Health Consultation

Rainier Commons LLC
Polychlorinated Biphenyls (PCBs) Exposure
Seattle, King County, Washington

April 16, 2013

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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Foreword

The Washington State Department of Health (DOH) has prepared this health consultation with funds from 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 and is the principal federal public health agency responsible for health issues related to hazardous substances. 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 diseases related to toxic substances.

The purpose of a health consultation is to assess the health threat posed by hazardous substances in the environment and if needed, recommend steps or actions to protect public health. Health consultations are initiated in response to health concerns raised by residents or agencies about exposure to hazardous substances.

This health consultation was prepared in accordance with ATSDR methodologies and guidelines. ATSDR has reviewed this document and concurs with its findings based on the information presented. The findings in this report are relevant to conditions at the site during the time of this health consultation and should not be relied upon if site conditions or land use changes in the future.

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For additional information, please contact us at 1-877-485-7316 or visit our website at http://www.doh.wa.gov/consults.

For people with disabilities, this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TTY/TDD 711).

For more information about ATSDR, contact the Center for Disease Control and Prevention (CDC) Information Center at 1-CDC-INFO (1-800-232-4636) or visit the agency's Web site: www.atsdr.cdc.gov .

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Summary

Introduction:
The Washington State Department of Health (DOH) top priority is to ensure that residents and workers at the Rainier Commons site have the best information possible to safeguard their health. In 2010, DOH prepared a letter health consultation addressing concerns from exposure to exterior paint chips containing polychlorinated biphenyls (PCBs) at this site. Later, the U.S. Environmental Protection Agency (EPA) conducted indoor dust and air sampling at the site. This Health Consultation (HC) is a follow up evaluation of PCBs in indoor dust and air at the Rainier Commons buildings.

Conclusion:
DOH concludes that touching, breathing or accidentally ingesting PCBs in dust and air within the Rainier Commons buildings will not harm people's health.

Basis for decision:
The amount of PCBs that people could come into contact with at Rainier Commons' apartments, offices, stairwells, and storage and warehouse areas are below levels known to harm people's health. DOH estimated an increase in cancer risk that is insignificant to very low.

Next steps:

DOH recommends the following:

1. Rainier Commons LLC remove all paint containing PCBs above 50 parts per million (ppm) from the Rainier commons buildings.

2. Take steps to avoid tracking PCB contamination from Rainer Commons paint from outside the buildings to indoor spaces by removing or wiping shoes before entering homes or work areas.

3. Vacuum carpets and rugs frequently using a HEPA filter vacuum, use a wet/damp cloth or mop on other surfaces, and dispose of the cloth/mop and cleaning solution.

4. Follow (Rainier Commons LLC) Washington State Department of Labor and Industries rules and regulations and the regulations at 40 Code of Federal Regulations (C.F.R.) Part 761 for specific requirements relating to PCBs and PCB-containing materials regarding workers' rights.

Action planned

DOH will provide copies of this health consultation to the EPA, Ecology, Public Health-Seattle and King County, tenants, and the owners of the Rainier Commons buildings.

For More Information:
If you have any questions about this health consultation contact Lenford O'Garro (360-236-3376 or 1-877-485-7316) at Washington State Department of Health. For more information about ATSDR, contact the Center for Disease Control and Prevention (CDC) Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

Purpose and Statement of Issues

The Washington State Department of Health (DOH) has prepared this Health Consultation (HC) at the request of U.S. Environmental Protection Agency (EPA). The purpose is to evaluate whether polychlorinated biphenyls (PCBs) found in indoor air and dust from the Rainier Commons site in Seattle, Washington, pose a health hazard to people. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Rainier Commons LLC is the former Rainier Brewery located along Airport Way South in the Georgetown district of south Seattle, King County, Washington (see Figure 1). The brewery was built in 1884 and has 26 buildings on about 4.6 acres. Today, the former brewery buildings are used for artist lofts, restaurants, the headquarters of a large business, and storage facilities [1].

In October 2005, the City of Seattle Public Utility Department (SPU) sampled sediments from the stormwater collection system around the old brewery. Polychlorinated biphenyls (PCBs) were found at very high levels ranging from 17.5 parts per million (ppm) to 2,200 ppm compared to the state soil clean up level of 1.0 ppm [1]. In May 2006, consultants for Rainier Commons sampled sediment from the stormwater collection system around the old brewery and the exterior paint [1]. The exterior paint contained high levels of PCBs, up to 2,300 ppm, as compared to allowable amounts (50 ppm) under the Toxic Substances Control Act (TSCA) and EPA PCB regulations. In January 2008, SPU sampled the sediments again from the stormwater collection system around the old brewery and found lower concentrations of PCBs. In February 2008, SPU removed the PCB-contaminated sediments from the stormwater collection system.

