Health Consultation

Indoor Air Evaluation
Cadet Manufacturing Company Site
Vancouver, Clark County, Washington

May 6, 2003

Prepared by

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

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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 a health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation, and should not necessarily be relied upon if site conditions or land use changes in the future.

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

Barbara J. Trejo
Washington State Department of Health
Office of Environmental Health Assessments
P.O. Box 47846
Olympia, WA 98504-7846
(360) 236-3373
FAX (360) 236-2251
1-877-485-7316
Website: www.doh.wa.gov/consults

For more information about ATSDR, contact the ATSDR Information Center at 1-888-422-8737 or visit the agency's Web site: www.atsdr.cdc.gov/.

Glossary

Acute	Occurring over a short time.
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.
Aquifer	An underground formation composed of materials such as sand, soil, or gravel that can store and/or supply groundwater to wells and springs.
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate it's ability to cause cancer in humans.
Carcinogen	A substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year).
Comparison value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute**], of intermediate duration [**intermediate**], or long-term [**chronic**].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces.
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.
Indeterminate public health hazard	The category used in ATSDR's health consultation documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.
Ingestion rate	The amount of an environmental medium which could be ingested typically on a daily basis. Units for ingestion rate are usually liter/day for water, and mg/day for soil.
Intermediate	Occurring over an intermediate time (more than 14 days and less than one year).

Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
Monitoring wells	Special wells drilled at locations on or off a hazardous waste site so groundwater can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.
Nonaqueous phase liquids	Nonaqueous phase liquids (NAPLs) are chemicals that are present in the subsurface as a liquid. These can be individual chemicals like trichloroethene (TCE), a solvent, or a mixture such as gasoline. Light NAPLs (i.e. LNAPLs) are liquids that float on the groundwater table and include chemicals like gasoline. Dense NAPLs (i.e. DNAPLs) are heavier than water and sink forming lenses or pockets of the chemical in a groundwater aquifer. Both LNAPLs and DNAPLs can also be found in the vadose zone as residue on soil particles or in pools or pockets on low permeability soil lenses.
No apparent public health hazard	A category used in ATSDR's health consultation reports for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard	A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides which are not easily dissolved in water.
Plume	A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.
Public Health Hazard	A category used in ATSDR's health consultation reports for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances that could result in harmful health effects.
Remedial investigation	The process of determining the type and extent of hazardous substance contamination at a site.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

U.S. Environmental Protection Agency (EPA)	Established in 1970 to bring together parts of various government agencies involved with the control of pollution.
Vadose Zone	Soils located above the groundwater table.
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

The Washington State Department of Health (DOH) conducted this health consultation at the request of the Washington State Department of Ecology (Ecology). The purpose of the health consultation is to evaluate whether residents of the Fruit Valley Neighborhood (FVN), located within the City of Vancouver, Clark County, Washington, are being exposed to harmful levels of chlorinated solvents suspected to be migrating from groundwater into indoor air. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

The FVN is located in a mixed industrial, commercial, and residential area of Vancouver. It is bounded by West Fourth Plain Boulevard to the south; Burlington Northern Santa Fe (BNSF) railroad tracks to the east; West 39th Street and Lafrombois Road to the north; and industrial properties including the Cadet Manufacturing Company (Cadet) to the west (Figure 1). Port of Vancouver (POV) property is located to the south of West Fourth Plain Boulevard.

Chlorinated solvents, including trichloroethene (TCE) and tetrachloroethene (PCE), have been detected in groundwater samples collected from the unconsolidated sedimentary aquifer underlying the FVN. TCE concentrations in the shallow portion of this aquifer below the FVN have been measured as high as 5,010 micrograms per liter (ug/L). The major source of this groundwater contamination appears to be Cadet, an electric heater manufacturing facility, located at 2500 West Fourth Plain Boulevard, which is west and hydraulically upgradient of the FVN (Figure 1). TCE concentrations in the shallow portion of this aquifer underlying the Cadet facility have been measured as high as 70,000 ug/l. TCE was used at the Cadet facility, in the past, for metal degreasing.[1] Based on groundwater and soil gas solvent concentrations detected below the Cadet property, other chlorinated solvents including PCE may also have been used at the facility. Sources to the south of the FVN may also be contributing low levels of some of the same chemicals to the groundwater. The Cadet site, which includes the Cadet property and properties within the FVN affected by releases from Cadet, is being investigated and remediated under the oversight of Ecology pursuant to the Model Toxics Control Act (MTCA).[1]

Recent groundwater data, which was obtained using nitrogen gas-driven sampling pumps, suggest that the chlorinated solvent-contaminated groundwater plume has migrated eastward to the BNSF railroad tracks, northward between W. 31st Street and LaFrambois Road, and southeastward toward the Port of Vancouver property.[2] It should be noted that nitrogen gas-driven sampling pumps may cause some volatilization of the groundwater contaminants if not operated properly.

Groundwater solvent concentrations at some of the monitoring wells located on the Cadet property suggest that dense nonaqueous phase liquids (DNAPLs) exist in the underlying aquifer. Chlorinated solvent concentrations in soil gas on the property suggest that DNAPLs may also exist in vadose zone soils.[1] These subsurface DNAPLs are a continuing source of chemicals to groundwater.

Cadet conducted a well survey in the FVN in mid-2001 to determine whether anyone within the area bounded by West Fourth Plain Boulevard to the south, BNSF railroad tracks to the east, Weigel Avenue to the west, and West 31th Street to the north was using groundwater. However, only 34% of the addressees contacted responded. Cadet reviewed Ecology well logs and contacted the Southwest Washington Health District to supplement the information obtained during the survey.[1] In some cases, Cadet obtained information about water use from observations made from the exterior of the residence.[3] One private well, which appears to have been unused for at least the last 16 years, was the only well identified.[1] This information suggests none of the homes and businesses in this area use the groundwater for domestic purposes (drinking water or other household uses), industrial use, or irrigation and that they likely receive water from a local public water supply system. As a result, residents and workers within the surveyed area are not expected to be exposed to the groundwater contaminants through ingestion or dermal (skin) contact . The area surveyed by Cadet, however, is only a portion of the area now known to be underlain by contaminated groundwater.[2]

Significant levels of chlorinated solvents have been detected in soil gas below the Cadet building, including TCE, which has been measured as high as 1,800,000 micrograms per cubic meter (ug/m^3). Soil gas sampling conducted by Cadet in 2000 along the eastern property boundary and the sanitary sewer easement, which connects the Cadet sewer line with the main sewer line in Weigel Avenue, indicates that relatively low levels of chlorinated solvents are migrating from the Cadet property into the FVN via soil gas. The sanitary sewer easement, where backfill similar to native soils was encountered, does not appear to be a preferential pathway for contaminant release to the FVN. No other utility line easements connect the Cadet property with the nearby FVN.[1]

Cadet conducted soil gas sampling directly below the FVN in August 2001 to measure chlorinated solvent concentrations. Contaminant concentrations in these samples were one to two orders of magnitude higher than the soil gas levels measured along the sanitary sewer easement.[1] This data suggest that the chlorinated solvents dissolved in the shallow groundwater are volatilizing and moving up through the soil column posing a potential inhalation health risk to building occupants living above the contaminated groundwater.

