Health Consultation

Trainsong Neighborhood Indoor Air Assessment

UNION PACIFIC RAILROAD COMPANY – EUGENE YARDS

EUGENE, OREGON

Prepared by the
Oregon Department of Human Services

January 21, 2010

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Oregon Public Health Division
Environmental Health Assessment Program
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Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Public Health Division (OPHD) has prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services, Public Health Service. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease related exposures to toxic substances. This Health Consultation was prepared in accordance with ATSDR methodology and guidelines.

ATSDR and its cooperative agreement partners review the available information about hazardous substances at a site, evaluate whether exposure to them might cause any harm to people, and provide the findings and recommendations to reduce harmful exposures in documents called Public Health Assessments (PHAs) and Health Consultations (HCs). ATSDR conducts a Public Health Assessment for every site on or proposed for the National Priorities List (the NPL, also known as the Superfund list). Health Consultations are similar to Public Health Assessments, but they usually are shorter, address one specific question, and address only one contaminant or one exposure pathway. Another difference is that Public Health Assessments are made available for public comment, while Health Consultations usually are not. Public Health Assessments and Health Consultations are not the same thing as a medical exam or a community health study.

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Summary

Introduction

The Environmental Health Assessment Program's (EHAP's) top priority is to ensure that residents in the Trainsong neighborhood have the best information possible to safeguard their health.

The Union Pacific Rail Road (UPRR) operates a railyard in a mixed residential and industrial area in northwest Eugene, Oregon (OR). Operations at the railyard over the past several decades have contaminated the groundwater and soil on the site with volatile organic compounds (VOCs) and other chemicals. Environmental investigations found that VOC-contaminated groundwater has migrated into nearby neighborhoods, including the Trainsong and River Road neighborhoods.

In 2006, the Oregon Department of Environmental Quality (DEQ) and the Oregon Toxics Alliance (OTA) requested that EHAP investigate whether contamination from the UPRR site posed any health risks to residents living near the railyard. In a 2007 public health assessment of the UPRR site, EHAP concluded that the occasional outdoor use of VOC-contaminated irrigation well water posed no health risks to children or adults. However, based on the information available at that time, EHAP was not able determine if there were health risks from the vapor intrusion of VOCs from groundwater into the indoor air of homes in the Trainsong neighborhood near the railyard.

This follow-up health consultation addresses the outstanding questions about potential health risks from VOCs in indoor and crawlspace air in Trainsong neighborhood homes located near the UPRR site. This health consultation uses data from the Crawlspace Remediation Pilot (CRP) Study, which collected data to evaluate the vapor intrusion pathway in nine homes. Specifically, this health consultation examines the following questions:

1. Based on data collected as part of the CRP Study, do the levels of VOC vapors measured in indoor air pose health risks to residents in these homes?
2. In homes where VOC levels exceed health guidelines, is there evidence that the railyard contamination is the source of these VOCs, and are vapor barriers/ventilation systems in these homes effective in reducing these levels?
3. At locations where past measurements showed large variations in VOC levels, have concentrations remained consistently below health guidelines?

Conclusions	EHAP reached three conclusions in this Public Health Consultation:
Conclusion 1	EHAP concludes that breathing trichloroethylene (TCE) and tetrachloroethylene (PCE) in the indoor air at two CRP Study homes (homes D and G) for a year or longer could harm people's health. However, EHAP does not have enough information to determine the exact source of TCE and PCE in these homes.
Basis for Decision	TCE and PCE were found in the indoor air of homes D and G at levels that could cause increased risks for cancer. However, the TCE and PCE levels in the soil gas, crawl space, and indoor air of these homes do not follow the expected pattern for the vapor intrusion pathway. TCE and PCE in the indoor air of these homes appear to be from sources inside the homes.
Next Steps	We are taking the following actions: • In order to prevent contact with harmful VOCs, EHAP recommends that residents of homes D and G identify and remove VOC sources potentially affecting the indoor air quality of their homes. • EHAP is available for assistance in identifying potential activities or products used that would cause these homes to have higher VOC levels. EHAP can also provide information on air purification or treatment systems, and information on obtaining follow-up air samples. • EHAP will coordinate with DEQ on outreach to Trainsong residents in Fall/Winter 2009 to answer questions and concerns related to the UPRR investigation and cleanup, and the findings of this report.
Conclusion 2	EHAP concludes that breathing TCE and PCE in the indoor air at the other seven CRP Study homes is not expected to harm people's health.
Basis for Decision	The measured levels of TCE and PCE in these homes are below current health guidelines.
Next Steps	We are taking the following actions: • EHAP recommends Trainsong residents limit their use of water from VOC-contaminated irrigation wells. We advise residents with contaminated wells to only use these wells for irrigation, hosing off outside surfaces, and other outdoor uses. We recommend that residents not drink water from these wells, and

	use municipal (city) water for drinking, cooking and other home uses. • EHAP is available to answer questions related to the findings of this report, and will provide information and resources to Trainsong residents through fact sheets and other educational materials as needed.
Conclusion 3	EHAP concludes that the levels of VOCs in the CRP Study homes, except homes D and G, appear to be consistently below health guidelines, based on data collected in 2007 and 2008.
Basis for Decision	The data from the CRP study do not show the large variations that were seen in the data collected between 2004 and 2006. With the exception of homes D and G, the levels in all other CRP Study homes have remained at levels that are below health guidelines.
Next Steps	We are taking the following actions: • EHAP will coordinate with DEQ to answer questions and concerns related to the UPRR investigation and cleanup, and the findings of this report. This may include joint outreach to residents in the Trainsong neighborhood in the fall of 2009.
For More Information	If you have concerns about the findings of this report, you should contact the Environmental Health Assessment Program at 971-673-0977 (Sujata Joshi) or ehap.info@state.or.us. For information about the DEQ Cleanup Program's work at the UPRR Site, you should contact Don Hanson at 541-687-7349 or hanson.don@deq.state.or.us. You can also call ATSDR at 1-800-CDC-INFO and ask for information on the UPRR site.

Purpose and Health Issues

EHAP prepared this health consultation to evaluate the health risks from VOCs in the indoor air of homes located in the Trainsong neighborhood of Northwest Eugene. Portions of this neighborhood are located above a groundwater plume of VOCs originating from the UPRR site, and the indoor air quality in some homes is potentially affected by vapor intrusion of VOCs. In a previous public health assessment (PHA) released in 2007, EHAP did not have enough information to determine if the VOCs found in homes near the railyard were at levels that could harm residents' health.

In 2007 and 2008, DEQ provided oversight for a study to determine if the indoor air quality of nine homes in the Trainsong neighborhood was affected by the railyard contamination. As part of this study, vapor barriers (along with ventilation systems in some crawlspaces) were installed and tested to determine if these systems were effective in reducing indoor VOC levels. This health consultation used the information from the study to address the following questions:

1. Based on data collected as part of DEQ's CRP Study, do the levels of VOC vapors measured in indoor air pose health risks to residents in these homes?
2. In homes where VOC levels exceed health guidelines, is there evidence that the railyard contamination is the source of these VOCs, and are vapor barriers/ventilation systems in these homes effective in reducing these levels?
3. At locations where past measurements showed large variations in VOC levels, have concentrations remained consistently below health guidelines?

Site Background

The Eugene UPRR site is located in a mixed industrial and residential area in the northwestern part of the city. The railyard has been in operation since the late 1880s, and has been used for maintenance, sorting, switching, repair, and washing of rail cars and engines since 1918. The railyard was formerly owned by the Southern Pacific Transportation Company and was taken over by UPRR in 1999. The railyard is currently used for cleaning, switching locomotives and railcars, and refueling by tanker trucks. There is also a diesel shop on the site that is leased by other companies [1]. There are other industrial and manufacturing operations in this area, including wood treatment and metal processing plants.

There are several neighborhoods located near the Eugene UPRR yard, including the Trainsong, River Road, and Bethel neighborhoods (Figure 1). The Trainsong neighborhood is bounded by the railyard to the east and an active rail road (Burlington Northern Santa Fe) to the west. In 2000, approximately 14,500 people lived in the three census tracts nearest to the Railyard, with 4,000 people living in the Trainsong neighborhood (census tract 42) [2]. Trainsong residents face a number of social and economic disparities. When compared to the city of Eugene and the Bethel and River Road neighborhoods, people living in Trainsong have lower median incomes, higher rates of poverty, lower educational attainment, and lower rates of home ownership. This area is more ethnically diverse than nearby neighborhoods and Eugene as a whole, and has higher rates of migration in and out of the neighborhood [2].

Figure 1. Map of the Eugene UPRR site and nearby neighborhoods

Community Concerns and Previous Investigations

EHAP has been involved in investigations in the NW Eugene area since 2003. Over the course of this involvement, EHAP has documented many of the community's concerns about environmental contamination in the area. Some of these concerns are related to chemical releases from a single site, such as creosote and odors from the JH Baxter site and VOCs from the UPRR site. Other concerns are related to area-wide environmental contamination in the Willamette Valley, which is influenced by industrial and agricultural pollutants, vehicle emissions, and weather patterns. Table 1 provides a general summary of the major environmental contamination issues and toxics of concern in this area.

Residents in the NW Eugene neighborhoods have reported a number of health problems and concerns. Many residents report respiratory illnesses, including asthma, difficulty breathing, eye, nose and throat irritation, allergies and sinus infections. There also have been reports of nausea, headaches, dizziness, anemia, and immune system impairment. The community has expressed concerns about perceived clusters of brain cancer and acute myeloid leukemia, including cases in children and young adults.

