Monitoring Site

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
Arsenic	3.08E-04	2.55E-04	1.04E-03	1.85E-04	1.00E-04	50	48
Beryllium	1.25E-05	8.00E-06	5.20E-05	9.70E-06	1.00E-05	50	25
Cadmium	8.92E-05	5.00E-05	4.30E-04	8.10E-05	1.00E-04	51	14
Cobalt	1.52E-04	1.33E-04	6.25E-04	1.26E-04	7.50E-05	50	36
Lead	1.89E-03	1.70E-03	8.00E-03	1.30E-03	1.00E-03	50	41
Manganese	9.58E-03	8.80E-03	3.83E-02	7.45E-03	1.00E-03	47	45
Nickel	5.29E-04	5.00E-04	1.40E-03	1.49E-04	1.00E-03	52	2
Selenium	1.30E-04	6.00E-05	3.90E-04	8.92E-05	1.20E-04	51	25
formaldehyde	4.61	2.71	15.06	4.05	0.02	38	38
acetaldehyde	2.18	1.85	5.59	1.31	0.03	36	36
propionaldehyde	0.44	0.41	1.18	0.28	0.04	40	40
crotonaldehyde	0.03	0.03	0.08	0.01	0.05	43	3
butyraldehyde	0.32	0.28	0.86	0.22	0.05	40	40
n-valeraldehyde	0.18	0.13	0.51	0.15	0.06	37	28
isovaleraldehyde	0.16	0.16	0.36	0.10	0.06	33	27
hexanal	0.38	0.22	1.23	0.37	0.06	37	33
benzaldehyde	0.24	0.15	0.87	0.23	0.06	38	33
m-tolualdehyde	0.04	0.04	0.08	0.01	0.07	42	3
p-tolualdehyde	0.04	0.04	0.12	0.02	0.07	39	2
1,2-dimethyl benzene	0.39	0.21	1.11	0.28	0.42	47	15
1,4/1,3-dimethylbenzene	1.16	1.10	2.64	0.67	0.83	45	31
2,2,4-trimethylpentane	0.43	0.22	1.30	0.28	0.45	42	17
methyl isobutyl ketone	0.21	0.20	0.79	0.09	0.39	47	1
acrylonitrile	0.11	0.10	0.49	0.06	0.21	47	1
benzene	0.78	0.67	1.92	0.43	0.31	46	40
bromomethane	0.23	0.19	0.63	0.12	0.37	46	7

	Mean, (μg/m^3)	**Median (μg/m^3)**	**Max (μg/m^3)**	**Standard Deviation (μg/m^3)**	**MRL (μg/m^3)**	**Count**	**Detects**
carbon tetrachloride	0.45	0.30	0.88	0.22	0.60	46	15
methyl chloride	1.21	1.27	1.82	0.34	0.20	41	40
cis-1,3-dichloropropene	0.22	0.22	0.50	0.04	0.43	47	1
ethyl benzene	0.26	0.21	0.74	0.14	0.42	43	7
hexachloro-1,3-butadiene	0.56	0.51	2.92	0.35	1.02	47	1
methylene chloride	0.64	0.56	2.00	0.46	0.33	45	33
n-hexane	0.24	0.17	0.88	0.18	0.34	47	7
toluene	3.20	2.38	27.42	4.05	0.36	46	45
1,2,4-trimethylbenzene	0.37	0.24	0.98	0.24	0.47	46	13
2-hexanone	0.34	0.20	1.66	0.40	0.39	47	6
p-ethyltoluene	0.50	0.47	1.71	0.18	0.94	47	1
cyclohexane	0.17	0.16	0.48	0.05	0.33	47	1
dichlorodifluoromethane	1.99	1.96	2.82	0.33	0.47	44	44
isopropyl alcohol	1.24	0.12	20.48	3.44	0.24	45	11
n-heptane	0.24	0.20	0.83	0.14	0.39	47	4
trichlorofluoromethane	0.92	1.01	1.77	0.42	0.54	45	36
trichlorotrifluoroethane	0.49	0.37	1.19	0.28	0.73	43	7