DOH used a computer model that predicted that some of the chlorinated solvents detected in groundwater below the FVN could move into indoor air at levels that pose a health risk. Based on these predictions and other factors, DOH recommended that indoor air samples be collected from buildings located in the FVN.[4] Cadet, in response to DOH's recommendations, developed a work plan and collected indoor air samples at thirty FVN residences in January 2002 to determine whether the groundwater contaminants were migrating into indoor air. Air samples were collected from living spaces, basements, and crawlspaces to help determine whether groundwater was a possible source of the indoor air contaminants. The FVN elementary school and a day care facility were also tested.[5,6] Cadet resampled seven of the residences in August 2002 to determine whether seasonal differences in indoor air chlorinated solvent levels existed.

Discussion

Three possible sources of chlorinated solvents exist in the FVN: background levels associated with outdoor air, background levels associated with indoor air, and shallow groundwater contaminated with chlorinated solvents. The following discussion evaluates exposure to contaminants measured in outdoor and indoor air and provides a rationale for determining whether these contaminants are coming from groundwater.

Indoor air samples were collected by Cadet in January 2002 from thirty FVN homes, a day care facility, and the Fruit Valley elementary school to determine whether the chlorinated solvents detected in groundwater were migrating through soil into the indoor air and posing an inhalation health risk (Figure 2). These buildings were selected for sampling because of their proximity to elevated levels of chemicals in soil gas and shallow groundwater. The foundation type (i.e., basement, crawlspace, slab-on-grade) was also a factor used by Cadet for selecting sampling locations. Homes with basements were considered the most vulnerable because they are closer to contaminated groundwater than homes built with a slab or crawl space. Although basement homes were considered the most vulnerable, indoor air samples were also collected at homes with crawl spaces and slab-on-grade construction. The samples were collected using 6-liter Summa canisters with preset flow control devices that allowed time-weighted samples to be collected over a 24-hour period.[5]

Cadet used 1,1-dichloroethene (1,1-DCE) as a screening compound when selecting buildings for resampling in August 2002 because 1,1-DCE is a breakdown product of 1,1,1-TCA and PCE, two chemicals previously detected in groundwater, and generally not associated with products used in typical homes or businesses. It should be noted, however, that 1,1-DCE has been found in food and other packaging materials like SARAN wrap and is used to produce flame retardant coatings for fiber and carpet backing.[7] Seven of the 30 homes that contained detectable levels of 1,1-DCE during the January indoor air sampling round were re-sampled by Cadet in August.[8] Six of the seven re-sampled homes had the highest concentrations of TCE and PCE detected in indoor air in January 2002.

The January sampling data, which served as the basis for selecting buildings for subsequent sampling in August, have some limitations. Samples collected in living spaces and/or basements of nine homes in January had Summa canister pressures near zero at the end of the sampling period.[6] This indicates that, for these canisters, air may not have been drawn into the sampler throughout the 24-hour sampling period. Consequently, there is some uncertainty about the time period associated with the indoor air results from these homes. Three of these nine homes were resampled in August (Building 23, Building 26, and Building 29).

Five outdoor air samples were also collected by Cadet from approximately six to eight feet above the ground surface during the August sampling round.[9] These samples were collected to evaluate overall background air quality within the FVN. Four of those samples were collected above the groundwater plume; one sample was collected outside the plume boundary along Fourth Plain Boulevard. Only slight differences were noted between the outdoor air samples taken

within and outside the plume boundary suggesting that the contaminant plume had little influence on overall outdoor air quality. This was expected because contaminants released from the ground surface would be quickly mixed with ambient air and diluted to background levels.

The January 2002 indoor air samples were analyzed for a limited suite of chlorinated solvents: TCE; PCE; 1,1-DCE; vinyl chloride; 1,1,1-trichlorethane (1,1,1-TCA); and cis 1,2-dichlorethene (cis 1,2-DCE). Other chemicals are associated with the breakdown of chlorinated solvents released from the Cadet facility including 1,1-dichloroethane (1,1-DCA); trans 1,2-dichloroethene (trans 1,2-DCE); 1,2 dichloroethane (1,2-DCA), and chloroethane. Samples were not analyzed for these additional chemicals although DOH had recommended that they be included.[10]All the above listed chemicals were analyzed during the August 2002 indoor air sampling round. Air samples collected in living spaces and/or basements of two of the seven homes in August 2002 had Summa canister pressures near zero at the end of the sampling period, which results in some uncertainty about the analytical results.

It should be noted that the data obtained from these two indoor air sampling rounds only provide a snapshot of a complex, dynamic indoor air environment that can be influenced by contaminant levels in soil, groundwater, and outdoor air. In addition, the use of chemicals by residents can also influence indoor air quality. How these potential sources contribute to indoor air contamination at homes and businesses in the FVN depends on a number of meteorological and hydrogeological factors as well as building characteristics, building maintenance activities, and occupant use of products that may contain these chemicals. (Table 1).

Table 1: Factors and conditions affecting the migration of contaminants from environmental media to indoor air.

Factors/Conditions	Examples
Meteorological	Temperature
	Falling barometric pressure
	Rainfall
Hydrogeological	Vadose zone soil characteristics (e.g., soil type, permeability, bulk density, moisture content)
	Depth to groundwater
Building	Foundation type (e.g., basement, slab on grade construction, crawl space)
	Heating and ventilation system operation
	Air exchange rates between indoor and outdoor air
	Maintenance activities (e.g.,cleaning products, paints, and solvents)
Building Occupant	Dry cleaned clothes, air fresheners, tobacco

Whether the conditions observed at the sampled homes and businesses are representative of all the homes and businesses located over the contaminated groundwater contaminant plume or whether the types and concentrations of contaminants will change significantly over time is

unknown. Only limited information is available about the structural integrity of buildings located over the plume and the underlying shallow subsurface soil conditions, which play a significant role in the migration of chlorinated solvents from contaminated groundwater to indoor air. In addition, groundwater contaminant concentrations will likely change over time as the solvent plume migrates and contaminants degrade. The rates and types of contaminant changes are difficult to predict. Consequently, the potential health risks posed by the contaminated groundwater on indoor air at homes and businesses overlying the plume may also change. The January and August 2002 indoor air sampling results, therefore, should be used with caution when evaluating long-term exposures to indoor air contaminants.

The following section summarizes the data evaluation process used by DOH to identify chemicals of health concern associated with the January and August 2002 sampling events.

Data Evaluation Summary

Groundwater and soil gas chemical data collected below the Cadet facility and the FVN were initially evaluated to try to determine whether a link exists between the contaminated groundwater and specific chemicals detected in indoor air. However, lack of concurrent sampling results and potential problems with the soil gas sample locations and groundwater sampling techniques were identified that prevented such an evaluation. Soil gas samples were collected well beyond the footprint of the building and were only analyzed for five of the ten chlorinated solvent chemicals of concern.[5] The soil gas results, therefore, may or may not be representative of soil gas concentrations potentially present directly below the building. For solid building floors in contact with the soil (e.g., concrete slabs), the soil gas directly beneath the floor may be at considerably higher concentrations than that beyond the building foot print.[11] A number of the chemicals detected in indoor air were also detected in groundwater (TCE, PCE, 1,1,1-TCA, 1,1-DCE, cis 1,2 -DCE, and1,1-DCA) while others were not (e.g., vinyl chloride). The groundwater sampling techniques (e.g., peristaltic and gas-driven pumps) and elevated laboratory reporting limits for some groundwater samples may account for this lack of detection.[1]

Because of these sampling problems, all the chemicals analyzed as part of the indoor air evaluation were assumed to be associated with contaminated groundwater and carried forward as chemicals of potential concern (COPC). This appears to be a prudent approach given that the levels of chemicals found in the basement/crawlspace at a number of homes, including the seven resampled in August 2002, generally exceeded the levels found in the living spaces (Appendix A, Tables A-1 and A-2). It should be noted that the COPCs selected for this health consultation are only applicable to the January and August 2002 data sets. In addition, COPCs selected by DOH may differ somewhat from the COPCs selected by Ecology for making cleanup decision under MTCA.

