Health Consultation

Evaluation of Indoor Air Sampling
Near the Philip Services Corporation
Seattle, King County, Washington

April 16, 2001

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

DOH 334-243 April 2001

Foreword

The Washington State Department of Health (DOH) has prepared this Health Consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This Health Consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this Health Consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. The Health Consultation allows DOH to respond quickly to a request from concerned residents for health information on hazardous substances. It provides advice on specific public health issues. DOH evaluates sampling data collected from a hazardous waste site or industrial site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

For additional information or questions regarding DOH, ATSDR or the contents of this health consultation, please call the Health Advisor who prepared this document:

Robert Duff
Washington State Department of Health
Office of Environmental Health Assessments
PO Box 47846
Olympia, WA 98504-7846
Phone: (360) 236-3371
Toll free: 1-877-485-7316
Website: www.doh.wa.gov/consults

Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Contaminant	Any chemical that exists in the environment or living organisms that is not normally found there.
Dose	A dose is the amount of a substance that gets into the body through ingestion, skin absorption or inhalation. It is calculated per kilogram of body weight per day.
Exposure	Contact with a chemical by swallowing, by breathing, or by direct contact (such as through the skin or eyes). Exposure may be short term (acute) or long term (chronic).
Groundwater	Water found underground that fills pores between materials such as sand, soil, or gravel. In aquifers, groundwater often occurs in quantities where it can be used for drinking water, irrigation, and other purposes.
Hazardous substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Monitoring wells	Special wells drilled at locations on or off a hazardous waste site so water can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides which are not easily dissolved in water.
U.S. Environmental Protection Agency (EPA)	Established in 1970 to bring together parts of various government agencies involved with the control of pollution.
Volatile organic compound (VOC)	An organic (carbon-containing) compound that evaporates (volatilizes) easily at room temperature. A significant number of the VOCs are commonly used as solvents.

Background and Statement of Issues

This health consultation evaluates the results of indoor air samples taken at homes and businesses near the Philip Services Corporation facility (Philip) located in the Georgetown neighborhood of Seattle, King County, Washington. The samples were taken in order to determine whether residents and workers are being exposed to contaminants migrating from groundwater into indoor air. The purpose of this consultation is to determine whether any such exposure exceeds a level of health concern. The Washington State Department of Health (DOH) prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Philip is located at 734 S. Lucile Street in the Georgetown neighborhood of Seattle. The facility receives, packages and ships hazardous waste for off-site treatment and/or disposal. Extensive groundwater monitoring in 1991 revealed significant levels of volatile organic compounds (VOCs) in on-site groundwater and lower VOC levels in off-site groundwater. The source of the contamination is thought to have been twenty-two underground chemical storage tanks used by a previous owner. These tanks were removed along with contaminated soil in 1987.[1]

Drinking water for the area is supplied by the City of Seattle and there are no known active drinking water wells near Philip. Therefore, *drinking water is not a source of exposure for area residents*. However, concern was raised for the potential of these volatile groundwater contaminants to move up into the indoor air of homes and business near the Philip site. A computer simulation of this pathway yielded conflicting results but suggested that some of the VOCs found in off-site groundwater could accumulate in indoor air at levels of health concern.[2] In response to this finding, Philip, the U.S. Environmental Protection Agency and DOH sampled the indoor air of nearby homes and businesses in August 2000.

Maximum and average levels of contaminants of concern detected in the indoor air of residences and businesses near Philip are given in Table 1 below. Selection of contaminants of concern was based on solely on exposure to indoor air since groundwater is not a source of drinking water. Contaminants detected in indoor air were compared to corresponding ATSDR air screening levels for each contaminant. Screening levels are based on the ability of the contaminant to cause either *cancerous* or *non-cancerous* health effects. Each of the contaminants of concern given in Table 1 exceed their respective screening value. Contaminants of concern do not necessarily represent a public health hazard, but signify the need for further evaluation. A complete list of contaminants detected in indoor air near the Philip site is provided in Appendix B, Table B1.

Table 1. Contaminants of concern in indoor air near the Philip Services Corporation site located in Seattle, Washington (ug/m^3)