Table C-4 Data from the Northwest Nazarene University (NNU) Monitoring Site

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
Arsenic	3.98E-04	2.90E-04	2.89E-03	5.07E-04	1.00E-04	46	42
Beryllium	1.16E-05	5.00E-06	4.10E-05	9.00E-06	1.00E-05	50	22
Cadmium	8.76E-05	5.00E-05	4.50E-04	8.26E-05	1.00E-04	51	14
Cobalt	1.33E-04	1.12E-04	4.50E-04	1.04E-04	7.50E-05	48	28
Lead	1.42E-03	1.30E-03	3.60E-03	8.80E-04	1.00E-03	50	32
Manganese	8.43E-03	6.15E-03	2.95E-02	6.93E-03	1.00E-03	46	44
Nickel	5.11E-04	5.00E-04	1.10E-03	8.02E-05	1.00E-03	56	1
Selenium	1.65E-04	1.50E-04	5.50E-04	1.04E-04	1.20E-04	49	33
formaldehyde	1.94	1.76	4.77	1.04	0.02	48	48
acetaldehyde	1.45	1.29	3.42	0.85	0.03	49	49
propionaldehyde	0.34	0.30	0.85	0.20	0.04	49	49
crotonaldehyde	0.03	0.03	0.05	0.00	0.05	52	2
butyraldehyde	0.21	0.20	0.55	0.13	0.05	49	49
n-valeraldehyde	0.09	0.09	0.24	0.06	0.06	45	31
isovaleraldehyde	0.18	0.17	0.42	0.10	0.06	48	47
hexanal	0.16	0.17	0.42	0.10	0.06	45	37
benzaldehyde	0.11	0.10	0.25	0.06	0.06	46	35
o-tolualdehyde	0.04	0.04	0.09	0.01	0.07	52	1
m-tolualdehyde	0.04	0.04	0.08	0.01	0.07	52	2
p-tolualdehyde	0.04	0.04	0.11	0.02	0.07	52	7
1,2-dimethyl benzene	0.47	0.21	1.34	0.36	0.42	51	21
1,4/1,3-dimethylbenzene	1.29	0.94	3.94	0.98	0.83	50	30
p-dichlorobenzene	0.50	0.29	10.91	1.49	0.58	51	1
2,2,4-trimethylpentane	0.55	0.22	1.86	0.47	0.45	49	20
methyl isobutyl ketone	0.28	0.20	1.12	0.25	0.39	51	5
benzene	0.96	0.81	2.78	0.63	0.31	49	45

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
bromomethane	0.20	0.19	0.63	0.07	0.37	51	2
carbon tetrachloride	0.44	0.30	0.90	0.23	0.60	51	15
methyl chloride	0.88	0.87	1.22	0.15	0.20	50	50
cis-1,3-dichloropropene	0.28	0.22	1.51	0.25	0.43	51	4
ethyl benzene	0.31	0.21	1.00	0.21	0.42	49	10
methylene chloride	0.27	0.17	1.52	0.25	0.33	48	12
n-hexane	0.30	0.17	1.72	0.34	0.34	51	8
styrene	0.21	0.20	0.65	0.06	0.41	51	1
toluene	2.37	2.09	6.14	1.71	0.36	50	47
trans-1,3-dichloropropene	0.25	0.22	1.60	0.20	0.43	51	2
1,2,4-trimethylbenzene	0.45	0.24	1.61	0.39	0.47	51	14
1,3,5-trimethylbenzene	0.26	0.24	1.26	0.14	0.47	51	1
2-hexanone	0.85	0.20	2.41	0.76	0.39	51	24
p-ethyltoluene	0.48	0.47	1.12	0.09	0.94	51	1
chloroethane	0.74	0.13	3.13	0.77	0.25	50	24
cyclohexane	0.18	0.16	0.51	0.08	0.33	51	3
dichlorodifluoromethane	1.91	1.90	2.73	0.32	0.47	49	49
isopropyl alcohol	0.64	0.12	3.90	0.85	0.24	51	17
n-heptane	0.33	0.20	1.28	0.30	0.39	51	11
trichlorofluoromethane	0.87	0.99	1.58	0.36	0.54	46	37
trichlorotrifluoroethane	0.48	0.37	1.20	0.27	0.73	48	7