Health Evaluation

The six buildings with the highest indoor air TCE and PCE concentrations (Building Numbers 13, 15, 26, 27, 29, and 31) were used to determine whether the elevated levels of contaminants in indoor air posed an inhalation health risk. The indoor air concentrations at these buildings were generally higher in the basement/crawlspace than the living space, indicating that contaminated groundwater was likely contributing COPCs to indoor air. In general, the indoor air contaminant concentrations detected at these six buildings declined between the January and August sampling rounds. These findings seem reasonable given that indoor air exchange rates are higher in the summer months when windows are open and fans are operating.

Table 2 summarizes occupant and structural information for each of the six buildings. As noted in the table, two of the six buildings had crawlspaces; the remaining buildings had basements. The basements in Buildings 13, 26, and 27 were unfinished; the Building 15 basement was semi-finished. Basements 13, 15, and 26 all contained exposed soils which provide potential pathways for groundwater contaminants to migrate into indoor air.

Table 2 - Occupant and building conditions for Buildings 13, 15, 26, 27, 29, and 31 near the Cadet Manufacturing Facility in Vancouver, Washington[6,8]

Building Number	Occupants	Foundation Type	Basement Characteristics			Comments
			Finished	Unfinished	Basement Sump	
13	A(2)*	Basement		X	Yes	Two by five foot section of exposed soil in one basement wall
15	A(1)	Basement	X-Semi		Yes	Exposed soil on one basement wall; water seepage - basement floor[a]
26	A(1)	Basement		X	Yes	Soil exposed in sump[a]; below ground window - not well sealed
27	A(2), C(2)*	Basement		X	No	
29	A(1)	Crawlspace				Crawlspace described as dirt covered with plastic sheeting
31	A(2)	Crawlspace				

a- Personal communication with Craig Rankine, Washington Department of Ecology, March 25, 2003.
*A - Adult C - Child (#) - number of each type of occupant

- Noncancer Health Effects Evaluation

To estimate the potential for noncancer health effects, the concentrations of individual COPCs detected in indoor air (living space and/or basement) at each building during the January and August sampling rounds were compared to EPA inhalation reference concentrations (RfCs). RfCs are concentrations of a chemical in air below which adverse noncancer health effects are not expected to occur over a lifetime of continuous (i.e., 24-hour per day) exposure.[12] RfCs are set well below the actual toxic effect levels (i.e., lowest observed adverse effect level (LOAEL) or no observed adverse effect level (NOAEL)) determined from those studies upon which they are based. This approach provides additional health protection to account for the uncertainty involved in setting these "safe" levels of exposure. For chemicals with no available RfC, such as PCE, a dose was calculated based on continuous 24-hour exposure and compared to the oral reference dose (RfD). The RfD is based on oral exposure and its use for comparison with inhalation exposure adds additional uncertainty. Appendix B provides a summary of the formulas and exposure assumptions used to estimate noncancer health effects. The RfCs and RfDs are summarized below in Table 3.

Table 3 - Toxicity values for Contaminants of Potential Concern (COPCs) for the Cadet Manufacturing Site, Vancouver, Washington.*

	Non-Cancer Reference Concentrations/Doses			Cancer Potency Factors	
	RfC	RfD	EPA Cancer Class	Inhalation Unit Risk	Slope Factor
COPCs	(mg/m^3)	(mg/kg/day)		(per ug/m^3)	$(mg/kg/day)^{-1}$
chloroethane	1.0e+01				
1,1-dichloroethane	5.0e-01				
1,2-dichloroethane			B2 [a]	2.6e-05	
1,1-dichloroethene	2.0e-01[12]				
cis 1,2-dichloroethene		1.0e-02[14]			
trans 1,2-dichlorethene		2.0e-02			
tetrachloroethene		1.0e-02	Other [b]		2.0e-03[16]
1,1,1-trichloroethane		2.8e-01[15]			
trichloroethene	4.0e-02		Other [b]		4.0e-01[17]
vinyl chloride	1.0e-01		A [c]	8.8e-06	

* Reference 13 unless otherwise noted.
a - Probable human carcinogen
b - TCE and PCE are both considered to be possible or probable human carcinogens.
c - Human carcinogen

The levels of COPCs detected in indoor air did not exceed any respective RfCs or RfDs at any of the six buildings. Comparisons of indoor air contaminant levels with RfCs and inhalation doses

with RfDs are given in Appendix C, Tables C1. Therefore, exposure to any of the individual chemicals detected in indoor air during these sampling rounds is unlikely to result in any adverse noncancer health effects.

- Cancer Risk Evaluation

Four of the COPCs detected in indoor air in the FVN are considered carcinogenic compounds by EPA and pose a potential cancer risk. Those carcinogenic chemicals and their corresponding EPA cancer class are provided in Table 3. In order to estimate carcinogenic risk, DOH used measures of cancer potency (i.e., unit risk and cancer slope factors) published by EPA and others in conjunction with estimates of continuous exposure lasting 75 years (i.e., lifetime exposures). Lifetime exposures were selected to maintain consistency with the standardized duration assumption for unit risks.[18] Appendix B provides a summary of the formulas and exposure assumptions used to estimate cancer risks. Cancer potency factors are summarized in Table 3.

The levels of the carcinogenic COPCs detected in indoor air (living space and/or basement) at the six buildings are relatively low. However, many years of exposure to these individual chemicals does result in some small increased cancer risk (Appendix C, Table C2). The COPC that contributes the most cancer risk at each of the six buildings is TCE. Estimated cancer risks for TCE ranged from very low (8 in 100,000) to moderate (3 in 1,000). Risks associated with PCE, 1,2 DCA, and vinyl chloride were also elevated at some of the six buildings. However, the risk for these chemicals are only slightly above what is considered an acceptable risk level (1 in 1,000,000). It should be noted, however, that the estimated risks 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.

TCE is a solvent that is commonly used to remove grease from metal parts. It is also found in household products including typewriter correction fluid, painter removers, glue, rug cleaning fluids, and spot removers.[19] TCE has been found in soil, soil gas, and groundwater at the Cadet facility. It also has been found in groundwater and soil gas downgradient of Cadet and is assumed to be associated with releases from Cadet and possibly other nearby hazardous waste sites. TCE can enter the body when breathing air that contains it. If a person breathes air containing TCE, approximately half the amount of TCE will enter the bloodstream and organs. The rest will be exhaled. Once in the blood, the liver changes much of the TCE into other chemicals. The majority of these other chemicals will leave the body through the urine within a day. A person will also quickly breathe out some of the TCE that is in the bloodstream. Some of the TCE or its breakdown products can be stored in body fat for a brief period, and thus may build up in the body if exposure is continuous.[19]

EPA recently reviewed available TCE data, which has led them to characterize TCE as “highly likely to produce cancer in humans.” This classification is based on sufficient evidence in animals and limited evidence in humans. The strongest evidence that TCE can cause cancer in humans comes from occupational studies that have found increases in lung, liver, and kidney cancers in workers exposed over several years. The levels of exposure in these studies are

generally higher than those estimated for the FVN while exposure doses used in animal studies are thousands of times higher.[17]

Although the data obtained from high-dose animal or worker exposure studies is not directly applicable to exposures found at the FVN, theoretical cancer risk estimates can be made based on this data. Such estimates are made with mathematical equations that use this high-dose data to predict how many cancers might occur at lower doses. This process involves much uncertainty. Current thinking suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen will give a very small cancer risk. Cancer risk estimates are, therefore, not *yes/no* answers but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat since any level of a carcinogenic contaminant carries an associated risk. The validity of the "no safe dose" assumption for cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer.