Contaminant	Maximum	Average	Screening Value	Background Level Indoor	Background Level Outdoor	Source of Background Level Indoor	Source of Background Level Outdoor
1,1,-Dichloroethane	60.0	26.3	NA	NA	0.08 - 0.2	NA	UATMP
1,1,2-trichloro-1,2,2-trifluoroethane (Freon-113)	2.8	1.3	NA	NA	1.3	NA	HSDB
1,2-Dichloroethane	4.1	1.4	0.04	0.5	0.12 - 0.2	Wallace	UATMP
1,2-Dichloropropane	6.5	2.0	4.0	NA	3.2 - 3.4	NA	Ecology
1,3-Butadiene	0.4	0.3	0.004	NA	0.07 - 0.4	NA	UATMP
Benzene	30.0	5.7	0.1	10-15	2.5 - 3.6	Shah [3]/Wallace [4]	Ecology [5]
Carbon Tetrachloride	1.7	1.0	0.07	1-2.5	0.74 - 0.82	Shah/Wallace	Ecology
Chlorobenzene	37.1	6.2	NA	16.5	0.14 - 0.18	Hoddinott [6]	UATMP [7]
Chloroform	3.3	1.3	0.04	0.51-3.0	0.24 - 0.36	Shah/Wallace	Ecology
cis-1,2-Dichloroethene	16.5	6.9	NA	NA	0.27	NA	HSDB [8]
Dichlorodifluoromethane (Freon-12)	11.9	5.4	NA	NA	0.0004	NA	HSDB
Methylene Chloride	330	95.1	3.0	6	0.37 - 1.2	Singh	Ecology
Tetrachloroethene	25.3	6.3	1.7	5.0-15	0.31 - 0.66	Shah/Wallace	Ecology
Trichloroethene	17.2	5.6	0.59	0.67-7.0	0.2 - 0.7	Shah/Wallace	Ecology
Trichlorofluoromethane (Freon-11)	10.1	4.9	NA	NA	1.1	NA	Singh
Vinyl Chloride	0.2	0.1	0.1	NA	0.08 - 0.13	NA	UATMP

The levels of the contaminants of concern listed in Table 1 are accompanied by background levels for both indoor and outdoor air. The background levels represent the amount of contaminants that would be expected in urban indoor and outdoor environments. Vapor migration from groundwater is not assumed to be a significant source for those contaminants in indoor air that are within the range of background.

Discussion

The indoor air samples taken at residences and businesses within the boundaries of the groundwater contamination plume contained several VOCs. Most of these VOCs were detected at levels consistent with those normally found in indoor urban environments. However, the presence of some VOCs in indoor air at levels above background indicate a possible connection with those found in groundwater. The following discussion examines the health implications associated with exposure to the contaminants found in indoor air. Results of groundwater and soil gas sampling are also discussed in terms of a potential link with contaminants found in indoor air.

Evaluating Non-cancer Risk

Inhalation Reference Concentrations (RfCs)

Inhalation reference concentrations (RfCs) are levels of a contaminant in air below which non-cancer adverse health effects are not expected to occur. RfCs are set by EPA based on continuous (i.e., 24-hour/day) exposure. They are set below the actual toxic effect levels seen in the studies upon which they are based in order to provide adequate health protection.

The maximum and average levels of indoor air contaminants were evaluated for their potential to cause *cancerous* and *non-cancerous* adverse health effects for residents and workers exposed over long periods of time. In order to evaluate the potential for *non-cancerous* adverse health effects, the concentrations in indoor air are compared with EPA's inhalation reference concentrations. RfCs are concentrations of a chemical in air below which non-cancer adverse health effects are not expected to occur.[9] RfCs are set well below the actual toxic effect levels (also known as the lowest observed adverse effect level or LOAEL) found in the studies upon which they are based. This approach provides additional health protection to account for the uncertainly involved in setting these "safe" levels of exposure.

A comparison of average levels of contaminants detected in indoor air samples showed that none exceeded their respective RfCs. Maximum levels of methylene chloride (330 ug/m^3) and 1,2-dichloropropane (6.5 ug/m^3) were slightly higher than their respective RfCs which are based on liver and respiratory tract toxicity, respectively.[a] However, these levels were more than 500 and 200-fold below their respective LOAELs.[9] The large discrepancy between the maximum detected indoor air concentrations and the LOAELs for theses two contaminants indicate that adverse health effects are unlikely.

In almost every situation of environmental exposure, there are multiple contaminants to consider. Since many of the VOCs detected in indoor air can affect the liver it is appropriate to consider the potential for *combined* exposure to cause liver toxicity. However, there is insufficient data to consider all the possible interaction in the body that may occur from multiple chemical exposure. While there is a considerable amount of uncertainty associated with assessing exposure to multiple chemicals, overall exposure to the levels detected in these indoor air samples can be *summed* and compared to a *"combined"* RfC, known as a hazard index. An assessment and discussion of combined exposure is given in Appendix C. Since many of the contaminants detected, including 1,2-dichloropropane, are commonly found in urban, indoor air environments, it is important to compare the hazard index calculated from these data with background. This comparison is given in Table 2 below following the cancer risk evaluation.

Evaluating Cancer Risk

[a] For contaminants with no RfC available, such as methylene chloride, a dose was calculated based on continuous exposure and compared to the oral reference dose (RfD). The RfD is based on oral exposure comparted to the inhalation route on which the RfC is based. Use of the RfD for comparison with inhalation exposure carries some uncertainty.