Table 1. Environmental concerns reported by NW Eugene residents

Source	Contaminants
Emissions from wood treatment plants	• Creosote • Pentachlorophenol (PCP) • Polycyclic Aromatic Hydrocarbons (PAHs) • Dioxins
Hazardous air toxics and small particle pollution from industrial facilities and roadway	• Volatile Organic Chemicals (VOCs) o Benzene o Toluene o PCE o TCE o Formaldehyde • Diesel particulate
Groundwater and soil pollution from railyard	• Volatile Organic Chemicals (VOCs) o PCE o TCE • Metals o Arsenic o Lead o Chromium o Manganese • Herbicides and pesticides applied near railroad tracks
Field Burning	• Smoke • Particulate Matter

EHAP's first investigation in NW Eugene was an assessment of the health risks from emissions at the JH Baxter wood treatment plant; the initial assessment was completed in 2004, and a follow up assessment was completed in 2007. Based on the available environmental data, EHAP concluded that while there were low health risks from the plant's air emissions, odors from the site could affect the quality of life of people living nearby [3]. From 2006 to 2008, EHAP conducted a separate investigation to examine whether there were elevated cancer rates in the neighborhoods near the JH Baxter and UPRR site. Area residents were concerned that there were higher than expected cancer rates in the Bethel, Trainsong and River Road neighborhoods, and that these cancers were associated with area-wide environmental contamination from nearby industrial operations. The cancer investigation found elevated rates of lung cancer in the neighborhoods, but because of limited data on confounding factors such as smoking and other exposures, EHAP was not able to link these elevations to an environmental source [4].

Investigations and Cleanup at the UPRR Site

Over the past several decades, operations at the railyard have contaminated the groundwater and soil on the site with creosote, polynuclear aromatic hydrocarbons, heavy metals and VOCs. The company that formerly owned the railyard entered DEQ's Voluntary Cleanup Program in 1992, and UPRR continued participation in the program in order to study and clean up environmental contamination from the railyard's activities. In 1994, an environmental investigation found that the groundwater beneath the site was contaminated with VOCs. Subsequent studies found that the contamination had migrated off-site and was affecting private groundwater wells in nearby neighborhoods.

There have been many studies to characterize the extent of the groundwater and soil contamination from the UPRR site. UPRR has initiated clean-up activities at the source of the contamination near the former UPRR Roundhouse. These actions have greatly reduced VOC concentrations on the site, and will help reduce VOC levels in the groundwater and soil gas in nearby neighborhoods. More recently, DEQ oversaw the Crawlspace Remediation Pilot (CRP) study, which provided the data used in this report. The CRP study examined the potential risks and possible mitigation strategies for vapor intrusion of VOCs in homes located closest to the UPRR site (described in more detail below).

In the fall of 2006, DEQ requested that EHAP investigate the human health risks from the contamination that had traveled off-site and into surrounding neighborhoods. Around the same time, a Eugene-based environmental justice group called the Oregon Toxics Alliance (OTA) petitioned EHAP to investigate whether contamination from the UPRR site posed any health risks to residents living near the railyard. OTA provided EHAP with information on some of the health concerns of residents living near the railyard, which included:

- Health risks from exposure to VOCs in groundwater through irrigation wells, particularly for children and adults who use the water for irrigation, gardening and recreational activities
- Health risks from the movement of VOCs from groundwater, through soil, and into indoor air (vapor intrusion) and outdoor air
- Concerns that residents with low incomes would not have resources to pay for testing or air/water treatment systems
- Frustration with the length of time of DEQ's investigation and UPRR's clean-up
- The need for better communication from state agencies, UPRR, and other stakeholders

Based on these concerns, and the available data from environmental assessments on the site, EHAP decided to conduct a PHA to examine the health risks from exposure to VOCs in irrigation well-water and indoor air.

2007 Public Health Assessment

EHAP completed the first draft of the PHA report, and released it for public comment in May 2007. In October 2007, EHAP released the final version of the UPRR PHA. The final PHA incorporated public comments, additional air sampling data that had been collected in April and August 2007, and provided additional geographic and temporal analyses of the data. In the report, EHAP concluded that there were no health risks to children or adults from using VOC-contaminated irrigation well water to irrigate gardens or hose off outside surfaces. However, EHAP was not able to reach a definitive conclusion about the risks from VOCs in indoor air because of uncertainties in the environmental sampling data, which are described in the following paragraphs.

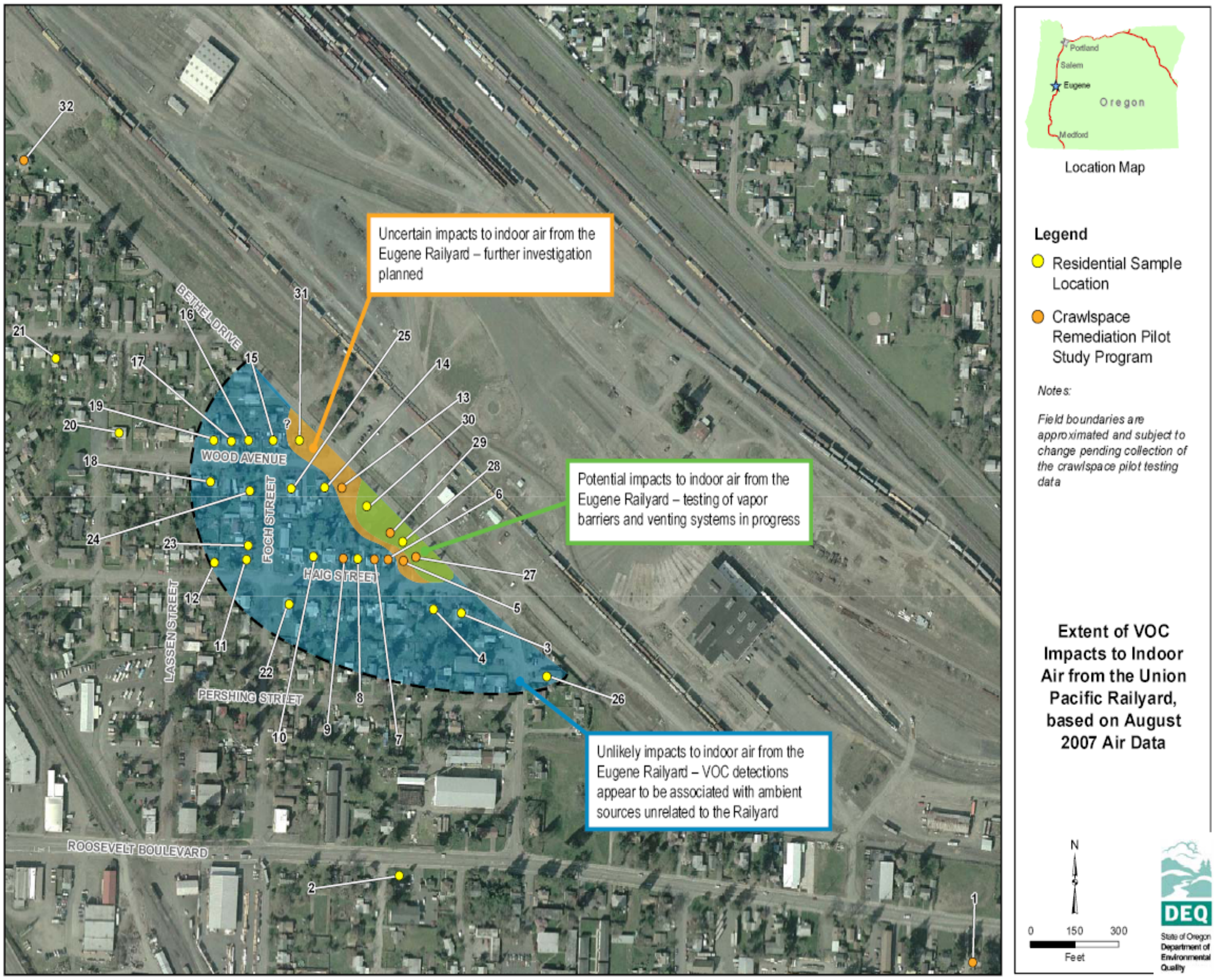
Indoor air measurements provide the most accurate information on the levels of contaminants that people come into contact with on a daily basis. However, prior to August 2007 there were very few indoor air samples that had been collected in homes near the railyard. In the absence of this information, EHAP used crawlspace VOC data as a surrogate for indoor air levels. Based on data collected between 2004 and 2006, EHAP found that the VOC levels were above health guidelines at the maximum and median levels measured in crawlspaces at 11 locations (a past public health hazard). However, the VOC levels measured at these locations a year later, in 2007, were much lower, and were not above health guidelines. In the PHA, EHAP stated that it was "plausible that levels could increase above health guidelines in the future; we therefore conclude that an *indeterminate public health hazard* exists currently in locations previously exceeding health guidelines" [5]. EHAP recommended that additional air sampling data be collected to ensure that the lower levels measured in 2007 remained stable and at levels that did not pose health risks.

The PHA also noted that there was "uncertainty about the relationship between the VOC plume [in groundwater] and the level of VOCs found in crawlspace air" in the homes that had been sampled. Based on data collected in 2007, DEQ believed that homes in a small area of the Trainsong neighborhood were potentially affected by the vapor intrusion of VOCs from the groundwater plume. Homes outside of this area (including those in the River Road neighborhood) were probably not affected by the plume, and the source of VOCs in crawlspace air in these homes was believed to be from outdoor sources. DEQ developed three categories to describe homes in the Trainsong neighborhood (Figure 2):

- Category 1 (four locations): homes that are *potentially* affected by the Railyard
- Category 2 (three locations): homes where it is uncertain whether indoor air is affected from the Railyard
- Category 3 (all remaining locations): homes where it is unlikely that indoor air is affected by the Railyard where VOC detections appear to be associated with ambient (outdoor) sources unrelated to the Railyard.