Chemical Mixtures

While the above exposure evaluation focuses on the health effects associated with individual chemicals, exposure to multiple chemicals also needs to be considered. This is particularly important for the FVN where TCE has been detected in indoor air because EPA reports that several chemicals have the potential to alter TCE 's metabolism and clearance from the body and subsequent toxicity. TCE exposure can also increase the toxicity of other chemicals. In addition, widespread environmental exposure to some of TCE 's metabolites makes it important to consider the cumulative effect of TCE along with other environmental contaminants.[17]

There are no available studies that directly characterize the health hazards associated with exposure to a mixture of the chemicals detected in indoor air in the FVN. However, ATSDR recently evaluated health hazards associated with exposure to mixtures of 1,1,1-TCA, 1,1-DCA, TCE, and PCE. Each of these chemicals can adversely affect the nervous system, kidney and liver of animals exposed at high doses. Studies of these chemicals administered to animals as a mixture showed that the combined toxicity will not be greater that the sum of the individual effects (i.e., no synergy). Based on these findings ASTDR recommends that the noncancer health risks estimated for chemicals such as 1,1,1-TCA, 1,1-DCA, TCE, and PCE be added when they occur together as a mixture.[20] ATSDR's recommended approach for estimating noncancer risks was used for each of the six buildings. The same approach (i.e., adding risks) was also used for estimating cancer risks, which is a standard risk assessment method and consistent with ATSDR general guidance for evaluating health risks associated with mixtures.[21]

The total noncancer and cancer health risks associated with the all COPCs detected at each building during the January and August 2002 sampling rounds are presented in Appendix C, Tables C1 and C2. Noncancer risk estimated for exposure to the total mixture of COPCs detected in indoor air was assessed using a hazard index approach. Hazard indices are the sum of the hazard quotients (i.e., ratio of the concentration or dose of a single chemical over a specified period of time to its reference concentration or dose). Hazard indices were less than one (a level that is unlikely to pose a health threat), at all locations except in the basement of Building 13 and the basement and living space of Building 15, where they were slightly elevated during the January sampling round. Cancer risk estimated for exposure to the total mixture of COPCs in FVN indoor ranged from very low to moderate levels (e.g., 8 in 100,000 to 3 in 1,000).

As previously noted, indoor air in a typical home that is not impacted by any contaminated groundwater source will contain chemicals that will carry an associated health risk. In order to evaluate the significance of the groundwater as an additional source of indoor air contamination at the FVN, it is therefore necessary to consider the level of "background" risk.

Comparison with Background Exposure

The presence of VOCs in urban indoor air, which includes some of the COPCs detected in indoor air in the FVN, has been well established. Therefore, it is important to consider the background risks associated with typical indoor air when evaluating whether indoor air contaminant levels near the Cadet facility are associated with contaminated groundwater. The estimated cancer risk associated with typical background exposure to VOCs has been estimated as high as 5 in 1,000.[22,23] While this background estimate is similar to the cancer risks estimates for the six buildings with the highest indoor air PCE and TCE concentrations (Appendix C, Table C2), it includes many chemicals (e.g., benzene) not analyzed for in those homes during the January and August 2002 indoor air sampling rounds.

To better evaluate the health risks posed by the COPCs detected in indoor air near the Cadet facility, health risks were estimated for only those COPCs that had corresponding background values (Appendix C, Tables C3 and C4). Indoor air background values were obtained from peer-reviewed studies, one of which was based on a large national indoor air database developed by the U.S. Environmental Protection Agency (EPA); indoor air values were also obtained from EPA's Urban Air Toxic Monitoring Program.[22, 24, 25] Median values were selected from these peer-reviewed studies, when available, to reduce the bias created by outliers. However, median values only exist for a few of the COPCs. Mean values were used when no median values were available. Table 4 provides the background indoor air literature values used to calculate the corresponding background risk.

Table 4 - Background indoor air literature values.

COPC	Background Indoor Air Literature Values			Health Risks*	
	Concentration (ug/m^3)	Reference Number	Statistical Parameter	Cancer Risk	HQ
chloroethane	NA				
1,1-dichloroethane	NA				
1,2-dichloroethane	0.5	20	mean	1.3e-05	
1,1-dichloroethene	6.5	20	mean		3.3e-02
cis 1,2-dichloroethene	NA				
trans 1,2-dichlorethene	NA				
tetrachloroethene	5	22	median	2.9e-06	2.8e-01
1,1,1-trichloroethane	19	23	mean		3.8e-02
trichloroethene	0.7	22	median	8.0e-05	1.8e-02
vinyl chloride	NA				

* Based on formulas and parameters described in Appendix B
NA - not available

Background indoor air risk estimates were then compared with the summed health risks associated with the corresponding subset of COPCs (Table 5). The cancer risk associated with exposure to the subset of COPCs for the January 2002 sampling round at the six FVN buildings is approximately one to two orders of magnitude greater than would be expected in background indoor air while the noncancer health risk ranges from one to two times greater than background indoor air. Both cancer and noncancer health risks were slightly lower for the August 2002 sampling round.

Table 5 - Indoor air health evaluation results for subset of Contaminants of Potential Concern (COPC) near the Cadet Manufacturing Facility in Vancouver, Washington versus corresponding background indoor air risk estimates.

Health Risk	Building						Background Indoor Air
	13		15		26		
	Basement	Living Space	Basement	Living Space	Basement	Living Space	
January 2002							
Hazard Index[a]	1	0.2	1	1	0.5	0.1	0.4
Cancer Risk[b]	3 in 1,000	5 in 10,000	3 in 1,000	3 in 1,000	1 in 1,000	2 in 10,000	8 in 100,000
August 2002							
Hazard Index[a]	0.4	0.02	0.3	0.2	0.3	0.07	0.4
Cancer Risk[c]	1 in 1,000	5 in 100,000	8 in 10,000	6 in 10,000	6 in 10,000	1 in 10,000	9 in 100,000

a - Hazard Index based on sum of hazard quotients for 1,1-DCE, PCE, 1,1-TCA; and TCE
b - Cancer Risk based on sum of individual cancer risks for TCE and PCE
c - Cancer Risk based on sum of individual cancer risks for 1,2-DCA, TCE and PCE

Table 5 (contd.) - Indoor air health evaluation results for subset of Contaminants of Potential Concern (COPC) near the Cadet Manufacturing Facility in Vancouver, Washington versus corresponding background indoor air risk estimates.

Health Risk	Building				Background Indoor Air
	27		29	31	
	Basement	Living Space	Living Space	Living Space	
January 2002					
Hazard Index[a]	0.3	0.2	0.1	0.2	0.4
Cancer Risk[b]	7 in 10,000	5 in 10,000	2 in 10,000	4 in 10,000	8 in 100,000
August 2002					
Hazard Index[a]	0.1	0.07	0.06	0.1	0.4
Cancer Risk[c]	2 in 10,000	1 in 10,000	8 in 100,000	2 in 10,000	9 in 100,000

a - Hazard Index based on sum of hazard quotients for 1,1-DCE, PCE, 1,1-TCA; and TCE
b - Cancer Risk based on sum of individual cancer risks for TCE and PCE
c - Cancer Risk based on sum of individual cancer risks for 1,2-DCA, TCE and PCE

Buildings with basements where subsurface soils are exposed (e.g., Buildings 13, 15, and 26) appear to be the most vulnerable to the movement of chlorinated solvents into indoor air (Table 5). The cancer risk levels associated with the COPCs detected in basements at these homes, as well as the living space at Building 15, during the January sampling round are estimated to be as high as 3 in a 1,000 or approximately two orders of magnitude greater than background indoor air. Since an obvious pathway exists between the chlorinated solvent contaminated groundwater and indoor air at these homes, the contaminated groundwater is a likely source of this additional contamination detected in these buildings. Contaminated groundwater may be contributing contaminants to indoor air at the other three buildings (Buildings 27, 29 and 31). However, the pathway is not as clear as it is for Buildings 13, 15, and 26, where subsurface soils are exposed in the basements.