Table C-5 Data from the Parma Monitoring Site

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
Arsenic	5.25E-04	4.55E-04	1.45E-03	3.51E-04	1.00E-04	42	41
Beryllium	1.27E-05	5.00E-06	5.00E-05	1.25E-05	1.00E-05	45	16
Cadmium	1.18E-04	5.00E-05	5.60E-04	1.10E-04	1.00E-04	54	23
Cobalt	1.33E-04	3.75E-05	4.88E-04	1.34E-04	7.50E-05	44	20
Lead	2.16E-03	1.60E-03	1.29E-02	2.21E-03	1.00E-03	45	34
Manganese	1.00E-02	5.35E-03	3.31E-02	9.40E-03	1.00E-03	42	39
Selenium	2.23E-04	2.00E-04	5.60E-04	1.49E-04	1.20E-04	45	31
formaldehyde	1.64	1.43	5.58	1.07	0.02	49	48
acetaldehyde	1.38	1.09	3.66	0.94	0.03	50	49
propionaldehyde	0.31	0.27	0.86	0.20	0.04	50	49
crotonaldehyde	0.03	0.03	0.05	0.00	0.05	55	2
butyraldehyde	0.19	0.16	0.58	0.14	0.05	51	48
n-valeraldehyde	0.08	0.07	0.24	0.06	0.06	47	30
isovaleraldehyde	0.16	0.15	0.43	0.10	0.06	45	42
hexanal	0.15	0.14	0.46	0.11	0.06	48	37
benzaldehyde	0.12	0.07	0.74	0.15	0.06	47	27
m-tolualdehyde	0.04	0.04	0.12	0.01	0.07	55	1
p-tolualdehyde	0.04	0.04	0.37	0.05	0.07	52	5
1,2-dimethyl benzene	0.45	0.21	5.35	0.76	0.42	54	14
1,4/1,3-dimethylbenzene	0.75	0.42	3.86	0.62	0.83	54	17
2,2,4-trimethylpentane	0.26	0.22	0.89	0.12	0.45	52	5
methyl isobutyl ketone	0.25	0.20	1.05	0.20	0.39	54	4
acrylonitrile	0.31	0.10	1.91	0.41	0.21	54	12
benzene	0.80	0.78	4.03	0.54	0.31	50	46
bromomethane	0.20	0.19	0.75	0.09	0.37	54	3
carbon disulfide	0.15	0.15	0.43	0.04	0.30	54	1

	Mean, (μg/m^3)	Median (μg/m^3)	Max (μg/m^3)	Standard Deviation (μg/m^3)	MRL (μg/m^3)	Count	Detects
carbon tetrachloride	0.40	0.30	0.99	0.20	0.60	54	11
chloroform	0.27	0.23	2.14	0.26	0.47	54	1
methyl chloride	0.91	0.82	2.47	0.45	0.20	49	47
cis-1,3-dichloropropene	3.98	0.22	127.40	17.81	0.43	54	11
ethyl benzene	0.23	0.21	0.80	0.10	0.42	54	4
methylene chloride	0.22	0.17	0.82	0.14	0.33	51	9
styrene	0.21	0.20	0.67	0.06	0.41	54	1
toluene	1.90	1.50	6.00	1.39	0.36	51	44
trans-1,3-dichloropropene	2.33	0.22	57.11	8.42	0.43	54	10
1,2,4-trimethylbenzene	0.29	0.24	1.74	0.23	0.47	54	4
2-hexanone	0.57	0.20	2.36	0.63	0.39	54	16
chloroethane	0.21	0.13	0.54	0.14	0.25	54	16
dichlorodifluoromethane	1.76	1.83	2.75	0.50	0.47	49	47
isopropyl alcohol	0.65	0.12	4.26	0.87	0.24	54	19
n-heptane	0.22	0.20	0.60	0.08	0.39	54	3
trichlorofluoromethane	0.79	0.95	1.50	0.39	0.54	50	35
trichlorotrifluoroethane	0.38	0.37	1.21	0.12	0.73	52	1

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Appendix D. Preliminary Risk-Based Screening