EHAP accepted DEQ's determination that the indoor air at four locations was potentially affected by the contamination at the UPRR Railyard, and that it was uncertain if three additional locations were affected by the contamination. EHAP recommended that additional studies be conducted to determine the contribution of VOCs in indoor/crawlspace air from the railyard. EHAP also recommended installing vapor barriers and/or ventilation systems to reduce VOCs in homes where indoor air levels were above health-based standards, and where there was evidence that VOC-contaminated groundwater was the source of vapors.

Figure 2. Trainsong homes by category



Crawlspace Remediation Pilot (CRP) Study

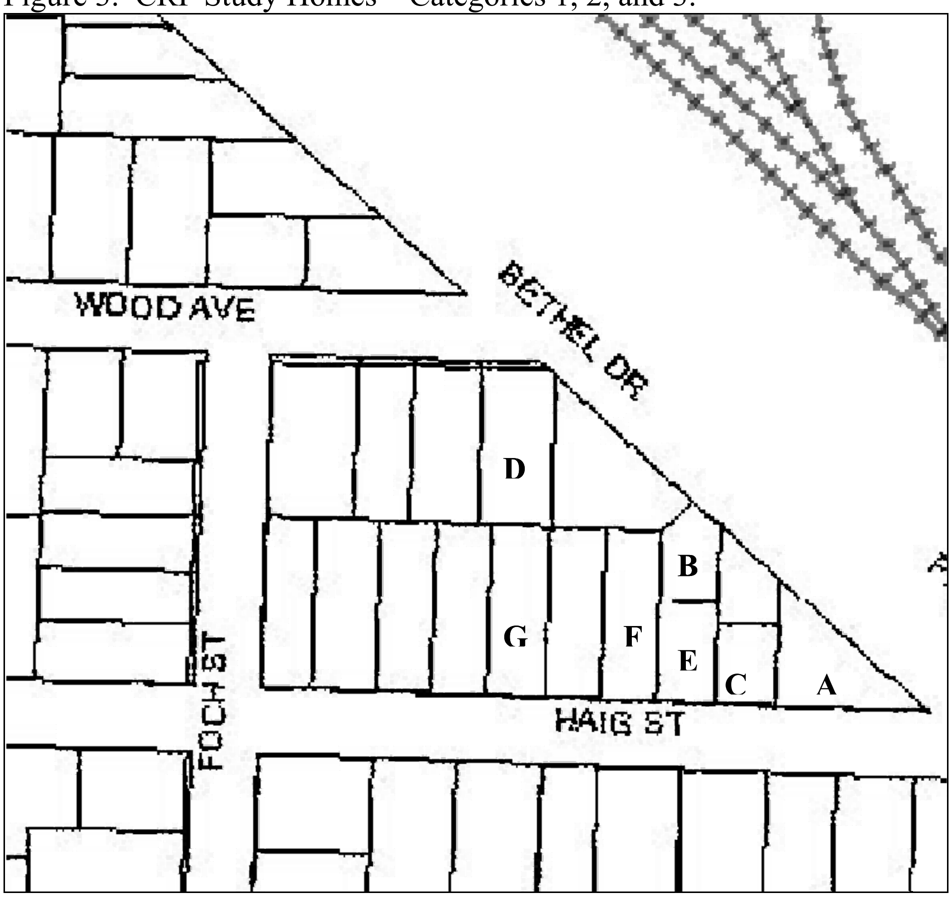
In 2007, DEQ began the CRP study to examine whether the indoor air of homes located near the UPRR site was being affected by vapor intrusion of VOCs from the contaminated groundwater. The study also examined whether vapor barriers and ventilation systems (or mitigation systems) in these homes' crawlspaces were effective in preventing VOCs from migrating into indoor air. The study was conducted by UPRR's consultants CH2M Hill, with oversight by DEQ.

Seven of the nine study homes are in the portion of the Trainsong neighborhood located closest to the UPRR site. These homes include two Category 1 homes, two Category 2 homes and three Category 3 homes. In addition, two homes located outside this area were selected to represent background levels (Category 4 homes). The Category 1, 2, and 3 homes are located close to one another on the east side of the neighborhood block bounded by Bethel Drive, Wood Ave., Haig St. and Foch St. (Figure 3).

In August 2007, samples were collected from the soil gas, crawlspace air, indoor air, and ambient air in order to establish base line concentrations of VOCs in the nine homes. UPRR then installed mitigation systems in six of the Category 1, 2 and 3 homes. Home G (a Category 3 home) was selected as a control for the study, and mitigation systems were not installed in this home. The mitigation systems have been inspected and tested monthly during the pilot study in order to ensure that they are performing as intended.

At this site, the risk for vapor intrusion is expected to be higher during the wet season, since the contaminant plume in groundwater would be closer to the surface of the ground. Therefore, the VOC sampling was repeated in January 2008 to measure chemical concentrations during the peak of the wet season, when groundwater levels were at their highest (less than five feet below the surface). Samples were also collected in September and November 2008 to measure VOC levels during the dry season, when groundwater levels were at their lowest point (approximately 11 feet below ground surface) [6].

Figure 3. CRP Study Homes – Categories 1, 2, and 3.



Discussion

This follow-up health consultation addresses the outstanding questions about the health risks from VOCs in indoor and crawlspace air in the Trainsong neighborhood. Specifically, this health consultation examines the following questions:

1. Based on data collected as part of the CRP Study, do the levels of VOC vapors measured in indoor air pose risks to residents in these homes?
2. In homes where VOC levels exceed health guidelines, is there evidence that the railyard contamination is the source of these VOCs, and are the vapor barriers/ventilation systems in these homes effective in reducing these levels?
3. At locations where past measurements showed large variations in VOC levels, have concentrations remained consistently below health guidelines?

This section begins with a discussion of the comparison values used in this analysis, and how EHAP addressed uncertainties. It is followed by an overview of the vapor intrusion pathway in the Trainsong neighborhood and information about the data used in this analysis. EHAP then provided its analysis of the three questions outlined above.

Comparison Values

EHAP uses comparison values (CVs or guidelines) as screening tools in order to quickly identify which contaminants at a site could potentially pose health risks to people who come into contact with them. EHAP uses CVs during two steps in its analysis of the health risks at a site: the environmental guideline comparison step and the health guideline comparison step. If the level of a contaminant is below its CV, the contaminant is not expected to pose any health risks, and does not need to be further evaluated. If a contaminant is above its CV, it may not necessarily pose risks to people who come into contact with the contaminant, but it needs to be examined more closely. EHAP uses CVs that have been developed by ATSDR, and chooses the lowest (most health-protective) value available for a contaminant. For contaminants that do not have ATSDR-developed guidelines, EHAP uses appropriate CVs that have been developed by the Environmental Protection Agency (EPA) or other agencies [7].

ATSDR, EPA, and other agencies develop CVs based on the available scientific information about the health risks from coming into contact with a chemical. This information comes from studies on the types of health effects that have been observed in humans and animals who have been exposed to the chemical. When developing CVs, ATSDR and other agencies consider whether a contaminant has been shown to cause non-cancer or cancer health effects, the levels where these effects have been observed, and how much certainty there is about the health risks from a chemical. CVs are set at levels that are much lower than the concentrations (or doses) that have been shown to cause harmful health effects in medical and toxicological studies of these chemicals.

Environmental agencies also use CVs as screening and decision-making tools at contamination sites, and sometimes these CVs are different from those used by health agencies. Environmental agencies use CVs in their risk assessments to identify the major contamination issues at a site, develop and prioritize clean-up activities, and enforce actions and policies to reduce exposure to toxic chemicals. Health agencies use CVs to determine whether contaminants at a site could harm people's health, understand the potential health risks at a site, and develop recommendations to protect people from harmful exposures. Despite any apparent differences, health and environmental agencies use these guidelines with the common goal of protecting people from coming into contact with harmful levels of chemicals in the environment.

Uncertainties in Analysis

EHAP tries to provide communities with an accurate assessment of the health risks from chemical contamination in their homes and environment. However, there often are missing data, which results in some uncertainties in the analysis. For example, in this assessment, EHAP did not have information on how much time residents spend in their homes on a daily basis, whether they work in jobs or have hobbies that involve regular exposures to VOCs, or if these residents have certain characteristics that could make them more sensitive to the effects from VOC exposure (e.g., having underlying health conditions).

There are also uncertainties related to the air sampling data. The concentration of a chemical in air can fluctuate over the course of a day, week, month, or year. Therefore, the information from one air sample represents a "snapshot" of air quality at a single point in time. Data from multiple sampling events helps provide a more comprehensive understanding of the concentrations of a chemical in air, although these data are still limited in how accurately they reflect what people are coming into contact with on a daily basis. Environmental investigators try to control some of these limitations by documenting the methods they use to collect and analyze the samples, and taking detailed notes on locations, time, and environmental conditions while collecting samples.

Because of these uncertainties, EHAP made conservative assumptions about Trainsong residents' exposures to VOCs. For example, EHAP used comparison values that assume that adults living in the Trainsong neighborhood would be breathing the air in their homes for 24 hours a day over 365 days a year for 70 years. This probably overestimates the actual time a person would spend in their home. Further, in the preliminary screening steps of the analysis, EHAP assumed that residents would be exposed to the maximum concentration of a contaminant that was detected during the CRP Study. This represents a "worst-case" scenario for exposure, since the concentrations that residents actually breathe would vary depending on the day, season, and weather patterns. This conservative approach ensures that this assessment is as protective of health as possible.