It is important to note that indoor air contaminant concentrations can vary over time because of the factors described previously. Consequently, homes tested in January and August 2002, where indoor air concentrations were only an order of magnitude lower than background levels (Buildings 27, 29, and 31) could contain levels of the COPC significantly above background in the future. Other homes within the FVN, including those that have not been tested or where questionable samples were collected (i.e., samples where the Summa canister pressures were near zero) may also be vulnerable to the migration of contaminants and contain levels of COPC significantly above background.

Child Health Initiative

The FVN is a residential area where children potentially could be exposed to site contaminants through the indoor air exposure pathway. Children can be uniquely vulnerable to the hazardous effects of environmental contaminants. Children breathe more air per pound of body weight than do adults resulting in higher levels of exposure to contaminants in air. Additionally, the fetus is highly sensitive to many chemicals, particularly with respect to potential impacts on childhood development. For these reasons, it is very important to consider the specific impacts that contaminants may have on children, as well as other sensitive populations.

Exposure to detected indoor air contaminants were evaluated as described in the discussion section, above. The doses calculated for some of the individual chemicals are not expected to result in noncancer health effects for children, or adults, based on comparison with toxicity values. The assessment did find that chronic exposure to individual and multiple chemicals over a lifetime (i.e., 75 years) does indicate an increased theoretical cancer health risk.

Conclusions

The levels of some chlorinated solvents in the indoor air of some of the homes in the FVN are above those normally found in an indoor air environment. Some of these solvents were also found in groundwater and soil gas. Consequently, some of the estimated health risk associated with the chemicals found in indoor air is likely related to chlorinated solvents migrating from contaminated groundwater.

1. Levels of chlorinated solvents found in indoor air in the FVN pose *no immediate or short-term health concern.* Levels are not high enough to cause adverse health effects over weeks or months of exposure.

2. Long-term exposure to the levels of chemicals detected in indoor air during the January and August 2002 sampling rounds indicates a cancer risk greater than what is normally expected at Buildings 13, 15, and 26. While the health risks associated with chlorinated solvents detected in indoor air in Buildings 13, 15, and 26 in January and August 2002 are not considered to be high and are unlikely to cause any adverse health effects, these buildings contain exposed soils that provide a direct pathway between the chlorinated solvent-contaminated groundwater and indoor air. This fact, combined with renewed concern from EPA over the potential for TCE to cause cancer, indicates that public health actions are necessary to eliminate exposure from this pathway.

   , In addition, there is some uncertainty associated with the representativeness of the limited indoor air samples collected in January and August 2002. Higher levels of TCE and other solvents may be migrating from the groundwater to indoor air at these buildings.

3. It is not known whether the levels of chlorinated solvents detected at buildings sampled in January and August 2002 are representative of all the buildings located over the shallow groundwater contaminant plume. Several factors can affect sampling results including seasonal change, soil characteristics, and differences in building structure. In addition, the chemical composition of the groundwater contaminant plume is likely to change over time as contaminants migrate and degrade. Consequently, additional chlorinated solvent monitoring (i.e., groundwater, soil gas, indoor air, and/or outdoor air) is needed to accurately assess long-term exposures related to the groundwater to indoor air pathway.

4. Groundwater monitoring well results obtained in August/September 2002 indicates that the contaminated groundwater migrating from the Cadet facility extends beyond the area where the well survey was conducted in the FVN in mid-2001.

Recommendations/Action Plan

1. Exposures to chlorinated solvents migrating from groundwater to indoor air at Buildings 13, 15, and 26 should be eliminated.

   Actions Proposed

   Measures to eliminate these exposures could include covering exposed soils and installing subsurface depressurization systems. It should be noted, however, that covering exposed soils alone will be unlikely to eliminate exposures. Follow-up indoor air sampling of basements and living spaces would be required to verify the effectiveness of any remedial measures.

2. Further evaluation of the groundwater to indoor air pathway at the Cadet site is necessary to ensure that building occupants are not being exposed to harmful levels of chemicals migrating from the contaminated groundwater underlying the FVN. More environmental sampling data and information about buildings overlying the plume are also needed to adequately characterize long-term exposures (i.e., greater than one year) to contaminants in indoor air.

   Actions Proposed

   Work plan(s) should be developed to better characterize the groundwater to indoor air pathway. The work plan(s) should include more groundwater, soil gas, and indoor and outdoor air monitoring and should be provided to DOH for review. Appropriate sampling equipment and procedures should be used to ensure that representative samples are collected.

   Work plan(s) should be developed for inspecting buildings overlying the groundwater contaminant plume to identify building features that make the building vulnerable to the migration of chlorinated solvents from groundwater to indoor air. The plan(s) should be provided to DOH for review.

3. Building owners and occupants overlying the shallow groundwater plume should be notified that changes in the structure and use of their homes/businesses and property could result in increased exposure to contaminants migrating from groundwater to indoor air. Movement of contaminants from groundwater to indoor air could increase following activities like soil excavations, installation of basement sumps, blocking of crawl space vents and installation of fans or air conditioners.

   Actions Proposed

   DOH is available to assist in education and outreach efforts to communicate with FVN residents on ways to minimize exposure to contaminants moving from groundwater to indoor air.

4. Agencies responsible for land use planning and permitting should be notified about the potential for chlorinated solvents to migrate from contaminated groundwater to indoor air

at the Cadet facility and in the FVN. This will help ensure that any proposed plans for new structures in the vicinity of the Cadet site will consider this pathway during building design and construction.

Actions Proposed

Written notification should be provided to all appropriate construction and land use planning and permitting agencies notifying them about the subsurface contamination associated with the Cadet site.

5. Companies and government entities who have workers that may encounter contaminated soil gas and groundwater near the Cadet facility and in the FVN should be notified about subsurface conditions so they can take appropriate steps to protect worker health and safety. Such steps may prevent work stoppages that can occur when unknown contaminants are encountered.

Actions Proposed

Written notification should be provided to all appropriate companies and government entities about the subsurface contamination associated with the Cadet site.

6. The well survey conducted by Cadet in mid-2001 should be expanded to include the areas recently investigated and determined to be underlain by chlorinated solvent contaminated groundwater.

Action Proposed

In addition to contacting people directly and reviewing wells logs during the expanded well survey, water utilities should also be contacted to determine whether water lines exist in the survey area. The results of the expanded well survey should be provided to DOH for review.

7. Only limited groundwater sampling has been conducted along the northern and eastern boundaries of the groundwater contaminant plume. Future groundwater sampling results should be reviewed to ensure that the northern and eastern boundaries are well defined. This is particularly important for determining whether additional homes or buildings are at risk from groundwater contaminants migrating to indoor air.

Actions Proposed

Ground water sampling plans and reports should be provided to DOH for review.