Table D-1 White Pine Monitoring Site

	Max ($\mu g/m^3$)	Chronic Screening Value ($\mu g/m^3$)	Acute Screening Value ($\mu g/m^3$)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
Arsenic	1.25E-03	0.000303[a]	0.19[a]	Yes (29)	No	Highest
Beryllium	3.70E-05	0.000417[b]		No		Moderate
Cadmium	2.00E-03	0.000238[a]	900[d]	Yes (4)	No	Moderate
Chromium	5.30E-03	0.00000667[a]	1000[e]	Yes (100)	No	Low
Cobalt	3.80E-04	0.01[c]		No		Moderate
Lead	1.92E-02	0.0833[a]		No		High
Manganese	2.69E-02	0.004[a]	50000[d]	Yes (60)	No	High
Nickel	5.00E-04	0.0042[a]		No		Low
Selenium	3.50E-04	2[a]		No		Moderate
formaldehyde	6.52	0.167[a]	49[c]	Yes (98)	No	High
acetaldehyde	6.01	0.37[a]	18000[f]	Yes (98)	No	High
propionaldehyde	1.45			NA		High
1,1,2,2-tetrachloroethylene	1.46	0.169[b]	1400[c]	Yes (100)	No	Low
1,2,4-trichlorobenzene	1.88			NA		Low
1,2-dimethyl benzene	1.97	22.1[c]		No		Moderate
1,4/1,3-dimethylbenzene	5.92	22.1[c]		No		High
p-dichlorobenzene	0.29	0.0909[a]	4800[a]	Yes (100)	No	Low
2,2,4-trimethylpentane	3.95			Na		Moderate
methyl isobutyl ketone	1.14	300[b]		No		Low
acrylonitrile	0.26	0.00345[a]	220[c]	Yes (100)	No	Low
benzene	3.77	0.0345[a]	160[c]	Yes (100)	No	High
bromomethane	0.63	0.5[b]	190[c]	Yes (5)	No	Low

	Max (μg/m^3)	Chronic Screening Value (μg/m^3)	Acute Screening Value (μg/m^3)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
carbon disulfide	0.15	80[c]		No		Low
carbon tetrachloride	0.88	0.0238[a]	1900[a]	Yes (100)	No	Low
chlorobenzene	0.22	100[a]		No		Low
chloroform	0.23	0.0435[a]	150[a]	Yes (100)	No	Low
methyl chloride	2.98	9[b]		No		Highest
cis-1,3-dichloropropene	0.22	0.0625[a]	4500[e]	Yes (100)	No	Moderate
ethyl benzene	1.54	0.4[a]	350[d]	Yes (33)	No	Moderate
hexachloro-1,3-butadiene	0.51	0.0455[b]	11000[f]	Yes (100)	No	Low
methylene chloride	2.98	1[a]	2100[c]	Yes (2)	No	Moderate
n-hexane	2.95	70[a]		No		Moderate
styrene	0.50	90[a]		No		Low
toluene	12.56	500[b]		No		High
trans-1,3-dichloropropene	0.22	0.0625[a]	4500[e]	Yes (100)	No	Moderate

Sources: Chronic screening values were obtained from Washington Ecology (Washington State Ecology, proposed 2009) with the primary source designated by the superscript letters as specified below. The acute screening values were obtained from EPA (EPA, 2006) with the primary source designated by the superscript letters as specified below.

a OEHHA – California Office of Environmental Health Hazard Assessment

b EPA – U.S. Environmental Protection Agency

c ATSDR – Agency for Toxic Substances and Disease Registry

d NIOSH – National Institute for Occupational Safety and Health

e DOE – U.S. Department of Energy

f AIHA – American Industrial Hygiene Association

Table D-2 Mountain View Monitoring Site

	Max (µg/m^3)	Chronic Screening Value (µg/m^3)	Acute Screening Value (µg/m^3)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
Arsenic	1.25E-03	0.000303^a	0.19^a	Yes (44)	No	Highest
Beryllium	3.70E-05	0.000417^b		No		Moderate
Cadmium	2.00E-03	0.000238^a	900^d	Yes (6)	No	Moderate
Chromium	5.30E-03	0.00000667^a	1000^e	Yes (100)	No	Low
Cobalt	3.80E-04	0.01^c		No		Moderate
Lead	1.92E-02	0.0833^a		No		High
Manganese	2.69E-02	0.004^a	50000^d	Yes (71)	No	High
Nickel	5.00E-04	0.0042^a		No		Low
Selenium	3.50E-04	2^a		No		Moderate
formaldehyde	6.52	0.167^a	49^c	Yes (97)	No	High
acetaldehyde	6.01	0.37^a	18000^f	Yes (76)	No	High
propionaldehyde	1.45			NA		High
1,1,2,2-tetrachloroethylene	1.46	0.169^b	1400^c	Yes (100)	No	Low
1,2,4-trichlorobenzene	1.88			NA		Low
1,2-dimethyl benzene	1.97	22.1^c		No		Low
1,4/1,3-dimethylbenzene	5.92	22.1^c		No		Low
p-dichlorobenzene	0.29	0.0909^a	4800^a	Yes (100)	No	Low
2,2,4-trimethylpentane	3.95			NA		Highest
methyl isobutyl ketone	1.14	300^b		No		Moderate
acrylonitrile	0.26	0.00345^a	220^c	Yes (100)	No	Moderate
benzene	3.77	0.0345^a	160^c	Yes (100)	No	Low
bromomethane	0.63	0.5^b	190^c	Yes (4)	No	Moderate
carbon disulfide	0.15	80^c		No		Moderate