EPA has designated some of the contaminants as known human carcinogens (Group A) while others are considered probable (Group B) or possible (Group C) or carcinogens. A chemical is considered to be a probable or possible carcinogen when laboratory studies on animals are the only credible evidence available. A chemical will be designated as a known human carcinogen when sufficient evidence of cancer in humans exits.[b] The relevance of cancer found in high dose laboratory animal studies for humans exposed to much lower levels found in the environment is questionable. Such animal data are considered to be much stronger when supported by evidence of cancer in humans. The EPA cancer classification for each detected contaminant is given in Appendix C, Table C1.

Estimating Cancer Risk

For many carcinogens, cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of excess cancers expected in a lifetime:

Term		# of Excess Cancers
moderate	is approximately equal to	1 in 1,000
low	is approximately equal to	1 in 10,000
very low	is approximately equal to	1 in 100,000
slight	is approximately equal to	1 in 1,000,000

In addition to this weight of evidence approach, the potential for these chemicals to cause cancer can be evaluated using numeric estimates of cancer potency. The estimates generated by this approach are theoretical and are associated with much uncertainty. Actual cancer risks associated with low level exposure to these contaminants may be lower and could be zero. *Overall cancer risk estimates associated with exposure to the contaminants detected in these indoor air samples range from moderate to low.* The contaminants that contribute most of this risk are 1,4-dichlorobenzene, benzene,1,3-butadiene, methylene chloride, chloroform, 1,2-dichloroethane and 1,1-dichloroethane (see Appendix C, Table C1).

Comparison with Background

The presence of contaminants in ambient and indoor air in urban areas has been well established. It is also clear that levels of VOCs in indoor air are consistently higher than those found in ambient air. Therefore, it is important to consider the background risks associated with exposure to indoor air contaminants in order to better evaluate whether unique sources such as VOCs in groundwater are contributing additional exposure. Table 2 below gives a comparison

Background

Background is defined here as the amount of VOCs expected to be present in air without any known contribution from a particular source. Since VOCs are expected to be present in urban indoor and outdoor air, it useful to estimate what the expected level is in order to determine whether levels are higher due to an identified source.

[b] EPA has proposed new guidelines for the assessment of chemical carcinogenicity. These new guidelines make several modifications to existing guidance including the use of new classification categories (i.e., known/likely, cannot be determined and not likely) in place of the alpha-numeric grouping system (i.e., Group A, B, C, D, E).

of the maximum, average and background non-cancer and cancer risk associated with indoor air exposure near the Philip site.

Table 2. Cancer risk associated with exposure to indoor air near the Philip Services Corporation site located in Seattle, Washington (ug/m^3).

	Indoor Air Near Philip		**Background Indoor Air** (Urban)
	Maximum	Average	
Cancer Risk	2 in 1,000	5 in 10,000	5 in 10,000
Hazard Index [a]	7	2	2

a = Represents the overall non-cancer risk as explained in Appendix B.

As shown, the non-cancer and cancer risk associated with average levels of contaminants found in indoor air are similar to those expected in a typical, urban indoor-air environment (i.e., background). Estimates using maximum detected levels are about 4-fold higher than background in each case.[c] Upper-bound estimates of cancer risk associated with background exposure to VOCs have been estimated as high as one 1 in 1,000. [6,10] The presence of this level of background exposure in urban areas illustrates the need for an overall reduction in industrial emissions and home use of VOCs as well as good land use practices that will keep urban residences situated away from additional sources of exposure. It is important to note that other air contaminants not included in a VOC analysis are likely to contribute to this overall risk estimate (e.g., formaldehyde).

Contribution from Groundwater

Most of the contaminants of concern fall within the range of background concentrations and are not considered to be originating from groundwater. However, some contaminants found at elevated levels in indoor air were also found in groundwater and soil gas. Appendix D, Table D1 provides the maximum levels of all contaminants detected in soil gas near or beneath Residences 1 and 2 along with the corresponding maximum, average and background levels found in indoor air at these homes. This comparison shows that 1,1-dichloroethane, methylene chloride and cis-1,2-dichloroethene were elevated in both soil gas and indoor air. Vinyl chloride, present at high levels in groundwater, was also detected at trace levels in indoor air and soil gas. This comparison between soil gas and indoor air indicates a possible connection between contaminants in groundwater and indoor air. Establishing such a connection is complicated, however, by the possibility that other sources could be present.

Community Health Concerns

[c] Cancer risk associated with indoor air near Philip were calculated using the entire data set as presented in Appendix B, Table B1. Risks calculated using only samples from Residences 1 and 2 did not substantially differ. Non-detects were set at one-half detection limit in each case. Elimination of non-detects did not significantly alter risk numbers.

- **Exposure of Children at Georgetown Play Field**

Concerns have been expressed to EPA and DOH pertaining to the potential for exposure of children at a nearby city park to contaminants in groundwater originating from the Philip site. The potential for exposure and subsequent adverse health effects are often increased for young children as opposed to older children or adults. For example, children breathe more air per unit of body weight than do adults. In addition to the potential for higher exposures of young children, the risk of adverse health effects is also increased. ATSDR and DOH recognize that children are susceptible to developmental toxicity that can occur at levels much lower than those causing other types of toxicity.