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Place Holder - Figure 1

Place Holder - Figure 2

Appendix A

Indoor Air Sampling Results

The analytical results for the January and August 2002 indoor air sampling rounds in the FVN are summarized in Tables A-1 and A-2. A number of the chemicals were detected between the reporting limit, or practical quantitation limit (PQL)(i.e., the lowest level at which a chemical can be accurately quantified), and the method detection limit (i.e., the lowest level of a chemical that can be measured and reported with 99 percent (%) confidence that the value is greater than zero). These results are qualified as estimated values and presented in the tables with a "J" qualifier. All of the tetrachloroethene (PCE) values for the August sampling were also qualified because of its presence in two of the laboratory method blanks (B). However, the method blank results (0.0047 to 0.0055 ug/m^3) were significantly lower than the sample results (0.087 to 7.8J ug/m^3) indicating that the samples results were not significantly affected. Consequently the PCE results were not adjusted for this minor method blank contamination. The "B" qualifiers, however, were retained in the tables.

A number of the analyzed chemicals were not detected in the indoor air samples. However, because these chemicals are potentially associated with releases from the Cadet facility, one-half of the laboratory reporting limit, or PQL, was assigned to these results rather than a value of zero. This approach is conservative, but commonly used for evaluating chemicals that may be present but not detected below the PQL.[18]

Place Holder **Table A-1**: January 2002 indoor air sample results for residences near the Cadet Manufacturing Facility in Vancouver, Washington Page 1 of 3

Place Holder **Table A-1**: January 2002 indoor air sample results for residences near the Cadet Manufacturing Facility in Vancouver, Washington Page 2 of 3

Place Holder **Table A-1**: January 2002 indoor air sample results for residences near the Cadet Manufacturing Facility in Vancouver, Washington Page 3 of 3

Place Holder **Table A-2**: August 2002 indoor air sample results for residences near the Cadet Manufacturing Facility in Vancouver, Washington Page 1 of 1

Appendix B

Health Risk Formulas and Exposure Assumptions

The formulas and parameters given below were used to conservatively estimate cancer and non-cancer health risks. For those contaminants with no inhalation reference concentration (RfC) or inhalation unit risk (IUR) value, EPA oral reference doses (RfD) and oral cancer slope factors (CSFs) were used as surrogates. It is important to note that EPA RfC and IUR values assume continuous exposure. For consistency, continuous exposure was assumed when using a surrogate RfD or CSF.

Hazard Quotient using RfCs

$HQ = C_a/(RfC*1000)$

HQ - hazard quotient
C_a - indoor air concentration (ug/m^3)
Rfc - chemical specific inhalation reference concentration (mg/m^3)

Hazard Quotient using RfDs

$HQ = ((C_a/1000)*IR*EF*ED/(BW*AT))/RfD$

HQ - hazard quotient
C_a - indoor air concentration (ug/m^3)
IR - inhalation rate (child - 8.3 m^3/day)
EF - exposure frequency (365 days/year)
ED - exposure duration (5 years)
BW - body weight (15 kg)
AT - averaging time (1825 days)
RfD - chemical specific oral reference dose

Cancer Risk using Unit Risk Factors

$Cancer\ Risk = C_a*IUR$

C_a - indoor air concentration (ug/m^3)
IUR - inhalation unit risk (per ug/m^3)

Cancer Risk using Slope Factors

$Cancer\ Risk = ((C_a/1000)*IR*EF*ED/(BW*AT))*CSF$

C_a - indoor air concentration (ug/m^3)
IR - inhalation rate (adult - 20 m^3/day)
EF - exposure frequency (365 days/year)
ED - exposure duration (75 years)
BW - body weight (70 kg)
AT - averaging time (27,375days)
CSF - chemical specific cancer slope factor

Appendix C

Cancer and Non-Cancer Health Evaluation Results

Table C1 - Non-cancer health evaluation results for indoor air in
Buildings 13, 15, 26, 27, 29, and 31 near the Cadet Manufacturing Facility, Vancouver, Washington

COPC	Building 13				Building 15				Building 26			
	Basement		Living Space		Basement		Living Space		Basement		Living Space	
	Conc.*	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ
January 2002												
1,1-dichloroethene	0.36	1.8e-03	0.070	3.5e-04	0.55	2.8e-03	0.48	2.4e-03	0.31	1.6e-03	0.062	3.1e-04
cis 1,2-dichloroethene	0.032J	1.8e-03	0.0092	5.1e-04	0.064J	3.5e-03	0.059J	3.3e-03	0.014	7.7e-04	0.016J	8.9e-04
tetrachloroethene	7.8	4.3e-01	1.9	1.1e-01	9.0	5.0e-01	6.9	3.8e-01	4.1	2.3e-01	0.70J	3.9e-02
1,1,1-trichloroethane	5.7	1.1e-02	1.1J	2.2e-03	6.4	1.3e-02	4.7	9.3e-03	3.0	5.9e-03	2.8	5.5e-03
trichloroethene	25	6.3e-01	4.6	1.2e-01	31	7.8e-01	25	6.3e-01	11	2.8e-01	1.8	4.5e-02
vinyl chloride	0.018J	1.8e-04	0.040J	4.0e-04	0.011J	1.1e-04	0.012J	1.2e-04	0.011J	1.1e-04	0.014J	1.4e-04
Hazard Index		1.1e+00		2.2e-01		1.3e+00		1.0+00		5.1e-01		9.1e-02
August 2002												
chloroethane	*14*	1.4e-03	0.2J	2.0e-05	0.34J	3.4e-05	0.085J	8.5e-06	0.72J	7.2e-05	0.14J	1.4e-05
1,1-dichloroethane	*14*	2.8e-02	*0.75*	1.5e-03	*0.6*	1.2e-03	*0.8*	1.6e-03	*0.8*	1.6e-03	*0.7*	1.4e-03
1,2-dichloroethane	*14*		0.048J		0.027J		0.049J		0.023J		0.036J	
1,1-dichloroethene	*0.7*	3.5e-03	*0.037*	1.9e-04	0.042J	2.1e-04	0.038J	1.9e-04	0.10	5.0e-04	0.031J	1.6e-04
cis 1,2-dichloroethene	*14*	7.7e-01	*0.75*	4.2e-02	*0.6*	3.3e-02	*0.8*	4.4e-02	*0.8*	4.4e-02	*0.7*	3.9e-02
trans 1,2-dichlorethene	*14*	3.9e-01	*0.75*	2.1e-02	*0.6*	1.7e-02	*0.8*	2.2e-02	*0.8*	2.2e-02	*0.7*	1.9e-02
tetrachloroethene	3.3JB	1.8e-01	0.22JB	1.2e-02	2.8B	1.5e-01	2.1B	1.2e-01	2.5B	1.4e-01	0.64JB	3.5e-02
1,1,1-trichloroethane	1.6J	3.2e-03	0.20J	4.0e-04	1.1J	2.2e-03	0.83J	1.6e-03	2.1	4.2e-03	0.95J	1.9e-03
trichloroethene	7.5J	1.9e-01	0.39J	9.8e-03	6.8	1.7e-01	5.0	1.3e-01	5.6	1.4e-01	1.3	3.3e-02
vinyl chloride	*2.8*	2.8e-02	*0.15*	1.5e-03	*0.12*	1.2e-03	*0.16*	1.6e-03	*0.16*	1.6e-03	*0.13*	1.3e-03
Hazard Index		8.2e-01		4.6e-02		3.5e-01		2.7e-01		3.1e-01		9.2e-02

* Concentration Units = ug/m^3 *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank
HQ = Hazard quotient
NOTE: Samples taken during January and August 2002