	Max ($\mu g/m^3$)	Chronic Screening Value ($\mu g/m^3$)	Acute Screening Value ($\mu g/m^3$)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
carbon tetrachloride	0.88	0.0238[a]	1900[a]	Yes (100)	No	Low
chlorobenzene	0.22	100[a]		No		High
chloroform	0.23	0.0435[a]	150[a]	Yes (100)	No	Moderate
methyl chloride	2.98	9[b]		No		Highest
cis-1,3-dichloropropene	0.22	0.0625[a]	4500[e]	Yes (100)	No	Moderate
ethyl benzene	1.54	0.4[a]	350[d]	Yes (42)	No	Moderate
hexachloro-1,3-butadiene	0.51	0.0455[b]	11000[f]	Yes (100)	No	Low
methylene chloride	2.98	1[a]	2100[c]	Yes (10)	No	Moderate
n-hexane	2.95	70[a]		No		High
styrene	0.50	90[a]		No		High
toluene	12.56	500[b]		No		Low
trans-1,3-dichloropropene	0.22	0.0625[a]	4500[e]	Yes (100)	No	Moderate

Sources: Chronic screening values were obtained from Washington Ecology (Washington State Ecology (proposed 2009)) with the primary source designated by the superscript letters as specified below. The acute screening values were obtained from EPA with the primary source designated by the superscript letters as specified below.

a OEHHA – California Office of Environmental Health Hazard Assessment

b EPA – U.S. Environmental Protection Agency

c ATSDR – Agency for Toxic Substances and Disease Registry

d NIOSH – National Institute for Occupational Safety and Health

e DOE – U.S. Department of Energy

f AIHA – American Industrial Hygiene Association

Table D-3 St. Luke's Monitoring Site

	Max ($\mu g/m^3$)	Chronic Screening Value ($\mu g/m^3$)	Acute Screening Value ($\mu g/m^3$)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
Arsenic	1.04E-03	0.000303[a]	0.19[a]	Yes (40)	No	Highest
Beryllium	5.20E-05	0.000417[b]		No		Moderate
Cadmium	4.30E-04	0.000238[a]	900[d]	Yes (4)	No	Moderate
Chromium	1.60E-03	0.00000667[a]	1000[e]	Yes (100)	No	Low
Cobalt	6.25E-04	0.01[c]		No		Moderate
Lead	8.00E-03	0.0833[a]		No		High
Manganese	3.83E-02	0.004[a]	50000[d]	Yes (70)	No	High
Nickel	1.40E-03	0.0042[a]		No		Low
Selenium	3.90E-04	2[a]		No		Moderate
formaldehyde	15.06	0.167[a]	49[c]	Yes (100)	No	High
acetaldehyde	5.59	0.37[a]	18000[f]	Yes (100)	No	High
propionaldehyde	1.18			NA		High
1,1,2,2-tetrachloroethylene	0.32	0.169[b]	1400[c]	Yes (100)	No	Low
1,2,4-trichlorobenzene	1.42			NA		Low
1,2-dimethyl benzene	1.11	22.1[c]		No		Low
1,4/1,3-dimethylbenzene	2.64	22.1[c]		No		Low
p-dichlorobenzene	0.29	0.0909[a]	4800[a]	Yes (100)	No	Low
2,2,4-trimethylpentane	1.30			NA		Highest
methyl isobutyl ketone	0.79	300[b]		No		Moderate
acrylonitrile	0.49	0.00345[a]	220[c]	Yes (100)	No	Moderate
benzene	1.92	0.0345[a]	160[c]	Yes (100)	No	Low
bromomethane	0.63	0.5[b]	190[c]	Yes (7)	No	Moderate
carbon disulfide	0.15	80[c]		No		Moderate