Contamination from the Philip property is not a concern relative to children contacting soil or surface water (i.e., puddles) at the park. Off-site contamination from Philip is restricted to groundwater. Since *groundwater is not being used as a drinking water source* in the neighborhood (including the park drinking water fountains), the only pathway by which residents could be exposed to chemicals in groundwater is by volatilization through the soil into air. The volatile nature of the chemicals in groundwater can present a problem if they move into and accumulate inside a structure. However, volatilization through the soil and into ambient air is not expected to result in significant exposure. In addition, groundwater sampling data indicate that the plume originating at Philip is moving west and not toward the park. Therefore, *groundwater contamination in the area is not a concern for children playing at the park.*

- **Ambient air emissions from Philip Services Corporation**

Community members have expressed concern over ambient air emission from the Philip facility. Residents and workers have complained about odors and headaches. Richard Stedman (DOH) conducted an inspection of the facility on September 1, 2000, for potential emission sources. No tanks were being loaded at the time and the soil-vapor extraction system was not operating. Tanks loadings and the vapor extraction system are considered to be the only potential air emission sources at the Philip facility. DOH will prepare a separate health consultation evaluating the impact of these sources on ambient air and the potential for exposure of nearby workers and residents.

- **Vegetable and Fruit Gardens**

Measurements made in July 2000 along Denver Avenue directly across from the Philip site indicate that the water table is approximately 10 feet below ground surface. The depth of the water table decreases moving west towards the Duwamish River. Root systems of vegetables and garden fruit (i.e., berries) are not expected to contact groundwater. Deposition on vegetables and garden fruit from VOCs moving from groundwater through soil into ambient air and onto the fruit is not expected to be a significant pathway. Therefore, *eating fruits and vegetables grown in gardens near the Philip site is not of concern with respect to contaminants in groundwater.*

Fruit trees have deeper root systems than vegetables and garden fruit but the depth of the roots will vary depending upon the type and age of the tree, soil, care and other factors. The only fruit trees noted in the area of groundwater contamination are located along Denver Avenue directly across from the Philip site. Since the water table could rise during the winter months, it is possible that some contaminated water could come in contact with these fruit trees. There is little information, however, regarding accumulation of contaminants in fruit through root uptake from groundwater. EPA has requested that Philip evaluate this potential pathway of exposure. The owners of these fruit trees will be made aware of the findings of this evaluation.

Conclusions

1) Levels of contaminants found in indoor air near the Philip Services site pose *no immediate health hazard*. Most of the detected chemicals are present at levels normally found in urban, indoor air environments. While long-term exposure risks are similar to those of any urban home, the presence of some contaminants in indoor air at levels above background indicate a slight increase in cancer risk. Cancer risks calculated here are estimates based on 30 years of exposure. Uncertainties associated with these estimates indicate that actual risks may be lower and could be zero.

2) Some chemicals that were found at higher than expected levels in indoor air were also found in soil gas. It is possible that the estimated increase in cancer risk from long-term exposure to these volatile organic compounds (VOCs) in indoor air could, at least in part, be related to contaminants moving from groundwater into indoor air. However, the available data are not sufficient to draw a clear connection between these elevated indoor air contaminants and groundwater. Therefore, *an indeterminate public health hazard exists with respect to risks associated with* ***long-term*** *exposure to VOCs that have migrated into in indoor from groundwater.*

3) VOCs are found in outdoor and indoor air in all urban areas. Outdoor sources include automobile exhaust and industrial emissions while indoor air contaminants often come from household cleaners, paints, carpeting and building materials. Background levels of VOCs in indoor and outdoor air are a significant source of exposure for residents living in urban environments. Health risks associated background exposure can be similar to or higher than risks from localized hazardous waste releases to the environment.

Recommendations

1) Further indoor air sampling of Residences 1 and 2 during should be conducted during late winter to assess any seasonal impacts on this pathway. A higher water table could increase the ability of VOCs to infiltrate from groundwater into indoor air.

    Actions Proposed

    < DOH will re-sample indoor air at Residences 1 and 2 during late winter when the water table is expected to be at its highest level.

2) Philip should repeat groundwater and soil gas sampling beneath and around Residences 1 and 2 concurrent with the next round of indoor air samples.

3) Residents should ensure that indoor sources of VOCs (e.g., cleaning fluids, gasoline, paints) are stored in sealed containers, preferably outside the home (e.g., garage or shed). Good ventilation is also necessary to maintain good indoor air quality. For more information on maintaining good indoor air quality in your home, call 1-877-485-7316.