Table C1 (cont')- Non-cancer health evaluation results for indoor air in Buildings 13, 15, 26, 27, 29, and 31 near the Cadet Manufacturing Facility, Vancouver, Washington

COPC	Building 27				Building 29		Building 31	
	Basement		Living Space		Living Space		Living Space	
	Conc.*	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ
January 2002								
1,1-dichloroethene	0.25	1.3e-03	0.22	1.1e-03	0.093	4.7e-04	0.29	1.5e-03
cis 1,2-dichloroethene	*0.6*	3.3e-02	*1.1*	6.1e-02	*0.6*	3.3e-02	*0.6*	3.3e-02
tetrachloroethene	2.7	1.5e-01	2.0J	1.1e-01	1.2	6.6e-02	2.2	1.2e-01
1,1,1-trichloroethane	2.3	4.5e-03	1.9J	3.8e-03	1.7	3.4e-03	3.8	7.5e-03
trichloroethene	6.0	1.5e-01	4.4	1.1e-01	1.7	4.3e-02	3.6	9.0e-02
vinyl chloride	*0.12*	1.2e-03	0.21	2.1e-03	*0.12*	1.2e-03	0.027J	2.7e-04
Hazard Index		3.4e-01		2.9e-01		1.5e-01		2.5e-01
August 2002								
chloroethane	0.19J	1.9e-05	0.21J	2.1e-05	0.18J	1.8e-05	0.13J	7.2e-06
1,1-dichloroethane	*0.8*	1.6e-03	*0.8*	1.6e-03	*0.6*	1.2e-03	*0.7*	1.4e-03
1,2-dichloroethane	0.029J		0.036J		0.044J		0.056J	
1,1-dichloroethene	0.023J	1.2e-04	0.041J	2.1e-04	0.055J	2.8e-04	0.072J	3.6e-04
cis 1,2-dichloroethene	*0.8*	4.4e-02	*0.8*	4.4e-02	*0.6*	3.3e-02	*0.7*	3.9e-02
trans 1,2-dichlorethene	*0.8*	2.2e-02	*0.8*	2.2e-02	*0.6*	1.7e-02	*0.7*	1.9e-02
tetrachloroethene	1.0JB	5.5e-02	0.8JB	4.4e-02	0.74JB	4.1e-02	1.1	6.1e-02
1,1,1-trichloroethane	0.66J	1.3e-03	0.52J	1.0e-03	0.49J	9.7e-04	0.76J	1.5e-03
trichloroethene	2.1	5.3e-02	1.2J	3.0e-02	0.72J	1.8e-02	1.6	4.0e-02
vinyl chloride	*0.16*	1.6e-03	0.015J	1.5e-04	0.015J	1.5e-04	0.026J	2.6e-04
Hazard Index		1.3e-01		9.9e-02		7.8e-02		1.2e-01

* Concentration Units = ug/m^3 *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank
HQ = Hazard quotient
NOTE: Samples taken during January and August 2002.

Table C2 - Cancer health evaluation results for indoor air in
Buildings 13, 15, 26, 27, 29, and 31 near the Cadet Manufacturing Facility, Vancouver, Washington

COPC	Building 13				Building 15				Building 26			
	Basement		Living Space		Basement		Living Space		Basement		Living Space	
	Conc.*	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk
January 2002												
1,1-dichloroethene	0.36		0.070		0.55		0.48		0.31		0.062	
cis 1,2-dichloroethene	0.032J		0.0092J		0.064J		0.059J		0.014		0.016J	
tetrachloroethene	7.8	4.5e-06	1.9	1.1e-06	9.0	5.1e-06	6.9	3.9e-06	4.1	2.3e-06	0.70J	4.0e-07
1,1,1-trichloroethane	5.7		1.1J		6.4		4.7		3.0		2.8	
trichloroethene	25	2.9e-03	4.6	5.3e-04	31	3.5e-03	25	2.9e-03	11	1.3e-03	1.8	2.1e-04
vinyl chloride	0.018J	1.6e-07	0.040J	3.5e-07	0.011J	9.7e-08	0.012J	1.1e-07	0.011J	9.7e-08	0.014J	1.2e-07
Total Cancer Risk		2.9e-03		5.3e-04		3.5e-03		2.9e-03		1.3e-03		2.1e-04
August 2002												
chloroethane	*14*		0.2J		0.34J		0.085J		0.72J		0.14J	
1,1-dichloroethane	*14*		*0.75*		*0.6*		*0.8*		*0.8*		*0.7*	
1,2-dichloroethane	*14*	3.6e-04	0.048J	1.2e-06	0.027J	7.0e-07	0.049J	1.3e-06	0.023J	6.0e-07	0.036J	9.4e-07
1,1-dichloroethene	*0.7*		*0.037*		0.042J		0.038J		0.10		0.031J	
cis 1,2-dichloroethene	*14*		*0.75*		*0.6*		*0.8*		*0.8*		*0.7*	
trans 1,2-dichlorethene	*14*		*0.75*		*0.6*		*0.8*		*0.8*		*0.7*	
tetrachloroethene	3.3JB	1.9e-06	0.22JB	1.3e-07	2.8B	1.6e-06	2.1B	1.2e-06	2.5B	1.4e-06	0.64JB	3.7e-07
1,1,1-trichloroethane	1.6J		0.20J		1.1J		0.83J		2.1		0.95J	
trichloroethene	7.5J	8.6e-04	0.39J	4.5e-05	6.8	7.8e-04	5.0	5.7e-04	5.6	6.4e-04	1.3	1.5e-04
vinyl chloride	*2.8*	2.5e-05	*0.15*	1.3e-06	*0.12*	1.1e-06	*0.16*	1.4e-06	*0.16*	1.4e-06	*0.13*	1.1e-06
Total Cancer Risk		1.2e-03		4.7e-05		7.8e-04		5.7e-04		6.4e-04		1.5e-04

* Concentration Units = ug/m^3 *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank
NOTE: Samples taken during January and August 2002

Table C2 (cont') - Cancer health evaluation results for indoor air in Buildings 13, 15, 26, 27, 29, and 31 near the Cadet Manufacturing Facility, Vancouver, Washington

COPC	Building 27				Building 29		Building 31	
	Basement		Living Space		Living Space		Living Space	
	Conc.*	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk
January 2002								
1,1-dichloroethene	0.25		0.22		0.093		0.29	
cis 1,2-dichloroethene	*0.6*		*1.1*		*0.6*		*0.6*	
tetrachloroethene	2.7	1.5e-06	2.0J	1.1e-06	1.2	6.9e-07	2.2	1.3e-06
1,1,1-trichloroethane	2.3		1.9J		1.7		3.8	
trichloroethene	6.0	6.9e-04	4.4	5.0e-04	1.7	1.9e-04	3.6	4.1e-04
vinyl chloride	*0.12*	1.1e-06	0.21	1.8e-06	*0.12*	1.1e-06	0.027J	2.4e-07
Total Cancer Risk		6.9e-04		5.0e-04		2.0e-04		4.1e-04
August 2002								
chloroethane	0.19J		0.21J		0.18J		0.13J	
1,1-dichloroethane	*0.8*		*0.8*		*0.6*		*0.7*	
1,2-dichloroethane	0.029J	7.5e-07	0.036J	9.4e-07	0.044J	1.1e-06	0.056J	1.5e-06
1,1-dichloroethene	0.023J		0.041J		0.055J		0.072J	
cis 1,2-dichloroethene	*0.8*		*0.8*		*0.6*		*0.7*	
trans 1,2-dichlorethene	*0.8*		*0.8*		*0.6*		*0.7*	
tetrachloroethene	1.0JB	5.7e-07	0.8JB	4.6e-07	0.74JB	4.2e-07	1.1	6.3e-07
1,1,1-trichloroethane	0.66J		0.52J		0.49J		0.76J	
trichloroethene	2.1	2.4e-04	1.2J	1.4e-04	0.72J	8.2e-05	1.6	1.8e-04
vinyl chloride	*0.16*	1.4e-06	0.015J	1.3e-07	0.015J	1.3e-07	0.026J	2.3e-07
Total Cancer Risk		2.4e-04		1.4e-04		8.4e-05		1.8e-04

* Concentration Units = ug/m^3 *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank

NOTE: Samples taken during January and August 2002.