	Max **(µg/m³)**	**Chronic Screening Value (µg/m³)**	**Acute Screening Value (µg/m³)**	**Max Concentration >= Chronic Screen (%)**	**Max Concentration >= Acute Screen**	**Confidence**
carbon tetrachloride	0.88	0.0238[a]	1900[a]	Yes (100)	No	Low
chlorobenzene	0.22	100[a]		No		High
chloroform	0.23	0.0435[a]	150[a]	Yes (100)	No	Moderate
methyl chloride	1.82	9[b]		No		Highest
cis-1,3-dichloropropene	0.50	0.0625[a]	4500[e]	Yes (100)	No	Moderate
ethyl benzene	0.74	0.4[a]	350[d]	Yes (16)	No	Moderate
hexachloro-1,3-butadiene	2.92	0.0455[b]	11000[f]	Yes (100)	No	Low
methylene chloride	2.00	1[a]	2100[c]	Yes (24)	No	Moderate
n-hexane	0.88	70[a]		No		High
styrene	0.20	90[a]		No		High
toluene	27.42	500[b]		No		Low
trans-1,3-dichloropropene	0.22	0.0625[a]	4500[e]	Yes (100)	No	Moderate

Sources: Chronic screening values were obtained from Washington Ecology (Washington State Ecology (proposed 2009)) with the primary source designated by the superscript letters as specified below. The acute screening values were obtained from EPA with the primary source designated by the superscript letters as specified below.

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b EPA – U.S. Environmental Protection Agency

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e DOE – U.S. Department of Energy

f AIHA – American Industrial Hygiene Association

Table D-4 Northwest Nazarene University Monitoring Site

	Max (μg/m^3)	Chronic Screening Value (μg/m^3)	Acute Screening Value (μg/m^3)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
Arsenic	2.89E-03	0.000303[a]	0.19[a]	Yes (43)	No	Highest
Beryllium	4.10E-05	0.000417[b]		No		Moderate
Cadmium	4.50E-04	0.000238[a]	900[d]	Yes (6)	No	Moderate
Chromium	1.60E-03	0.00000667[a]	1000[e]	Yes (100)	No	Low
Cobalt	4.50E-04	0.01[c]		No		Moderate
Lead	3.60E-03	0.0833[a]		No		High
Manganese	2.95E-02	0.004[a]	50000[d]	Yes (63)	No	High
Nickel	1.10E-03	0.0042[a]		No		Low
Selenium	5.50E-04	2[a]		No		Moderate
formaldehyde	4.77	0.167[a]	49[c]	Yes (100)	No	High
acetaldehyde	3.42	0.37[a]	18000[f]	Yes (100)	No	High
propionaldehyde	0.85			NA		High
1,1,2,2-tetrachloroethylene	0.32	0.169[b]	1400[c]	Yes (100)	No	Low
1,2,4-trichlorobenzene	1.42			NA		Low
1,2-dimethyl benzene	1.34	22.1[c]		No		Low
1,4/1,3-dimethylbenzene	3.94	22.1[c]		No		Low
p-dichlorobenzene	10.91	0.0909[a]	4800[a]	Yes (100)	No	Low
2,2,4-trimethylpentane	1.86			NA		Highest
methyl isobutyl ketone	1.12	300[b]		No		Moderate
acrylonitrile	0.10	0.00345[a]	220[c]	Yes (100)	No	Moderate
benzene	2.78	0.0345[a]	160[c]	Yes (100)	No	Low
bromomethane	0.63	0.5[b]	190[c]	Yes (2)	No	Moderate

	Max ($\mu g/m^3$)	Chronic Screening Value ($\mu g/m^3$)	Acute Screening Value ($\mu g/m^3$)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
carbon disulfide	0.15	80[c]		No		Moderate
carbon tetrachloride	0.90	0.0238[a]	1900[a]	Yes (100)	No	Low
chlorobenzene	0.22	100[a]		No		High
chloroform	0.23	0.0435[a]	150[a]	Yes (100)	No	Moderate
methyl chloride	1.22	9[b]		No		Highest
cis-1,3-dichloropropene	1.51	0.0625[a]	4500[e]	Yes (100)	No	Moderate
ethyl benzene	1.00	0.4[a]	350[d]	Yes (20)	No	Moderate
hexachloro-1,3-butadiene	0.51	0.0455[b]	11000[f]	Yes (100)	No	Low
methylene chloride	1.52	1[a]	2100[c]	Yes (4)	No	Moderate
n-hexane	1.72	70[a]		No		High
styrene	0.65	90[a]		No		High
toluene	6.14	500[b]		No		Low
trans-1,3-dichloropropene	1.60	0.0625[a]	4500[e]	Yes (100)	No	Moderate