Exposure Pathways at the UPRR Site

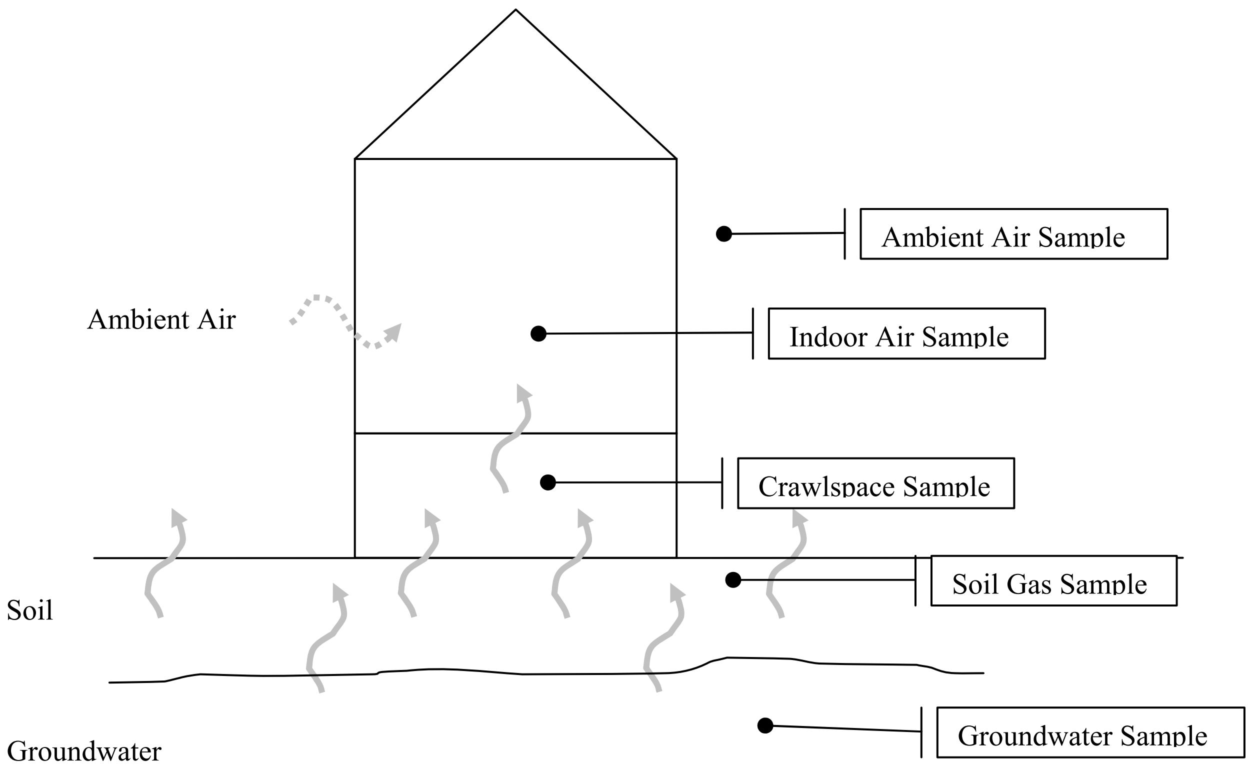
At the UPRR site, railyard operations contaminated the soil and groundwater on the site with VOCs. The contaminated groundwater has traveled into nearby residential areas, with the greatest off-site impacts in a localized area of the Trainsong neighborhood. The groundwater in this area is relatively shallow, and recent data indicate that the water ranges between five to ten feet below the ground's surface depending on the season [6]. Residents living above or near the contaminated groundwater could be exposed to the VOCs through two pathways: 1) using water from groundwater wells for domestic or irrigation purposes, and 2) vapor intrusion of VOCs from groundwater, through soil, and into indoor air.

DEQ found that residents in neighborhoods near the UPRR site used municipal (city) water for their domestic water supply, but some people used water from irrigation wells for primarily outdoor uses. In the 2007 PHA on UPRR, EHAP found no health risks to children or adults from using VOC-contaminated irrigation well-water to irrigate gardens or hose off outside surfaces. However, residents should not use this well-water for drinking, bathing, or other indoor applications.

Figure 4 shows a simplified diagram of how vapor intrusion can occur at sites with groundwater contamination. In this model, chemicals move upwards from the contaminated groundwater, through spaces in the overlying soil, and towards the surface. If there is a building above the contamination, the chemical vapors can enter into the indoor space through cracks or holes in the building's foundation. The vapors will then migrate upwards in the building. The levels of VOCs are expected to decrease as they move from the groundwater, through the soil, into the crawlspaces beneath the homes, and finally into the indoor air of the homes. Therefore, the indoor air samples should have the lowest concentrations compared to the crawlspace and soil gas samples. The ambient air samples provide information on background levels of VOCs outside a home.

This simplified model of vapor intrusion can be complicated by many factors. For example, if outdoor VOC levels are higher than those inside a home, there can be movement of VOCs from outdoor to indoor air through windows and doors (shown as a dashed arrow in Figure 4). The air pressure within a building also influences the movement of vapors into indoor air, depending on the difference between indoor and outdoor pressure. Further, there often are many indoor sources of VOCs (e.g., cleaning products, paint, dry cleaned clothes, and treated upholstery) that can contribute to indoor air concentrations of VOCs. All of these factors must be considered and evaluated when investigating the risks from vapor intrusion.

Figure 4. Diagram of vapor intrusion pathway



Data used in this report

EHAP used all of the data that were collected as part of the CRP Study (see Appendix B for a summary of the environmental data from the study). There were data quality issues with some of the environmental samples that were collected, particularly during the September and November 2008 sampling events. In CH2M Hill's report on these data, they noted that the laboratory equipment used to analyze some of the data malfunctioned, and that the samples had to be re-analyzed. This resulted in the samples being analyzed outside of the recommended time frame for obtaining accurate results. Because of this error, the homes were re-sampled in November. However, the equipment (Teflon tubing) used to obtain the November crawlspace samples was apparently contaminated with TCE. Therefore, the November 2008 crawlspace data were biased high, and the reported levels were probably higher than the actual levels at the time the samples were collected. CH2M Hill based this conclusion on the following: the November crawlspace data collected from all of the homes was consistently higher compared to previous sampling events; the Teflon tubing was only used for the crawlspace samples; and the November soil gas, indoor air, and ambient samples did not indicate any other reason for the crawlspace samples to be elevated.

1. Based on data collected as part of the CRP Study, do the levels of VOC vapors measured in indoor air pose risks to residents in these homes?

EHAP used a step-wise analysis to determine if the VOC levels in indoor air posed health risks to Trainsong residents, beginning with a comparison to environmental guidelines.

Environmental Guideline Comparison

In the environmental guideline comparison, the concentration of a contaminant in the environment (measured in air, soil, water, or other media) is compared to the environmental CV for that contaminant. If the concentration is below the CV, the contaminant is not at a level that could harm people's health. If the concentration exceeds the CV, it is considered a contaminant of potential concern (COPC), and is moved forward to the next step in the analysis. COPCs are not necessarily harmful to health, but need to be further examined to see if they could pose health risks.

The following environmental CVs (for contaminants in air) were used in this analysis:

- CREG (Cancer Risk Evaluation Guide): The CREG represents the concentration of a contaminant that is not expected to cause an increase in cancer rates in a population. The CREG represents a theoretical risk level of 1 additional cancer case in 1 million people exposed (1E-06), which is considered a slight cancer risk. The CREG was used as the CV for TCE, PCE, and vinyl chloride.
- DEQ Risk Based Concentration (RBC): The RBC represents the concentration of a contaminant that is not expected to cause harmful health effects, and is based on information about a substance's toxicological properties and standard assumptions about how people are exposed. The RBC was used for cis-1,2-dichloroethyelene, and is based on non-cancer health risks.
- Environmental Media Evaluation Guide (EMEG): The EMEG is the concentration of a chemical that a person can be exposed to for a specified time period without any risks for non-cancer health effects. In residential settings, where exposures are expected to occur for more than 1 year, the chronic EMEG would be the most appropriate CV. However, ATSDR has not developed a chronic EMEG for 1,1-dichloroethene and trans-1,2-dichloroethene, so the intermediate EMEG was used instead.

EHAP only used indoor air (and not crawlspace or ambient air) data in this comparison, since these data most likely reflect the contaminant levels that people come into contact within their homes. For each contaminant, EHAP compared the maximum concentration that was measured in the indoor air of any CRP Study home to the environmental CV. This is a health-protective approach which ensures that any contaminants that could pose health risks are carried forward to the next step in the analysis. Table 2 shows a summary of the environmental screening comparison step for CRP Study homes. TCE and PCE were the only contaminants that exceeded their environmental CVs, and were carried forward to the next step in the analysis as COPCs.

Table 2. Environmental Guideline Comparison.

Contaminant	Maximum Indoor Air Concentration (µg/m^3)	Environmental CV (µg/m^3)	Exceed CV?	CV Source	Oregon DEQ RBC^ (µg/m^3)
Trichloroethylene (TCE)	9.8	0.021*	Yes	2001 EPA Draft Risk Assessment	0.018
Tetrachloroethylene (PCE)	2.8	0.41*	Yes	Cal-EPA	0.34
Vinyl Chloride	0.074	0.1*	No	CREG	0.15
cis-1,2-Dichloroethene	0.072	37	No	DEQ RBC	37
trans-1,2-Dichloroethene	<0.055	800	No	Intermediate EMEG	62
1,1-Dichloroethene	0.091	80	No	Intermediate EMEG	210

CREG = Cancer Risk Evaluation Guide; RBC = Risk Based Concentration; EMEG = Environmental Media Evaluation Guide
^Oregon DEQ RBCs are shown for information purposes only; values shown are for urban residential indoor air.
*The CVs for TCE, PCE and Vinyl Chloride are based contaminant-specific inhalation unit risks (IURs) and a 1 in 1 million (1E-06) cancer risk level. EHAP used the following IURs (in [(µg/m^3)$^{-1}$]): TCE: 1.1E-04 (2001 EPA Draft Risk Assessment), PCE: 5.9E-06 (Cal-EPA), vinyl chloride: 8.8E-06 (IRIS)

Health Guideline Comparison

In the next step of the analysis, the COPCs were compared to their health CVs. As in the previous step, COPCs whose concentration did not exceed their CV were excluded from further analysis. COPCs with concentrations above the health guideline are considered contaminants of concern (COCs), and carried forward to the final step for an in-depth analysis of the health risks from exposure to these contaminants. Because exposure to high levels of TCE and PCE in air have been associated with both non-cancer and cancer health risks, the maximum concentration of these contaminants were compared to non-cancer and cancer CVs.