Table C3 - Non-cancer health evaluation results for indoor air COPCs that have corresponding background indoor air literature values

COPC	Building 13				Building 15				Building 26			
	Basement		Living Space		Basement		Living Space		Basement		Living Space	
	Conc.*	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ
January 2002												
1,1-dichloroethene	0.36	1.8e-03	0.070	3.5e-04	0.55	2.8e-03	0.48	2.4e-03	0.31	1.6e-03	0.062	3.1e-04
tetrachloroethene	7.8	4.3e-01	1.9	1.1e-01	9.0	5.0e-01	6.9	3.8e-01	4.1	2.3e-01	0.70J	3.9e-02
1,1,1-trichloroethane	5.7	1.1e-02	1.1J	2.2e-03	6.4	1.3e-02	4.7	9.3e-03	3.0	5.9e-03	2.8	5.5e-03
trichloroethene	25	6.3e-01	4.6	1.2e-01	31	7.8e-01	25	6.3e-01	11	2.8e-01	1.8	4.5e-02
Hazard Index		1.1e+00		2.2e-01		1.3e+00		1.0e+00		5.1e-01		9.0e-02
August 2002												
1,1-dichloroethene	*0.7*	3.5e-03	*0.037*	1.9e-04	0.042J	2.1e-04	0.038J	1.9e-04	0.10	5.0e-04	0.031J	1.6e-04
tetrachloroethene	3.3JB	1.8e-01	0.22JB	1.2e-02	2.8B	1.5e-01	2.1B	1.2e-01	2.5B	1.4e-01	0.64JB	3.5e-02
1,1,1-trichloroethane	1.6J	3.2e-03	0.20J	4.0e-04	1.1J	2.2e-03	0.83J	1.6e-03	2.1	4.2e-03	0.95J	1.9e-03
trichloroethene	7.5J	1.9e-01	0.39J	9.8e-03	6.8	1.7e-01	5.0	1.3e-01	5.6	1.4e-01	1.3	3.3e-02
Hazard Index		3.8e-01		2.3e-02		3.3e-01		2.4e-01		2.8e-01		7.0e-02

* Concentration Units = ug/m^3 Note: *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank

HQ = Hazard quotient

NOTE: Samples taken during January and August 2002

Table C3 (cont') - Non-cancer health evaluation results for indoor air COPCs that have corresponding background indoor air literature values

COPC	Building 27				Building 29		Building 31	
	Basement		Living Space		Living Space		Living Space	
	Conc.*	HQ	Conc.	HQ	Conc.	HQ	Conc.	HQ
January 2002								
1,1-dichloroethene	0.25	1.3e-03	0.22	1.1e-03	0.093	4.7e-04	0.29	1.5e-03
tetrachloroethene	2.7	1.5e-01	2.0J	1.1e-01	1.2	6.6e-02	2.2	1.2e-01
1,1,1-trichloroethane	2.3	4.5e-03	1.9J	3.8e-03	1.7	3.4e-03	3.8	7.5e-03
trichloroethene	6.0	1.5e-01	4.4	1.1e-01	1.7	4.3e-02	3.6	9.0e-02
Hazard Index		3.1e-01		2.3e-01		1.1e-01		2.2e-01
August 2002								
1,1-dichloroethene	0.023J	1.2e-04	0.041J	2.1e-04	0.055J	2.8e-04	0.072J	3.6e-04
tetrachloroethene	1.0JB	5.5e-02	0.8JB	4.4e-02	0.74JB	4.1e-02	1.1	6.1e-02
1,1,1-trichloroethane	0.66J	1.3e-03	0.52J	1.0e-03	0.49J	9.7e-04	0.76J	1.5e-03
trichloroethene	2.1	5.3e-02	1.2J	3.0e-02	0.72J	1.8e-02	1.6	4.0e-02
Hazard Index		1.1e-01		7.5e-02		6.0e-02		1.0e-01

* Concentration Units = ug/m^3 Note: *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank
HQ = Hazard quotient
NOTE: Samples taken during January and August 2002

Table C4 - Cancer health evaluation results for indoor air COPCs that have corresponding background indoor air literature values

COPC	Building 13				Building 15				Building 26			
	Basement		Living Space		Basement		Living Space		Basement		Living Space	
	Conc.*	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk
January 2002												
tetrachloroethene	7.8	4.5e-06	1.9	1.1e-06	9.0	5.1e-06	6.9	3.9e-06	4.1	2.3e-06	0.70J	4.0e-07
trichloroethene	25	2.9e-03	4.6	5.3e-04	31	3.5e-03	25	2.9e-03	11	1.3e-03	1.8	2.1e-04
Total Cancer Risk		2.9e-03		5.3e-04		3.5e-03		2.9e-03		1.3e-03		2.1e-04
August 2002												
1,2-dichloroethane	*14*	3.6e-04	0.048J	1.2e-06	0.027J	7.0e-07	0.049J	1.3e-06	0.023J	6.0e-07	0.036J	9.4e-07
tetrachloroethene	3.3JB	1.9e-06	0.22JB	1.3e-07	2.8B	1.6e-06	2.1B	1.2e-06	2.5B	1.4e-06	0.64JB	3.7e-07
trichloroethene	7.5J	8.6e-04	0.39J	4.5e-05	6.8	7.8e-04	5.0	5.7e-04	5.6	6.4e-04	1.3	1.5e-04
Total Cancer Risk		1.2e-03		4.6e-05		7.8e-04		5.7e-04		6.4e-04		1.5e-04

* Concentration Units = ug/m^3 *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank

NOTE: Samples taken during January and August 2002

Table C4 (cont') - Non-cancer health evaluation results for indoor air COPCs that have corresponding background indoor air literature values

COPC	Building 27				Building 29		Building 31	
	Basement		Living Space		Living Space		Living Space	
	Conc.*	Risk	Conc.	Risk	Conc.	Risk	Conc.	Risk
January 2002								
tetrachloroethene	2.7	1.5e-06	2.0J	1.1e-06	1.2	6.9e-07	2.2	1.3e-06
trichloroethene	6.0	6.9e-04	4.4	5.0e-04	1.7	1.9e-04	3.6	4.1e-04
Total Cancer Risk		6.9e-04		5.0e-04		1.9e-04		4.1e-04
August 2002								
1,2-dichloroethane	0.029J	7.5e-07	0.036J	9.4e-07	0.044J	1.1e-06	0.056J	1.5e-06
tetrachloroethene	1.0JB	5.7e-07	0.8JB	4.6e-07	0.74JB	4.2e-07	1.1	6.3e-07
trichloroethene	2.1	2.4e-04	1.2J	1.4e-04	0.72J	8.2e-05	1.6	1.8e-04
Total Cancer Risk		2.4e-04		1.4e-04		8.4e-05		1.8e-04

* Concentration Units = ug/m^3 *Italicized Values* = ½ PQL J=Estimated Value B = Detected in Blank

NOTE: Samples taken during January and August 2002