Preparer of Report

Robert M. Duff
Office of Environmental Health Assessments
Washington State Department of Health

ATSDR Technical Project Officer

Debra Gable
Division of Health Assessment and Consultation
Superfund Site Assessment Branch

References

1. Philip Service Corporation. Georgetown Community Newsletter. August 3, 2000. Number 1.

2. Environmental Management Inc. Memorandum from Craig S. Mann to Marcia Bailey, Subject: Vapor Intrusion Pathway Analysis for the Philip Services Corporation. June 29, 2000.

3. Shah JJ. And Singh HB. Distribution of volatile organic chemicals in outdoor and indoor air. *Environ Sci Tecnol*. 1988;22(12):1381-1388.

4. Wallace LA and Pellizzari. Total Exposure Methodology (TEAM) Study: Personal exposures, indoor-outdoor relationships and breath levels of volatile organic compounds in New Jersey. *Environment International.* 1986;12:369-87.

5. Washington State Department of Ecology. Ambient air VOC measurements from January 13 through June 20, 2000. Electronic file.

6. Hoddinott KB and Lee AP. The use of environmental risk assessment methodologies for an indoor air quality investigation. *Chemosphere*. 2000;41:77-84.

7. U.S. Environmental Protection Agency. 1997 Urban Air Toxics Monitoring Program. January 1999. EPA-454/R-99-036.

8. National Libraries of Medicine. Toxicology Data Network (TOXNET): Hazardous Substances Dat Bank. October 2000. Internet: http://toxnet.nlm.nih.gov/.

9. U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS2). Internet: http://www.epa.gov/iris/ July 1999.

10. Wallace LA. Comparison of risks from outdoor and indoor exposure to toxic chemicals. *Environ Health Perspect*. 1991;95:7-13.

APPENDIX A: Figures

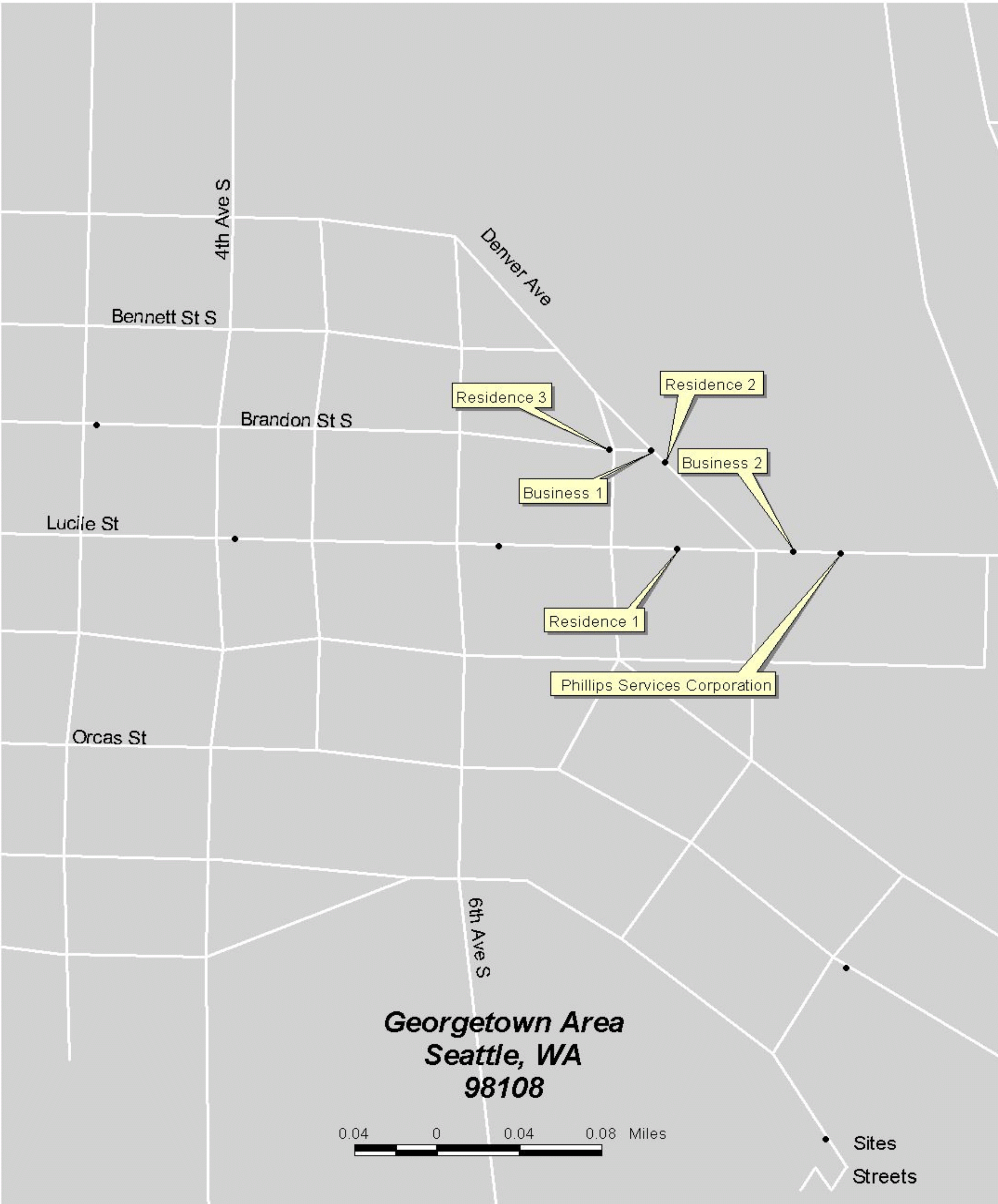

Figure 1. Location of Philip Services Corporation and Indoor Air Sampling Sites.