Non-cancer Health Guideline Comparison

Non-cancer health CVs are based on information on studies of humans and animals who have been exposed to high levels of a chemical. These studies provide information on the types of health effects a chemical can cause, and the exposure levels that resulted in these effects. ATSDR and EPA derive health CVs by identifying the lowest level of a chemical that has been shown to cause a health effect, and applying a number of safety factors that result in a guideline that is health-protective for the most sensitive populations (such as pregnant women and children).

Exposure to high levels of TCE and PCE in air has been shown to increase the risk for damage to the central nervous system, immune system, kidney, and liver [8, 9]. Some studies have found that these chemicals can cause reproductive and developmental effects, though the evidence is less conclusive about these risks. The following health guidelines were used in this analysis:

- PCE – ATSDR Chronic Minimal Risk Level (MRL): ATSDR's chronic MRL is the concentration of a chemical that a person can be exposed to on a daily basis for a year or longer without any risks for non-cancer health effects. The chronic MRL for PCE is based on a study that found neurobehavioral effects in women who had been exposed to high levels of PCE while working in dry cleaning shops. In this study, the median air concentration of 101,700 μg/m^3 was identified as the lowest level where harmful health effects from PCE exposure were observed. This level was used to derive the chronic MRL of 270 μg/m^3, which is more than 300 times lower than the effect level identified in the MRL study [8].

- TCE – EPA Draft Reference Concentration (RfC): Currently, ATSDR and EPA do not have a health CV for TCE. Therefore, EHAP used the CV that was proposed in EPA's 2001 External Review Draft Health Risk Assessment for TCE. The RfC is the concentration of a contaminant in air that a person can be exposed to on a daily basis without any risks to their health. The RfC for TCE is based on studies that have found effects to the central nervous system, liver, and endocrine system in people who have been exposed to TCE in air; the lowest concentrations where these effects have been observed were 38,000 – 40,000 μg/m^3. The RfC of 40 μg/m^3 is approximately 1,000 times lower than the effect levels identified in these studies [10].

Table 3 shows a summary of the non-cancer health guideline comparison for homes in the CRP Study. The maximum detected concentration of TCE and PCE detected in any home was compared to the non-cancer health CVs for TCE and PCE. Even at these maximum concentrations, the levels of these contaminants were below the non-cancer health CVs. Based on this finding, EHAP does not expect that residents in these homes have increased risks for non-cancer health effects associated with exposure to PCE and TCE.

Table 3. Non-cancer health guideline comparison for CRP Study homes

	TCE	**PCE**
Maximum Concentration (μg/m^3)	9.8	2.8
Health Comparison Value (μg/m^3)	40*	270^
Exceed CV?	No	No

*EPA Draft RfC
^ATSDR Chronic MRL

Cancer Health Guideline Comparison

Cancer risks are evaluated by first examining if there is scientific evidence that a substance causes cancer, and then determining if exposures at a site could theoretically result in increased cancer risks. The EPA, the National Toxicology Program (NTP) and the International Agency on Research of Cancer (IARC) classify substances in terms of whether they are known, probable, possible, or unlikely carcinogens. For many carcinogens, there is not enough scientific evidence to determine if there is a threshold level of cancer risk (i.e., a level below which there would not be any increased cancer risks). Therefore, a theoretical cancer risk is used to estimate the number of additional cancer cases that would occur if a population was exposed to a potentially carcinogenic substance. It is important to note that the theoretical cancer risk does not predict if an exposed person will get cancer. Instead, it is used by public health and environmental agencies to make decisions about appropriate measures to reduce exposures.

The EPA has developed Inhalation Unit Risk factors (IURs) for air contaminants that are known, probable, or possible carcinogens. The IUR is multiplied by the concentration of a contaminant in air to get the theoretical cancer risk, which is expressed in terms of additional cancer cases in a population. EHAP describes exposures to carcinogens as having slight, low, moderate, or high increased cancer risks. Exposures that could cause one additional case of cancer in a population of one million (1E-06) are considered to have a slight cancer risk, while exposures that could cause one additional case in 10,000 (1E-04) have a low cancer risk. EHAP considers exposures that exceed a low level of cancer risk to pose an unacceptable level of increased cancer risk.

PCE and TCE are both "reasonably anticipated to be human carcinogens" by the NTP and are classified as "probable human carcinogens" by the IARC. Currently, the EPA does not have IURs for these contaminants. In its 2001 External Review Draft Health Risk Assessment for TCE, the EPA proposed an IUR range for TCE cancer risk assessment. To be protective of health, EHAP used the upper end of this range (1.1E-04 $(\mu g/m^3)^{-1}$), which provides the most conservative estimate of cancer risk. EHAP used California EPA's IUR for PCE, which is 5.9E-06 $(\mu g/m^3)^{-1}$. EHAP used the maximum concentration of TCE and PCE detected in the indoor air of CRP study homes to calculate the cancer risks from individual contaminants, and then summed these risks to obtain a combined cancer risk.

Table 4. Cancer risks in CRP Study homes at maximum concentrations

	TCE	**PCE**
Maximum Concentration ($\mu g/m^3$)	9.8	2.8
Inhalation Unit Risk $(\mu g/m^3)^{-1}$	1.1E-04	5.9E-06
Cancer Risk*	1.1E-03	1.7E-05
Combined Cancer Risk	1.1E-03	
*Cancer Risk = Concentration in air x IUR		

Table 4 shows the cancer risks in CRP study homes at the maximum concentrations detected. There was a moderate level of increased cancer risk (1 in 1,000 cancer risk) at the maximum levels of TCE and PCE detected in any homes. This exceeds an acceptable level of cancer risk of 1 in 10,000 (a low level of additional cancer risk). These increased cancer risks are based on a "worst-case scenario", which assumes that people would be inhaling the highest detected levels of TCE and PCE every day over their lifetime. In order to obtain a more realistic estimate of cancer risks, EHAP examined the cancer risks by location using the maximum and average concentrations detected in these homes.

Cancer Risk by Location

As mentioned previously, DEQ identified four categories of homes based on their proximity to the UPRR site. EHAP examined the cancer risks based on the maximum and average (mean) indoor air concentrations of TCE and PCE measured in each category. For example, between August 2007 and November 2008 there were four sampling events at the two CRP Study homes in Category 1 (eight total measurements). To find the maximum concentration in Category 1 homes, EHAP chose the highest concentration out of the eight measurements; to find the average concentration, EHAP took the average of the eight measurements. Table 5 shows the maximum and mean concentrations of TCE and PCE in CRP Study homes by location.

Table 5. Cancer risks at maximum and average indoor air levels by category

Concentration	Category	TCE	PCE	TCE Risk	PCE Risk	Combined Cancer Risk
Max	1	0.25	1.2	2.8E-05	7.1E-06	3.5E-05
	2	3.7	2.8	4.1E-04	1.7E-05	**4.2E-04***
	3	9.8	0.47	1.1E-03	2.8E-06	**1.1E-03***
	4	0.09	0.36	9.9E-06	2.1E-06	1.2E-05
	All	9.80	2.80	1.1E-03	1.7E-05	1.1E-03
Mean	1	0.11	0.75	1.2E-05	4.4E-06	1.7E-05
	2	0.92	0.94	1.0E-04	5.5E-06	1.1E-04
	3	2.78	0.24	3.1E-04	1.4E-06	**3.1E-04***
	4	0.06	0.24	6.6E-06	1.4E-06	8.0E-06
	All	0.97	0.54	1.1E-04	3.2E-06	1.1E-04
*Exceeds a low level of cancer risk						

EHAP expected to find the highest risks in Category 1 homes, since they are located closest to the railyard and were determined to have the highest potential of being affected by contamination from the site. However, Category 1 homes had risks that were comparable to those found in Category 4 homes, which represent background levels. At the maximum concentrations of TCE and PCE measured, Category 1 and 4 homes had a very low level of cancer risk (from 1 to 3 additional cases in 100,000); at the average concentrations, these homes had a slight to very low level of cancer risk. The concentrations of TCE and PCE in Category 1 and 4 homes are not at levels that could harm the health of residents living in these homes.

EHAP found the highest cancer risks in Category 2 and 3 homes, which were identified as having uncertain or unlikely impacts to indoor air from the railyard. The highest concentrations of TCE and PCE were in Category 3 homes, where cancer risks exceeded a moderate level of cancer risk at the maximum levels measured (1 additional case in 1,000), and a low level of cancer risk at the average levels measured (3 additional cases in 10,000). There were low cancer risks (4 additional cases in 10,000) at the maximum levels found in Category 2 homes.

EHAP reviewed the indoor air data from the five homes in Categories 2 and 3 (Table B.1 in Appendix B). There were two homes that appeared to have higher indoor air levels of TCE and PCE compared to the other three homes: Home D in Category 2 and Home G in Category 3. The other three Category 2 and 3 homes had indoor air levels that were comparable to those found in background homes, and did not exceed health guidelines for cancer risks.

In summary, EHAP found that two of the nine homes in the CRP Study had TCE and PCE levels in indoor air that could pose increased cancer risks to residents living in these homes. The levels of these contaminants in the other seven homes were below health guidelines, and were not at levels that could pose health risks to people living in these homes.

2. In homes where VOC levels exceed health guidelines, is there evidence that the rail yard contamination is the source of these VOCs, and are the vapor barriers/ventilation systems in these homes effective in reducing these levels?

