



Final Report: Puget Sound Air Toxics Evaluation

Executive Summary
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This report was released as a draft in 2002 and we received comments on the draft from a variety of reviewers. These reviewers include Dr. Sally Liu from the University of Washington, Dr. Jane Koenig from the University of Washington, Dr. David Solet from the Metro King County Public Health Department, Dr. Matt Kadlec from the Washington Department of Ecology, Dr. Harriet Ammann from the Washington Department of Health, Ms. Julie Wroble from the US Environmental Protection Agency, and Dr. Kay Jones from Zephyr Consulting Company. We also received comments from Dr. Houck of Omni Consulting on behalf of the Hearth Products Association.

The authors addressed many of these comments in this final report. We would like to thank our reviewers, and appreciate the time they took to provide valuable feedback on our draft.

Executive Summary

The Puget Sound Clean Air Agency conducted this screening study to identify chemicals and emission sources that pose the greatest potential health risks to citizens in the Puget Sound region. We also hope to better characterize the potential health risks to our three million residents from a group of air contaminants referred to as air toxics. This study is intended to assist the Agency in focusing resources on those emissions and sources that may pose the highest risks. The results should also help improve air toxics regulations and voluntary programs. The estimates of cancer and non-cancer health effects should not be viewed as actual cancer or non-cancer cases resulting from air pollution but as an estimate of relative impact of the evaluated toxic-air pollutants so the Agency can prioritize its efforts to reduce air pollution.

Defining Air Toxics

Air toxics are different from the 6 traditional air pollutants or “criteria pollutants” that have been regulated by environmental regulatory agencies for a number of years. Our agency defines “air toxics” as a broad category of chemicals that covers over 400 air pollutants along with woodsmoke and diesel particles. Similarly, the United States Environmental Protection Agency (USEPA) commonly refers to “air toxics” as a synonym for the 189 hazardous air pollutants listed in the 1990 amendments to the federal Clean Air Act. Because resources are not available to evaluate every chemical, this study evaluates a short list of 17 to 30 air toxics. We hope to expand the list of toxics when more resources become available.

Persistent, Bioaccumulative Toxics (PBTs)

Some persistent, bioaccumulative toxics (PBTs) such as mercury, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), cadmium, and arsenic were included in our study. However, we evaluate potential health risks only from the inhalation pathway, as the ingestion pathway was considered to be beyond the scope of this study.

Methods

This study uses basic risk assessment concepts and models, such as toxicity and exposure assessment, to provide a general overview of the potential health impacts that could be due to air toxics. Because of limited resources, this report does not perform a comprehensive risk

assessment, which would include more detailed analyses and discussion of toxicity and exposure parameters, as well as a more in-depth risk characterization section. More comprehensive information on various details of this study can be found in the technical support documents referenced throughout this report.

Toxicity

The toxicity chapter includes dose-response information on the variety of air toxics evaluated in the Puget Sound region. The majority of this information is based on toxicity analyses performed by USEPA and included in their Integrated Risk Information System (IRIS). For some chemicals and mixtures, such as diesel particulate matter, chromium, and woodsmoke, we depart from recommended USEPA IRIS toxicity values. For example, for diesel particulate matter, we use the California Environmental Protection Agency's toxicity evaluation. Our rationale for this and other departures is described in the toxicity chapter.

Exposure

The toxicity values described above are combined with exposure assessment information to estimate both cancer and non-cancer potential health risks. We use results from three different exposure assessments to characterize air emissions and to estimate potential exposure concentrations for the residents of the Puget Sound area. These three exposure assessments include a monitoring study conducted in the greater Seattle/King County area, and two modeling assessments conducted as part of USEPA National-scale Air Toxics Assessment (NATA) in the four counties in the Puget Sound Clean Air Agency jurisdiction (King, Kitsap, Pierce, and Snohomish counties).

The monitoring study, which was conducted by the Washington State Department of Ecology in partnership with the Puget Sound Clean Air Agency and USEPA, sampled outdoor air at six different locations throughout the greater Seattle/King County area during 2000 and 2001. These six locations include areas near or in Beacon Hill, Georgetown, Lake Sammamish, Lake Forest Park, the Maple Leaf reservoir in north Seattle, and the city of SeaTac.

In addition to the monitoring study, we used exposure estimates from two models used by USEPA in their nationwide air toxics study entitled the National-scale Air Toxics Assessment (NATA). In this study, USEPA predicts outdoor air concentrations using the ASPEN model for 32 air toxics in counties across the country. We obtained the outdoor air concentrations for the four Puget Sound counties, compared them to monitored concentrations, and calculated potential health risks associated with those concentrations.

The third model used to predict exposure concentrations is also part of the NATA study. This model, entitled the Hazardous Air Pollutant Exposure Model (HAPEM4), predicts human exposures to the outdoor air pollutants by considering typical human behaviors and micro-environments where these outdoor pollutants might accumulate or dissipate. For example, this model uses average commute time estimates for a variety of individuals to estimate potential exposures to vehicle exhaust while riding in cars or waiting in traffic. Exposures such as these are combined for multiple activities and locations to estimate an average exposure concentration for each of the 32 air toxics for different population groups.