APPENDIX B. Indoor Air Sampling Data

Table B1. Volatile organic compounds (VOCs) detected in indoor air near the Philip Services site located in Seattle, Washington (ug/m^3).

Contaminant	DOH				EPA		Philip	
	Residence 1	Residence 2	Residence 3	Business 1	Residence 2	Business 2	Residence 1	Residence 2
1,1,1-trichloroethane	*0.74*	*0.74*	**4.42**	*0.74*	NA	NA	3.20	2.10
1,1,2,2-tetrachloroethane	*1.61*	*1.61*	*1.61*	*1.61*	0.14	0.07	0.10	**0.24**
1,1,2-trichloroethane	*0.65*	*0.65*	*0.65*	*0.65*	**0.49**	0.05	0.08	0.19
1,1-dichloroethane	*0.67*	*0.67*	*0.67*	*0.67*	**59.96**	45.12	*0.06*	0.14
1,1-dichloroethene	*1.03*	*1.03*	*1.03*	*1.03*	0.71	**0.87**	*0.06*	0.14
1,2,4-trichlorobenzene	*5.56*	*5.56*	*5.56*	*5.56*	**0.22**	0.15	NA	NA
1,2-dichloroethane	*1.42*	5.91	*1.42*	*0.74*	0.81	0.69	0.20	**4.10**
1,2-dichlorobenzene	*0.66*	*0.66*	*0.66*	*0.66*	0.12	0.06	*0.09*	**0.21**
1,2-dichloropropane	*1.02*	*1.02*	*1.02*	*1.02*	**6.47**	1.34	*0.07*	0.16
1,3-butadiene	NA	NA	NA	NA	**0.42**	0.11	NA	NA
1,3-dichlorobenzene	*0.60*	*0.60*	*0.60*	*0.60*	0.12	0.06	*0.09*	**0.21**
1,4-dichlorobenzene	*0.87*	*0.87*	*0.87*	*0.87*	16.71	**35.70**	0.38	0.21
2-butanone	*1.77*	**22.41**	9.73	5.90	NA	NA	NA	NA
acetone	28.49	23.27	28.49	26.12	NA	NA	**38.00**	35.00
benzene	*0.65*	*0.65*	0.65	1.50	**29.95**	6.39	3.90	1.60
bromoethane	*1.18*	*1.18*	*1.18*	*1.18*	3.79	**3.48**	NA	NA
cis-1,2-dichloroethene	*0.57*	*0.57*	*0.57*	*0.57*	10.82	**16.49**	*0.06*	0.14
cis-1,3-dichloropropene	*0.77*	*0.77*	*0.77*	*0.77*	**0.54**	0.27	*0.07*	*0.16*
carbon tetrachloride	*0.56*	*0.56*	*0.56*	*0.56*	0.69	1.70	1.00	0.69
chlorobenzene	*0.90*	*0.90*	*0.90*	*0.90*	**37.09**	8.97	0.14	*0.16*
chloroform	2.20	*0.85*	*0.85*	*0.85*	**3.32**	0.98	0.83	0.37
chloromethane	1.57	*0.64*	1.88	1.80	NA	NA	**2.00**	1.50
ethylbenzene	*1.35*	*1.35*	*1.35*	**8.25**	2.55	7.79	1.90	0.80
freon-11	1.91	10.11	5.62	2.02	**15.16**	11.16	NA	NA
freon-113	*0.61*	*0.61*	*0.61*	2.30	7.58	**56.28**	0.70	2.80
freon-12	2.92	3.36	**11.86**	3.26	13.30	3.84	NA	NA
m,p-xylene	5.21	*1.74*	3.99	**27.78**	20.97	30.73	5.80	2.20
dichloromethane (methylene chloride)	93.75	180.55	18.75	4.17	2.99	0.28	130.00	**330.00**
o-xylene	*1.32*	*1.32*	*1.32*	6.08	3.30	**9.80**	1.70	0.70
tetrachloroethene	*1.32*	*1.49*	*1.49*	6.44	**25.22**	10.17	2.60	1.40
styrene	1.23	*0.57*	*0.57*	*0.57*	NA	2.84	0.62	0.41
trans-1,2-dichloroethene	*1.27*	*1.27*	*1.27*	*1.27*	NA	NA	0.06	**0.14**
trichloroethene	*1.42*	*1.42*	**17.19**	1.42	3.06	12.52	3.30	4.50
toluene	9.42	21.10	22.98	33.90	**349.98**	23.81	23.00	13.00
vinyl chloride	*0.74*	*0.74*	*0.74*	*0.74*	**1.05**	NA	0.15	0.04

Bolded values indicate the maximum detection for that contaminant.
Italicized values represent one-half the detection limit for those contaminants that were below detection.