Sources: Chronic screening values were obtained from Washington Ecology (Washington State Ecology (proposed 2009)) with the primary source designated by the superscript letters as specified below. The acute screening values were obtained from EPA with the primary source designated by the superscript letters as specified below.

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b EPA – U.S. Environmental Protection Agency

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f AIHA – American Industrial Hygiene Association

Table D-5 Parma Monitoring Site

	Max (µg/m^3)	Chronic Screening Value (µg/m^3)	Acute Screening Value (µg/m^3)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
Arsenic	1.45E-03	0.000303[a]	0.19[a]	Yes (62)	No	Highest
Beryllium	5.00E-05	0.000417[b]		No		Moderate
Cadmium	5.60E-04	0.000238[a]	900[d]	Yes (11)	No	Moderate
Chromium	1.60E-03	0.00000667[a]	1000[e]	Yes (100)	No	Low
Cobalt	4.88E-04	0.01[c]		No		Moderate
Lead	1.29E-02	0.0833[a]		No		High
Manganese	3.31E-02	0.004[a]	50000[d]	Yes (62)	No	High
Nickel	5.00E-04	0.0042[a]		No		Low
Selenium	5.60E-04	2[a]		No		Moderate
formaldehyde	5.58	0.167[a]	49[c]	Yes (98)	No	High
acetaldehyde	3.66	0.37[a]	18000[f]	Yes (92)	No	High
propionaldehyde	0.86			NA		High
1,1,2,2-tetrachloroethylene	0.32	0.169[b]	1400[c]	Yes (100)	No	Low
1,2,4-trichlorobenzene	1.42			NA		Low
1,2-dimethyl benzene	5.35	22.1[c]		No		Low
1,4/1,3-dimethylbenzene	3.86	22.1[c]		No		Low
p-dichlorobenzene	0.29	0.0909[a]	4800[a]	Yes (100)	No	Low
2,2,4-trimethylpentane	0.89			NA		Highest
methyl isobutyl ketone	1.05	300[b]		No		Moderate
acrylonitrile	1.91	0.00345[a]	220[c]	Yes (100)	No	Moderate
benzene	4.03	0.0345[a]	160[c]	Yes (100)	No	Low
bromomethane	0.75	0.5[b]	190[c]	Yes (2)	No	Moderate

	Max (μg/m^3)	Chronic Screening Value (μg/m^3)	Acute Screening Value (μg/m^3)	Max Concentration >= Chronic Screen (%)	Max Concentration >= Acute Screen	Confidence
carbon disulfide	0.43	80[c]		No		Moderate
carbon tetrachloride	0.99	0.0238[a]	1900[a]	Yes (100)	No	Low
chlorobenzene	0.22	100[a]		No		High
chloroform	2.14	0.0435[a]	150[a]	Yes (100)	No	Moderate
methyl chloride	2.47	9[b]		No		Highest
cis-1,3-dichloropropene	127.40	0.0625[a]	4500[e]	Yes (100)	No	Moderate
ethyl benzene	0.80	0.4[a]	350[d]	Yes (8)	No	Moderate
hexachloro-1,3-butadiene	0.51	0.0455[b]	11000[f]	Yes (100)	No	Low
methylene chloride	0.82	1[a]	2100[c]	No		Moderate
n-hexane	0.17	70[a]		No		High
styrene	0.67	90[a]		No		High
toluene	6.00	500[b]		No		Low
trans-1,3-dichloropropene	57.11	0.0625[a]	4500[e]	Yes (100)	No	Moderate

Sources: Chronic screening values were obtained from Washington Ecology (Washington State Ecology (proposed 2009)) with the primary source designated the superscript letters as specified below. The acute screening values were obtained from EPA with the primary source designated by the superscript letters as specified below.

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