All exposure concentrations are based on annual averages or medians (the 50th percentile), and residents are assumed to be exposed for 70 years, an average lifetime for an individual. We also assumed that these residents are healthy adults. Because of limited resources, we did not include exposure or toxicity adjustments specific to children, such as changes to body weight. Some health-protective assumptions (e.g., assuming a 70-year exposure period) are included in the toxicity estimates to protect sensitive people such as the elderly or diseased individuals. The health risk estimates are based on a combination of average and reasonably conservative or health-protective assumptions. *This is expected to lead to risk estimates that are reasonably high for the chemicals included in the analysis, but not worst case.*

Results

The primary health effect of concern from the chemicals evaluated in this study is cancer. More specifically, lung cancer is associated with both diesel soot and woodsmoke, although it is also associated with 1,3-butadiene, a mobile source-related contaminant. In addition to lung cancer, leukemia, nasal, and liver cancers are associated with chemicals that ranked high (e.g., benzene,

formaldehyde) in our study. The majority of the cancer risk estimated in our study is due to diesel soot. On average, diesel soot accounts for somewhere between 70% to 85% of the total cancer risk from air toxics in our area. Of the PBTs, arsenic is the only single compound to appear among the top ranking toxics, however, DPM and woodsmoke include numerous PAHs, so we conclude that these mixtures also contribute PBTs to the air in the Puget Sound region.

Our study found that the significant non-cancer health effects from air toxics in our area are primarily due to acrolein. This chemical is associated with upper respiratory irritation.

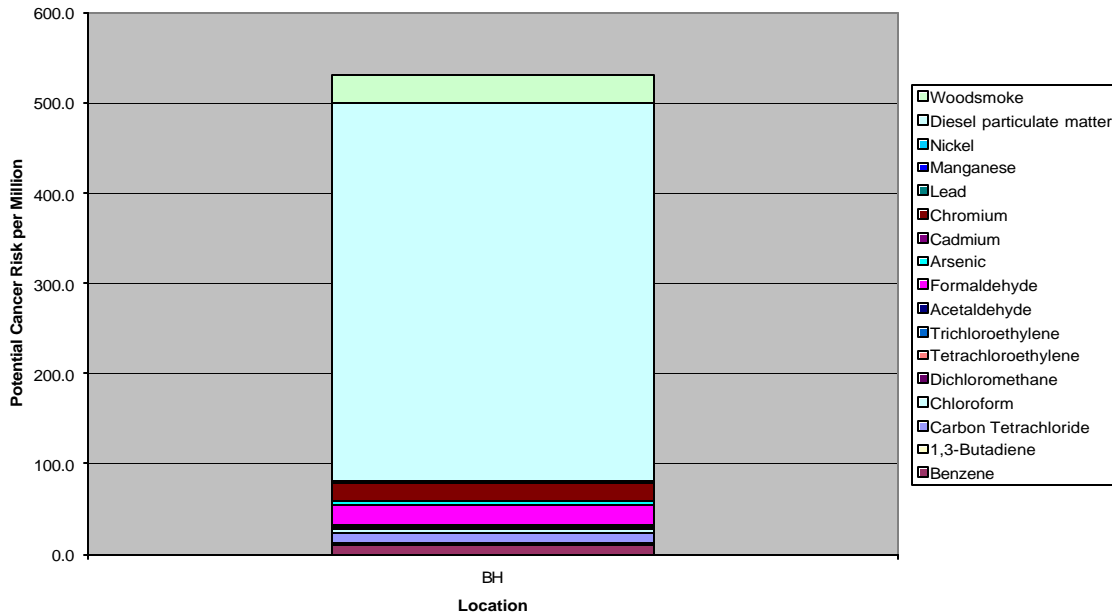
It is important to note, however, that our study does *not* include the serious non-cancer health effects associated with the particle fraction of 2 air toxics: diesel soot and woodsmoke. Non-cancer health effects associated with these particles have been extensively studied and documented in the scientific literature, and a full analysis is beyond the scope of this study.

Potential Cancer Risks

The average cancer risk estimates, even when human and pollutant movement/penetration are considered, are similar among the different methods of calculating exposure concentrations, and across different areas of the Puget Sound region. For example, average cancer risk estimates for King County alone range from approximately 400 to 700 in a million, based on 32 air toxics from the human exposure model and outdoor model data, respectively.

The average cancer risk estimates for the monitored data are approximately 550 in a million for the Beacon Hill area (see Figure ES-1). As described above, the monitoring study only looked at a total of 17 air toxics. The total cancer risks associated with the King County modeled estimates are higher because they include more chemicals, not because the estimates of each chemical are higher.