APPENDIX C. Health Risk Estimates

In order to evaluate the potential for *non-cancer* adverse health effects that might result from exposure to contaminants found in indoor air, maximum and average levels detected were compared to RfCs. The RfC represents a concentration of a contaminant in air below which continuous exposure is not expected to cause adverse health effects. Each RfC was also divided by the exposure concentration to give a *hazard quotient* which were then summed to yield a hazard index that provides an assessment of overall exposure relative to the potential for non-cancer adverse health effects. Cancer risk estimates were generated by multiplying the maximum and average detected levels by inhalation unit risk values which were then summed to provide an overall risk estimate.

RfCs and unit risk values were not available for many of the contaminants detected. Many of these were evaluated by calculating a dose based on continuous exposure and using oral reference doses (RfDs) and oral cancer potency factor to generate hazard quotients and cancer risks. The use of toxicity data from oral exposure studies introduces some uncertainty in the overall assessment. Since no toxicity values were available for some of the contaminants (e.g., the freons), these chemicals were not included in the health evaluation and could represent an underestimate of the overall risk. Only those contaminants detected in at least one sample are included. Non-detect results are included in the calculation of maximum and average exposure point concentrations as one-half the limit of detection.

A continuous adult exposure scenario of 24 hours/day 365 days/year over 70 years was used to generate doses for use with RfDs and oral cancer potency factors. This approach is consistent with the derivation of the RfCs and inhalation unit risks.

Multiple Chemical Exposure

In almost every situation of environmental exposure, there are multiple contaminants to consider. The potential exists for these chemicals to interact in the body and increase or decrease the potential for adverse health effects. The vast number of chemicals in the environment make it impossible to measure all of the possible interactions between these chemicals. Individual cancer risk estimates can be *added* since they are measures of probability. When estimating non-cancer risk, however, similarities must exist between the chemicals if the doses are to be added. Groups of chemicals that have similar toxic effects can be added such as volatile organic compounds (VOCs) which cause liver toxicity. Although some chemicals can interact to cause a toxic effect that is *greater than* the added effect, there is little evidence demonstrating this at concentrations commonly found in the environment.

Table C1. Estimated health risk associated with exposure to volatile organic compounds (VOCs) found indoor air near the Philip Services Corporation

Contaminant	**Concentration** Max (ug/m^3)	**Concentration** Average (ug/m^3)	**Inhalation Unit Risk** (per ug/m^3)	**RfC** [a] (mg/m^3)	**Cancer Risk** Max	**Cancer Risk** Average	**Hazard Quotient** Max	**Hazard Quotient** Average	**EPA Cancer Class**
1,1,1-trichloroethane	4.4	2.0							D
1,1,2,2-tetrachloroethane	1.6	0.9	5.8e-05		9.4e-05	5.1e-05			C
1,1,2-trichloroethane	0.7	0.4	1.6e-05	*4.0e-03*	1.0e-05	6.9e-06	4.7e-02	3.1e-02	C
1,1-dichloroethane	60.0	13.5	1.6e-06		9.6e-05	2.2e-05			C
1,1-dichloroethene	1.0	0.7	5.0e-05		5.2e-05	3.7e-05			C
1,2,4-trichlorobenzene	5.6	3.8		*1.0e-02*			1.6e-01	1.1e-01	D
1,2-dichloroethane	5.9	1.9	2.6e-05		1.5e-04	5.0e-05			B2
1,2-dichlorobenzene	0.7	0.4		*9.0e-02*			2.1e-03	1.2e-03	D
1,2-dichloropropane	6.5	1.5	1.8e-05 [b]	4.0e-03	1.2e-04	2.7e-05	**1.6e+00**	3.8e-01	NA
1,3-butadiene	0.4	0.3	2.8e-04		1.2e-04	7.4e-05			B2
1,3-dichlorobenzene	0.6	0.4							D
1,4-dichlorobenzene	35.7	7.1	1.1e-05 [b]	8.0e-01	3.9e-04	7.8e-05	4.5e-02	8.8e-03	NA
2-butanone	22.4	10.0		1.0e+00			2.2e-02	9.9e-03	D
acetone	38.0	29.9		*1.0e-01*			1.1e-01	8.5e-02	D
benzene	30.0	5.7	7.8e-06		2.3e-04	4.4e-05			A
bromomethane	3.8	2.0		5.0e-03			7.6e-01	4.0e-01	D
cis-1,3-dichloropropene	0.8	0.5	4.0e-06	2.0e-02	3.1e-06	2.1e-06	3.9e-02	2.6e-02	B2
cis-1,2-dichloroethene	16.5	3.7							D
carbon tetrachloride	1.7	0.8	1.5e-05	*7.0e-04*	2.5e-05	1.2e-05	6.9e-01	3.2e-01	B2
chlorobenzene	37.1	6.2		*2.0e-02*			5.3e-01	8.9e-02	D
chloroform	3.3	1.3	2.3e-05	*1.0e-02*	7.6e-05	2.9e-05	9.5e-02	3.7e-02	B2
chloromethane	2.0	1.6							NA
ethylbenzene	8.3	3.2		1.0e+00			8.2e-03	3.2e-03	D
freon-11	15.2	7.7							NA
freon-113	56.3	8.9							NA
freon-12	13.3	6.4							NA
m,p-xylene	30.7	12.3		*2.0e+00*			4.4e-03	1.8e-03	D
methylene chloride (dichloromethane)	330.0	95.1	4.7e-07	*6.0e-02*	1.6e-04	4.5e-05	**1.6e+00**	4.5e-01	B2
o-xylene	9.8	3.2		*2.0e+00*			1.4e-03	4.6e-04	D
tetrachloroethene	25.2	6.3	5.8e-07		1.5e-05	3.6e-06			C-B2
styrene	2.8	1.0		1.0e+00			2.8e-03	9.8e-04	NA
trans-1,2-dichloroethene	1.3	0.9		*2.0e-02*			1.8e-02	1.3e-02	NA
trichloroethene	17.2	5.6	1.7e-06		2.9e-05	9.5e-06			C-B2
toluene	350.0	62.2		4.0e-01			8.7e-01	1.6e-01	D
vinyl chloride	1.0	0.5	8.8e-06	1.0e-01	9.2e-06	4.6e-06	1.0e-02	5.3e-03	A
SUM					**2e-03**	**5e-04**	**7e+00**	**2e+00**	