Homes D and G were the only homes where indoor air concentrations of PCE and TCE levels exceeded health guidelines. While home G did not have a mitigation system, home D had a system installed in late 2007, which should have prevented VOCs from migrating from the crawlspace area into indoor air. However, VOC levels continued to be high in this home even after the system was installed. This could be because the mitigation system was not functioning properly, or because the VOCs found in indoor air were not migrating in from the crawlspace area.

EHAP further investigated Homes D and G by examining all of the available data on these homes. Table 6 shows all of the indoor air, crawlspace, soil gas, and ambient air data for these homes from the CRP Study. As mentioned previously, there may have been some equipment contamination issues that resulted in higher November 2008 crawlspace results for TCE.

Table 6. Air sampling data (in $\mu g/m^3$) for homes exceeding health guidelines.

Location ID	Contaminant	Sample Type	Aug-07	Mitigation System Installed	Jan-08	Sep-08	Nov-08
D	TCE	Indoor	3.70		0.26	1.90	1.20
		Crawlspace	0.02		0.11	0.08	0.80*
		Soil Gas	16.00		<2.2	<2.1	<8.0
		Ambient	0.03		0.13	0.01	0.05
	PCE	Indoor	0.31		1.80	0.32	2.80
		Crawlspace	0.38		0.33	0.10	0.30
		Soil Gas	360.00		<2.7	500.00	110.00
		Ambient	0.30		0.33	0.06	0.32
G	TCE	Indoor	6.00		4.90	1.30	9.80
		Crawlspace	0.06		0.11	0.16	0.42*
		Soil Gas	<2.2		<2.2	<2.1	<2.1
		Ambient	0.04		0.10	0.09	0.04
	PCE	Indoor	0.18		0.47	0.10	0.24
		Crawlspace	0.31		0.35	0.11	0.22
		Soil Gas	31.00		<2.7	24.00	16.00
		Ambient	0.33		0.25	0.098	0.13

*Crawlspace data may be higher than expected due to equipment contamination.

At both locations, the indoor air levels of TCE were consistently higher than crawlspace levels; this was especially evident at location G, where the indoor TCE levels were on average 30 times higher than crawlspace levels. The majority of soil gas measurements showed non-detectable levels of TCE, which indicates that soil gas is not the primary source of this chemical in crawlspace or indoor air. The crawlspace levels of TCE at these homes were often comparable to ambient air.

The indoor PCE levels at location D were, for the most part, higher than crawlspace levels. The August 2007 measurements (taken before the mitigation systems were installed) show similar indoor, crawlspace, and ambient air levels. However, the subsequent sampling events showed that the crawlspace PCE levels were similar to those in ambient air, and lower than the levels in indoor air. The crawlspace levels did not seem to be correlated with soil gas levels, since they did not consistently increase or decrease as soil gas levels fluctuated over time. At location G, there were comparable PCE levels in indoor, crawlspace, and ambient air during all four sampling events. There appeared to be very little difference between the PCE levels measured in indoor and crawlspace air at this location. The crawlspace PCE levels were roughly 100 times lower than the concentrations measured in soil gas.

In the vapor intrusion pathway, the concentrations of VOCs are expected to decrease as the chemicals move from soil gas, into crawlspace air, and finally to indoor air. This would be true even in homes that do not have mitigation systems that actively block and remove vapors from the crawlspace area. Homes with these systems in place are expected to have indoor air concentrations of VOCs that are similar to the levels found in ambient (outdoor) air.

The data from locations D and G suggest that the VOCs in these homes are not moving in ways that are consistent with the vapor intrusion pathway. The indoor TCE and PCE levels were at best similar, and often higher than the levels measured in crawlspace air. The data did not show a strong or consistent correlation between crawlspace and soil gas VOC levels. However, the crawlspace levels were similar to ambient air levels at both locations. These data lead EHAP to conclude that the VOCs in homes D and G air are from a source other than the railyard contamination.

Though the levels of TCE and PCE at homes D and G have fluctuated over time, they have consistently remained above background air concentrations, and at levels that could pose health risks to residents in these homes. This indicates that there is some constant source inside the homes that is affecting the air quality in these homes. However, EHAP has limited information to identify what this source is, or even if there is a common source for the two homes. The following discussion provides information on some possible sources of TCE and PCE in these homes.

Potential Indoor Sources of VOCs

VOCs are found in many common household products, including paints, household cleaners, hobby supplies, and building materials. These products can affect the indoor air quality of homes, and sometimes can result in concentrations that exceed health guidelines. PCE is used in some metal degreasing products, but is most commonly used as a dry cleaning solvent. TCE is a common metal degreaser, and is also found in adhesives and other types of cleaning products. VOCs can off-gas from some products and materials over a long period of time (e.g., paint, dry cleaned clothes, or upholstery that has been treated or has absorbed VOCs).

Indoor sources of VOCs pose problems during vapor intrusion investigations by making it difficult to interpret indoor air data and identify the source of air contaminants. Household inventories are sometimes used to document potential indoor sources of VOCs; these inventories identify VOC-based products in the home, activities that involve the use of these products, and building characteristics that affect the movement of air through the home. Ideally, these sources and activities are removed or stopped prior to a vapor intrusion assessment in order to obtain accurate data on indoor air quality.

Prior to the August 2007 sampling event, DEQ and CH2M Hill did indoor air assessment surveys at the CRP Study homes. The residents of home D have lived in this location for three years, and did not report any recent or regular activities that could explain the elevated VOC levels in their home. They infrequently had clothes dry-cleaned, did not work with solvents, and used standard household cleaners (including window and carpet cleaners). They reported that the previous occupant of the home was a heavy smoker. The owners of home G have lived in their home for 13 years, and did not have any hobbies or work in jobs that involved the regular use of VOC-containing solvents. They reported the occasional use of insecticides, disinfectants and window and oven cleaners. The residents are moderate smokers, and reported that they had recently had their back porch painted.

The painting at home G could have resulted in higher VOC levels at this location during the August 2007 sampling event. The VOC levels at this home appeared to decrease in January and September 2008 samples. However, the highest VOC levels were measured during the November 2008 sampling, which over one year after the back porch was painted. The survey did not provide information on a possible VOC source for home D.

In summary, homes D and G had indoor air concentrations of PCE and TCE that exceeded health guidelines. Based on the available data, it does not appear that the VOCs in these homes are the result of vapor intrusion of chemicals from the soil gas, through the crawlspace, and into indoor air. EHAP currently does not have enough information to determine the exact source of VOCs, but believes there are consistent sources of PCE and TCE that is affecting the air quality in these homes.

3. At locations where past measurements showed large variations in VOC levels, have concentrations remained consistently below health guidelines?

In the 2007 PHA, EHAP found that crawlspace VOC levels that were measured between 2004 and 2006 exceeded health guidelines at 11 locations in the Trainsong neighborhood. However, the VOC levels measured at these locations in 2007 were all below health guidelines, and in some locations were more than 100 times (two orders of magnitude) lower than those measured in previous years. Some Trainsong residents expressed their concerns about the changes, and their distrust of the more recent sampling results. The large differences seen in the VOC levels were believed to be related to changes in UPRR's environmental consultants and the methods they used to collect samples. UPRR previously contracted with Kennedy-Jenks, but changed to CH2M Hill in 2007.

There have been many advances in the science of vapor intrusion over the past several years, which have resulted in changes in the methods used to investigate this complex pathway. DEQ has utilized the most up-to-date science and recommendations while overseeing the methods and procedures used to clean up contamination at the UPRR site. They also have responded to the community's concerns by collecting split samples to verify the accuracy of samples collected by UPRR's consultants (described in more detail below).

EHAP's health assessment process includes an evaluation of whether there are sufficient environmental data to determine if people could be harmed by a chemical exposure. This evaluation involves identifying trends, gaps, and possible discrepancies in the data. However, it does not provide a thorough quantitative analysis of the accuracy and precision of the laboratory data; DEQ is the best source of information on the test and sampling methods used in the investigation. The following discussion provides a more qualitative examination of the CRP Study data.

Based on the data collected as part of the CRP study, the indoor, crawlspace, and ambient air measurements appear to be staying stable over time (Table B.2 in Appendix B). In most of the homes, there was less than an order of magnitude (10 times) difference between the highest and lowest indoor air measurements. The indoor VOC levels at homes D and G appeared to have more fluctuations between sampling events, though the crawlspace and ambient air levels measured at these homes were stable throughout the study period.

Data from duplicate and split samples provide another line of evidence about the precision of the air measurements from this study. Duplicate air samples are collected at the same time, location, and under the same conditions, and provide a measurement of the precision of the entire sample collection and analysis process. Split samples are obtained by dividing an air sample into two parts and analyzing the samples at two different laboratories; these data provide a measure of the precision of the laboratory analysis process. Table B.3 in the Appendix shows the duplicate, triplicate, and split sample results from the CRP Study. CH2M Hill collected original, duplicate, and triplicate samples at Location A during the September and November sampling events. Overall, the duplicate and triplicate results were similar to those obtained from the original samples, with especially strong agreement for the indoor air results. Split samples were collected at locations A, B, C and E at different times during the CRP Study, and were analyzed separately by CH2M Hill and ODEQ. The split samples showed relatively similar concentrations of TCE and PCE.

Overall, the data from the CRP study do not show the large differences that were seen in the data collected between 2004 and 2006. There were sufficient data for EHAP to examine the health risks to residents living in these homes. With the exception of homes D and G, the VOC levels in all other CRP Study homes have remained below health guidelines.

Children's Health Considerations

EHAP and ATSDR recognize that infants and children may be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter, resulting in a greater likelihood to breathe dust, soil, and heavy vapors close to the ground.
- Children are smaller, resulting in higher doses of chemical exposure per body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

There are indications that exposure to TCE and PCE in air can cause reproductive and developmental health effects, but studies have shown mixed findings. A limited number of human and animal studies suggest that exposure to TCE can cause changes in sperm count in men, and increased risks for birth defects in offspring of women (or female animals) who were exposed during pregnancy [9, 10]. Studies on women with high levels of occupational exposure to PCE (such as those working in dry cleaning industries) have found increased risks for spontaneous abortions and changes in their menstrual cycle [8].