Figure ES-1: Potential Cancer Risks at Beacon Hill including Diesel Particulate Matter and Woodsmoke



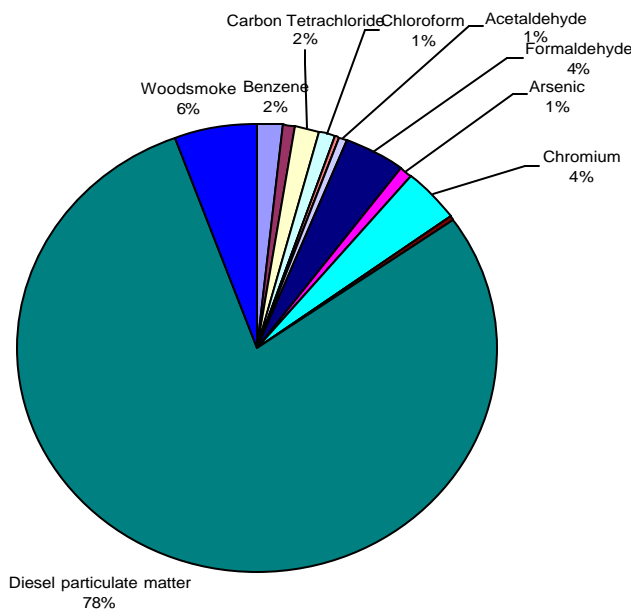
The average cancer risk estimates are also similar in the remaining three counties in the Puget Sound jurisdiction (Kitsap, Pierce, and Snohomish counties), although we do not have monitored information to confirm our findings. The estimated cancer risks range from 400 in a million for all air toxics included in the HAPEM4 model in Snohomish County, including diesel soot, to a high of 600 in a million as an average for 32 ASPEN-modeled ambient concentrations in King County, including diesel soot. All risk estimates reflect a 70-year exposure period. Upper 95th percentile risk estimates based on the modeled ambient concentrations are approximately 980 in a million for King County.

The air toxics that contribute most to the cancer risks are also consistent across the different methods of analysis. **The top toxics for all 3 methods include diesel soot, benzene, formaldehyde, and carbon tetrachloride.** Woodsmoke also contributes to the risk estimates based on the monitored data.

In addition, the percent contribution of the top air toxics is also very similar across the different methods of analysis. For example, at Beacon Hill, diesel soot accounts for over 75% of the potential cancer risks (see Figure ES-2) with another 10% or so coming from volatile organic compounds (VOCs) associated with mobile sources. The King County results from the outdoor

NATA model estimate diesel particulate matter at 86%, with other mobile-source-related chemicals at about 8%, and stationary-source-related chemicals at about 6%. Similarly, the NATA human exposure results indicate a diesel soot contribution of 86%, with other mobile-source-related chemicals at 7%, and stationary sources at about 4%. ***This indicates that mobile sources are likely to account for approximately 85% to 95% of the potential cancer risks among outdoor air toxics.***

Figure ES-2: Contributions to Potential Cancer Risk at Beacon Hill (2001)



The only emission source that ranks high in the monitoring data but not in the modeled data is woodsmoke. This is because woodsmoke emissions are estimated differently. The modeled concentrations associated with woodsmoke reflect very few chemicals in the woodsmoke mixture, while the concentrations based on monitored data reflect a greater number of chemicals present in woodsmoke.

Uncertainties

The large number of assumptions necessary in our study reflects the amount of uncertainty and variability associated with the health risk estimates. It is possible that risk is underestimated because (1) not all air toxics are considered in this analysis, and (2) many chemicals have been shown to accumulate in indoor micro-environments, which could increase exposure. In addition,

potential cancer estimates will underestimate risk for those individuals living near large point sources or “hot spots”. Alternatively, risk may be underestimated or overestimated by assuming that the concentration at the monitor accurately reflects lifetime exposure to ambient pollutants. Obviously, chemical concentrations could increase or decrease throughout the lifetime exposure period.

It is important to note that this analysis does not evaluate indoor sources of air pollution (i.e., from paints, home furnishings, cleaning products, building materials, and other indoor sources). Uncertainties in the toxicity information could also serve to over- or underestimate potential risk estimates. These are only a few of the uncertainties associated with this study. A more detailed discussion can be found in Chapter 5.

In summary, we use screening risk estimates as a tool to focus Clean Air Agency attention on those compounds and mixtures that are likely to present the greatest risk of cancer and some non-cancer effects. Concentrations, and corresponding risks, were relatively consistent among areas measured and modeled throughout the Puget Sound region. Although some differences were apparent, overall it is clear that the sites and the region as a whole have similar emission sources of concern (e.g., diesel particulate matter, mobile-source-related VOCs, and probably woodsmoke).

Diesel soot ranks high in potential contributions to cancer risk, higher than other air toxics measured in this study. However, volatile organics associated with mobile sources, such as benzene and formaldehyde, contribute significantly to the potential cancer risks from air toxics. Diesel soot, benzene, 1,3-butadiene, and formaldehyde are classified as class A or B carcinogens under the USEPA cancer rating system. This indicates that USEPA is relatively confident that these chemicals probably cause cancer in humans. These chemicals should have high priority during development of an air toxics reduction program for the Puget Sound area. Finally, acrolein appears to present a potential non-cancer risk as well. As stated earlier, the non-cancer health effects associated with the particulate-matter-related combustion mixtures (e.g., woodsmoke and diesel soot) are not evaluated here, but present serious non-cancer health risks