a = RfC is given in units of mg/m^3 and assumes a continuous exposure (i.e., 24 hours/7 days/week/365 days/year). *Italicized* values indicate a surrogate RfD value.

b = Inhalation unit risk taken from California Environmental Protection Agency's Criteria for Carcinogens.

Bolded hazard quotient values exceed 1 (i.e., concentration exceeds RfC).

APPENDIX D. Volatile Organic Compounds (VOCs) in Soil Gas and Indoor Air.

Table D1. A comparison of contaminants found in soil gas and indoor air at Residences 1 and 2 located near the Philip Services Corporation site in Seattle, Washington (ug/m^3).

Chemical	Soil Gas		Indoor Air		Background [a]	
	Maximum	Average	Maximum	Average	Indoor	Ambient
Acetone	280	141.6	38	31.2	20.4	1.2 -3.6
Benzene	4.4	2.6	30	7.4	10 -15	2.5 - 3.6
Carbon Tetrachloride	340	169.6	1	0.7	1 - 2.5	0.74 - 0.82
Chlorobenzene	62	21.3	37.1	7.8	16.5	0.14 - 0.18
Chloroform	160	17.4	3.3	1.5	0.51 - 3.0	0.24 - 0.36
Chloromethane	1.2	0.5	2	1.4	NA	1.7 - 3.5
1,1-Dichloroethane	350	69	60	12.3	NA	0.08 - 0.2
1,1-Dichloroethene	6.9	1.8	1	0.6	NA	NA
1,2-Dichloroethane	0.4	0.4	5.9	2.5	0.5	0.12 - 0.2
cis-1,2-Dichloroethene	160	72.4	10.8	2.4	NA	0.27
trans-1,2-Dichloroethene	2.9	1.6	1.3	0.7	NA	0.18
Ethylbenzene	84	25.5	2.5	1.6	7	0.38 - 2.8
Methylene Chloride	3.8	1.9	330	147.5	6	0.37 - 1.2
Styrene	1.2	1	1.2	0.7	1	0.14 - 0.73
Freon-113	850	209.7	7.6	2.5	NA	1.3
Tetrachloroethene	75	20.9	25.2	6.4	5	0.31 - 0.66
Toluene	7.6	4.7	350	83.3	17.6	2.4 - 26.4
1,1,1-Trichloroethane	2500	432.3	3.2	1.7	10 - 30	0.38
1,1,2-Trichloroethane	13.5	6.6	0.7	0.4	10	NA
Trichloroethene	22	4.8	4.5	2.7	0.67 - 7.0	0.2
Vinyl Chloride	0.5	0.3	1	0.5	NA	0.08
Total Xylenes	420	102.9	24.3	8.9	5.7 - 17.3	0.56

a = Background values for indoor and ambient air are derived from References 3 - 7.

Certification

This health consultation was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

____

Debra Gable
Technical Project Officer, SPS, SSAB, DHAC
ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

____

Richard Gillig
Chief, SPS, SSAB, DHAC
ATSDR