Because children depend on adults for risk identification and management decisions, EHAP is committed to evaluating their special interests in instances where their behaviors or sensitivity to contaminants could put them at greater risk. The screening values and guidelines used in this evaluation are protective of the health of the most sensitive populations including children.

Conclusions

EHAP reached three conclusions in this health consultation:

EHAP concludes that breathing trichloroethylene (TCE) and tetrachloroethylene (PCE) in the indoor air at two CRP Study homes (homes D and G) for a year or longer could harm people's health. However, EHAP does not have enough information to determine the exact source of TCE and PCE in these homes. TCE and PCE were found in the indoor air of homes D and G at levels that could cause increased risks for cancer. However, the TCE and PCE levels in the soil gas, crawl space, and indoor air of these homes do not follow the expected pattern for the vapor intrusion pathway. TCE and PCE in the indoor air of these homes appear to be from sources inside the homes.

EHAP concludes that breathing TCE and PCE in the indoor air at the other seven CRP Study homes is not expected to harm people's health. This is because the measured levels of TCE and PCE in these homes are below current health guidelines.

EHAP concludes that the levels of VOCs in the CRP Study homes, except homes D and G, appear to be consistently below health guidelines, based on data collected in 2007 and 2008. The data from the CRP study do not show the large variations that were seen in the data collected between 2004 and 2006. With the exception of homes D and G, the levels in all other CRP Study homes have remained below health guidelines.

Recommendations

EHAP developed the following recommendations to protect the health of residents in the Trainsong neighborhood:

- In order to prevent contact with harmful VOCs, EHAP recommends that residents of homes D and G identify and remove VOC sources potentially affecting the indoor air quality of their homes. EHAP is available for assistance in identifying potential activities or products used that would cause these homes to have higher VOC levels. EHAP can also provide information on air purification or treatment systems, and information on obtaining follow-up air samples.

- EHAP recommends Trainsong residents limit their use of water from VOC-contaminated irrigation wells. We advise residents with contaminated wells to only use these wells for irrigation, hosing off outside surfaces, and other outdoor uses. We recommend that residents not drink water from these wells, and use municipal (city) water for drinking, cooking, and other home uses.

Public Health Action Plan

The Public Health Action Plan includes a description of actions that have been or will be taken by EHAP and other agencies in the Trainsong neighborhood. EHAP is committed to implementing these actions in order to reduce or prevent exposures to hazardous substances in the environment.

Public Health Actions that have been implemented to date:

- EHAP completed its initial evaluation of the health risks from the UPRR site, and released the findings in a 2007 PHA.
- EHAP and DEQ co-presented at a public meeting in November 2007 to present the findings of the 2007 PHA, answer questions from residents, and outline the next steps for the investigation and clean-up of the UPRR site.
- EHAP reviewed the January and September/November 2008 sampling results from the CRP Study, and provided technical assistance to DEQ by reviewing and providing language for letters to Trainsong residents.
- EHAP reviewed and provided feedback for a DEQ fact sheet on using VOC-contaminated well-water for irrigation and gardening.

Public Health Actions that will be implemented in the future:

- EHAP will release the final version of this report, and will communicate the findings to the affected community, partner agencies, and other stakeholders.
- EHAP will coordinate with DEQ on outreach to Trainsong residents in Fall/Winter 2009 to answer questions and concerns related to the UPRR investigation and cleanup and the findings of this report.
- EHAP is available to provide assistance and resources to residents of homes D and G to identify and remove the sources of VOCs in these homes, and develop follow-up plans to ensure that the indoor VOC levels are reduced to levels that do not pose health risks.
- DEQ will continue to provide oversight for monitoring and clean-up of off-site VOC contamination of groundwater and soil.
- EHAP will provide information and resources to Trainsong residents through fact sheets and other educational materials as needed.

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Certification

The Oregon Department of Human Services prepared the Portland Harbor Public Health Assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedures existing at the time that this public health assessment was initiated. Editorial review was completed by the Cooperative Agreement partner.

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

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Appendix A: Additional Information on Vapor Intrusion and VOCs

Overview of vapor intrusion of VOCs

Vapor intrusion occurs when chemicals in groundwater or soil move into the air of nearby homes or buildings. Vapor intrusion has emerged as an important source of exposure at sites that are contaminated with volatile organic chemicals, or VOCs. VOCs are chemicals that can exist in liquid or solid form, but turn easily into gases at normal temperatures and air pressure. VOCs are found in many industrial and household solvents and products, and are among the most common contaminants found at hazardous waste sites. These chemicals get into the environment through industrial dumping, leaks, spills, or from the use and improper disposal of household products that contain these chemicals [13].

At vapor intrusion sites, VOCs in groundwater or soil will transition into gas form and travel through the ground towards the surface. If there are no buildings or barriers at the ground surface, the VOC vapors will enter the outdoor air, become diluted, and eventually break down. However, if there are buildings at the surface, the VOC vapors can enter the building through cracks, pipes, or other openings in the building's foundation. The rate that these chemicals move into buildings depends on a number of factors, including the concentration of VOCs in soil and indoor air, the building's construction, and indoor and outdoor air pressure.

Some common VOCs that are found at vapor intrusion sites include TCE, PCE, benzene and petroleum. People can come in to contact with these chemicals by drinking (ingesting) contaminated groundwater, breathing in (inhaling) the chemicals in air, and absorbing small amounts through the skin. Inhaling VOCs in air can especially pose risks to human health because these chemicals are easily absorbed by the lungs [14]. Exposure to high levels of VOCs in air has been associated with non-cancer health risks such as damage to the nervous system, liver, kidney and immune system. These chemicals also have been associated with increased risks for some types of cancer.

Tetrachloroethylene (PCE)

Tetrachloroethylene (also known as perchloroethylene, or PCE) is a volatile organic compound that is commonly used as a dry cleaning solvent and as a metal degreaser. PCE usually enters the environment when it evaporates into the air during dry cleaning and industrial operations, but it also can contaminate the soil and groundwater from releases during dumping or leaks from storage, dry cleaning shops, and waste sites. Exposure to PCE occurs in occupational settings (especially in dry cleaning operations), from coming into contact with contaminated water or soil (by ingesting, inhaling or dermal contact with the contaminated media), and from exposure during the use of household products that contain PCE.

Most of the PCE that enters the body is not metabolized and leaves the body during exhalation. The liver metabolizes much of the remaining PCE. At high doses, exposure to PCE can cause dizziness, headaches, confusion and other effects to the central nervous system. The main health effects associated with chronic exposure to PCE include neurobehavioral effects and damage to central nervous system, the liver, and kidney. Some animal studies have shown reproductive and developmental effects from PCE exposure. The EPA considers PCE to be a probable human carcinogen based on animal studies that have also shown an association with kidney and liver cancers [8]. The EPA has set a limit on the amount of PCE in public drinking water systems at 5 ppb.

Trichloroethylene (TCE)

Trichloroethylene (TCE) is a volatile organic compound that is used as a metal degreaser and as a solvent in paint removers and certain types of cleaners and adhesives. TCE enters the environment through improper use and disposal, and is known to affect many groundwater and surface waters sources in the U.S. TCE evaporates quickly from surface water, but can persist in contaminated soil and groundwater for long periods of time. Exposure to TCE can occur in occupational settings, from coming into contact with contaminated water through the ingestion, inhalation, and dermal absorption routes, and breathing in vapors from shower water or indoor air sources (such as paint removers, correction fluid, and spot removers) [9].

The health risks associated with exposure to TCE include effects to the central nervous system (including headaches, dizziness, and difficulty concentrating), damage to the kidney and liver, impaired function of the cardiovascular and immune systems, and nerve damage[9]. There is also evidence that TCE exposure can result in reproductive and developmental effects, including an increased risk for birth defects[10]. There is strong evidence that exposure to TCE can increase the risks for several types of cancer including kidney, liver, lung, prostate, cervical, and lympho-hematopoietic (blood) cancers [10]. The EPA has set a limit on the amount of TCE in public drinking water systems at 5 ppb.

Appendix B. Environmental Sampling Data

This section provides the environmental sampling data that EHAP used for this health assessment. These data are slightly different from the "raw" data provided by DEQ, because EHAP combined some of the sampling data in order to simplify the analysis. At some homes and during some sampling events, multiple samples may have been taken. For example, at Location A, duplicate (and sometimes triplicate) samples were taken for all environmental samples as a quality assurance measure. In cases where there were duplicate or triplicate samples taken at a location, EHAP chose the highest measurement of these samples to represent the maximum concentration of a contaminant during that sampling event, and took the average of all samples in order to represent the average concentration for that sampling event.

In many cases, the concentrations reported by the laboratory were below the reporting limit for the chemical, which were 0.027 and 0.14 $\mu g/m^3$ for TCE and PCE respectively. In these instances, the concentration of a chemical reported by the laboratory is an estimate.

Table B.1: Indoor Air Sampling Data (in µg/m^3) by Location and Category

Category	Location ID	Contaminant	Aug-07	Jan-08	Sep-08	Nov-08
1	A	TCE	0.07	0.19	0.10	0.13
		PCE	0.71	1.12	0.80	1.10
	B	TCE	0.25	0.09	0.02	0.01
		PCE	0.47	0.34	0.24	1.20
	Category 1 Average	TCE	0.16	0.14	0.06	0.07
		PCE	0.59	0.73	0.52	1.15
2	C	TCE	0.06	0.12	0.03	0.12
		PCE	0.84	0.69	0.18	0.60
	D	TCE	3.70	0.26	1.90	1.20
		PCE	0.31	1.80	0.32	2.80
	Category 2 Average	TCE	1.88	0.19	0.97	0.66
		PCE	0.58	1.25	0.25	1.70
3	E	TCE	0.11	0.14	0.11	0.24
		PCE	0.20	0.38	0.20	0.38
	F	TCE	0.02	0.11	0.07	0.04
		PCE	0.21	0.30	0.19	0.20
	G	TCE	6.00	4.90	1.30	9.80
		PCE	0.18	0.47	0.10	0.24
	Category 3 Average	TCE	3.01	2.51	0.69	4.92
		PCE	0.20	0.39	0.14	0.22
4	H	TCE	0.03	0.09	0.04	0.01
		PCE	0.07	0.30	0.08	0.31
	I	TCE	0.06	0.08	0.06	0.09
		PCE	0.34	0.29	0.16	0.36
	Category 4 Average	TCE	0.04	0.09	0.05	0.05
		PCE	0.21	0.30	0.12	0.33

Table B.2: All Environmental Sampling Data (in µg/m^3) by Location

Location ID	Contaminant	Sample Type	Aug-07	Jan-08	Sep-08	Nov-08
A	TCE	Indoor	0.07	0.19	0.10	0.13
		Crawlspace	0.07	0.14	0.07	0.41
		Soil Gas	<2.2	20.33	<2.2	<2.1
		Ambient	0.05	0.11	0.02	0.04
	PCE	Indoor	0.71	1.12	0.80	1.10
		Crawlspace	0.76	0.65	0.62	0.58
		Soil Gas	48.33	116.67	8.47	4.53
		Ambient	0.31	0.30	0.09	0.13
B	TCE	Indoor	0.25	0.085	0.024	<0.027
		Crawlspace	0.11	0.05	0.03	0.76
		Soil Gas	<2.2	<2.2	<2.1	<2.1
		Ambient	0.02	0.09	0.02	0.024
	PCE	Indoor	0.47	0.34	0.24	1.20
		Crawlspace	1.40	0.25	0.20	0.75
		Soil Gas	14.00	<2.7	<2.7	3.20
		Ambient	<0.14	0.28	0.33	0.41
C	TCE	Indoor	0.06	0.12	0.03	<0.24
		Crawlspace	0.03	0.13	0.02	0.98
		Soil Gas	<2.2	-	<2.1	<2.1
		Ambient	0.02	0.12	0.03	0.05
	PCE	Indoor	0.84	0.69	0.18	<1.2
		Crawlspace	0.44	0.44	0.12	0.22
		Soil Gas	160.00	-	120.00	32.00
		Ambient	0.25	0.47	0.1	0.2
D	TCE	Indoor	3.70	0.26	1.90	1.20
		Crawlspace	0.02	0.11	0.08	0.80
		Soil Gas	16.00	<2.2	<2.1	<8.0
		Ambient	0.03	0.13	0.01	0.05
	PCE	Indoor	0.31	1.80	0.32	2.80
		Crawlspace	0.38	0.33	0.10	0.30
		Soil Gas	360.00	<2.7	500.00	110.00
		Ambient	0.30	0.33	0.06	0.32
E	TCE	Indoor	0.11	0.14	0.11	0.24
		Crawlspace	0.03	0.12	0.04	0.74
		Soil Gas	<2.2	<2.2	<2.2	<2.1
		Ambient	0.03	0.14	0.04	0.08
	PCE	Indoor	0.20	0.38	0.20	0.38
		Crawlspace	0.40	0.44	0.10	0.30
		Soil Gas	80.00	52.00	2.70	24.00
		Ambient	0.30	0.36	0.09	0.28

Location ID	Contaminant	Sample Type	Aug-07	Jan-08	Sep-08	Nov-08
F	TCE	Indoor	0.02	0.11	0.07	0.04
		Crawlspace	0.03	0.12	0.13	1.10
		Soil Gas	<2.2	<2.2	<2.2	<2.1
		Ambient	0.02	0.13	0.06	0.07
	PCE	Indoor	0.21	0.30	0.19	0.20
		Crawlspace	0.25	0.34	0.27	0.34
		Soil Gas	75.00	<2.7	1.90	3.30
		Ambient	0.24	0.32	0.13	0.21
G	TCE	Indoor	6.00	4.90	1.30	9.80
		Crawlspace	0.06	0.11	0.16	0.42
		Soil Gas	<2.2	<2.2	<2.1	<2.1
		Ambient	0.04	0.10	0.09	0.04
	PCE	Indoor	0.18	0.47	0.10	0.24
		Crawlspace	0.31	0.35	0.11	0.22
		Soil Gas	31.00	<2.7	24.00	16.00
		Ambient	0.33	0.25	0.098	0.13
H	TCE	Indoor	0.026	0.094	0.043	<0.027
		Crawlspace	0.02	0.08	0.06	0.72
		Soil Gas	<2.2	<2.2	<2.1	<2.1
		Ambient	0.04	0.09	0.03	<0.027
	PCE	Indoor	<0.14	0.30	0.08	0.31
		Crawlspace	<0.14	0.31	0.07	0.45
		Soil Gas	<2.7	<2.7	<2.7	<2.7
		Ambient	<0.14	0.31	0.07	0.13
I	TCE	Indoor	0.061	0.083	0.058	0.0925
		Crawlspace	0.03	0.10	0.11	0.61
		Soil Gas	<2.2	<2.2	<2.1	<11.0
		Ambient	0.02	0.41	0.03	0.0675
	PCE	Indoor	0.34	0.29	0.17	0.36
		Crawlspace	0.41	0.27	1.76	0.20
		Soil Gas	<2.7	<2.7	<2.7	<14.0
		Ambient	0.43	0.38	0.07	0.16

Table B.3: Duplicate, Triplicate and Split Sample results (in µg/m^3)

Location ID	Sample Date	Sample Type	Collected By	TCE	PCE
A	Sept-08	Ambient	CH2M HILL	0.018	0.091
		Ambient Duplicate	CH2M HILL	0.020	0.093
		Ambient Triplicate	CH2M HILL	0.022	0.10
		Ambient Split	ODEQ	0.039	0.45
		Crawlspace	CH2M HILL	0.036	0.63
		Crawlspace (rerun)	CH2M HILL	0.032	0.61
		Crawlspace Duplicate	CH2M HILL	0.061	0.50
		Crawlspace Triplicate	CH2M HILL	0.110	0.74
		Crawlspace Triplicate (rerun)	CH2M HILL	0.091	0.78
		Crawlspace Split	ODEQ	0.056	0.56
		Indoor Air	CH2M HILL	0.10	0.76
		Indoor Air (rerun)	CH2M HILL	0.10	0.77
		Indoor Air Duplicate	CH2M HILL	0.10	0.90
		Indoor Air Triplicate	CH2M HILL	0.10	0.74
		Indoor Air Split	ODEQ	0.064	1.00
	Nov-08	Ambient	CH2M HILL	0.048	0.130
		Ambient Duplicate	CH2M HILL	0.031	0.150
		Ambient Triplicate	CH2M HILL	0.032	0.11
		Ambient Split	ODEQ	0.025	0.12
		Crawlspace	CH2M HILL	0.54	0.70
		Crawlspace Duplicate	CH2M HILL	0.36	0.31
		Crawlspace Triplicate	CH2M HILL	0.34	0.73
		Crawlspace Split	ODEQ	0.95	0.51
		Indoor Air	CH2M HILL	0.13	1.2
		Indoor Air Duplicate	CH2M HILL	0.13	1.0
		Indoor Air Triplicate	CH2M HILL	0.12	1.1
		Indoor Air Split	ODEQ	0.092	1.0
B	Jan-08	Ambient	CH2M HILL	0.087	0.28
		Ambient Split	ODEQ	0.1	0.28
		Crawlspace Split	CH2M HILL	0.053	0.25
		Crawlspace	ODEQ	0.11	0.42
		Indoor Air	CH2M HILL	0.085	0.34
		Indoor Air Split	ODEQ	0.11	0.35
C	Nov-08	Ambient	CH2M HILL	0.048	0.2
		Ambient Split	ODEQ	0.038	0.19
		Crawlspace	CH2M HILL	0.98	0.22
		Crawlspace Split	ODEQ	0.76	0.23
		Indoor Air	CH2M HILL	<0.24	<1.2
		Indoor Air Split	ODEQ	<2.9	<7.2

Location ID	Sample Date	Sample Type	Collected By	TCE	PCE
E	Sept-08	Ambient	CH2M HILL	0.045	0.11
		Ambient (rerun)	CH2M HILL	0.036	0.078
		Ambient Split	ODEQ	0.041	0.32
		Crawlspace	CH2M HILL	0.042	0.10
		Crawlspace Split	ODEQ	0.041	0.15
		Indoor Air	CH2M HILL	0.11	0.20
		Indoor Air Split	ODEQ	0.097	0.23

Appendix C. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science to take responsive public health actions and provides trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse health effect A change in body function or cell structure that might lead to disease or health problems.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment, or amounts of chemicals that occur naturally in a specific environment.

Bioavailability: See **Relative Bioavailability**.

Cancer: A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control.

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathway: See **Exposure Pathway**.

Comparison Value: **(CVs)** Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food, and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant**.

Delayed Health Effect: A disease or injury that happens as a result of exposures that may have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (see **Route of Exposure**).

Dose: The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as “amount of substance(s) per body weight per day”.

Dose / Response: The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure: Coming into contact with a chemical substance. For the three ways people can come in contact with substances, see **Route of Exposure**.

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:
1. Source of Contamination,
2. Environmental Media,
3. Point of Exposure,
4. Route of Exposure, and
5. Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, or twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist (Which is part of **Superfund**). A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

PRP: **P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s): See **PHA**.

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
– breathing (also called inhalation),
– eating or drinking (also called ingestion), and
– getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.

Sample Size: The number of people that are needed for a health study.

Sample: A small number of people chosen from a larger population (See **Population**).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.