In March 2009, the Environmental Protection Agency's (EPA) Region 10 PCB Inspection Team investigated the Rainier Commons site and collected exterior paint chips from the old brewery buildings. The maximum level of PCBs detected (10,490.5 ppm) was found in paint chips on the ground outside the building [2]. At that time, they also collected a sample from a stormwater collection system sediment trap and oil leaking from an elevator gearbox. PCBs were found at 101 ppm and 0.0089 ppm, respectively.

In June 2009, the EPA informed the owners of Rainer Commons that paint containing PCBs at levels above 50 ppm must be removed from the buildings, based on the March 2009 sampling results. In addition, the building did not comply with TSCA and EPA PCB regulations. In October 2009, an initial draft of a Health and Safety Plan for pilot testing paint removal techniques on Building 13 was presented to the EPA. The methods tested include ultra high pressure hydro blasting, abrasive blasting, and chemical stripping [3].

In April 2010, DOH completed a letter health consultation as an initial health assessment for this site [2]. At the time, it was not understood that some people live full time within portions of the building; therefore, only potential health threats to building workers and visitors were evaluated for exposure from PCBs in paint chip dust. This letter health consultation concluded that

accidentally breathing PCBs found in paint chips (dust) while idling in vehicle onsite or working in the buildings was not expected to harm people's health.

Rainer Commons LLC continues to develop plans for addressing PCBs at levels above 50 ppm in exterior paint and in the former exterior stairwell. The first priority is to deal with the former exterior stairwell since this stairwell used to be outside and its' paint is the same as other parts of the building's exterior. Following EPA's sampling, signs were posted on the stairwell doors requesting tenants only use them in case of emergency. In October 2011, paint removal from this interior stairwell began. According to EPA, the goal of complete paint removal based on a defined method of visual evaluation has been met. However, the owners will have to go back to "touch up" some areas in between cracks in the bricks. Currently, the EPA is working with the facility on a plan to properly remove and dispose of contaminated paint on the rest of the buildings.

Community Health Concerns

Following completion of the Rainier Commons PCB Paint Contamination letter health consultation in March 2010, DOH became aware that people were living in the building fulltime. DOH spoke with these residents both on the phone and at open houses held at the site and heard their concerns about potential exposures in the building's work and residential areas. Some specific concerns included:

- Were PCBs found inside the buildings?
- Was additional sampling planned?
- How could people be exposed PCBs?
- What could people do to reduce their exposure?

In response to these concerns, DOH provided the tenants with information on PCBs and ways to reduce their exposures. DOH also participated in multiple open houses to talk with building tenants and residents and answer health questions.

Figure 1: Aerial photograph and map of Seattle showing location of the Rainier Commons Buildings in King County, Seattle, Washington.

Discussion

EPA conducted indoor sampling for PCBs in June and October 2010. Samples were collected within residential, office, storage, and warehouse areas, along with a former exterior stairwell (now an enclosed interior stairwell). DOH provided input on the type of sampling conducted so the data could be used for assessing potential health risk. Conclusions of this assessment are provided in this document.

Screening Evaluation

Contaminants of concern (COC) were determined by employing a screening process. Tables 1 - 4 show the range of PCBs measured in wipes, vacuumed dust, and air relative to comparison values (CVs). Maximum contaminant concentrations were screened against several types of health-based CVs for soil and air [see the glossary for descriptions of CV, "cancer risk evaluation guide (CREG)," and "environmental media evaluation guide (EMEG)"]. Comparison values such as the CREG offer a high degree of protection and assurance that people are unlikely to be harmed by contaminants in the environment. For chemicals that cause cancer, the CVs represent levels calculated to increase the estimated risk of cancer by about one additional cancer in one million people exposed. ATSDR has no standards with which to evaluate data from surface wipe sampling. However, EPA has a regulatory clean-up standard or spill cleanup criteria for PCBs of 10 micrograms per one hundred square centimeters (ug/100cm^2) on wipes collected from indoor surfaces [4]. EPA estimated that inhalation cancer risk from exposure to PCBs at 10 ug/100cm^2 would be at 1 excess cancer case per 1,000,000 exposed (1x 10^{-6}) [4]. Similarly, EPA estimated that cancer risk from dermal contact with PCBs at 10 ug/100cm^2 would be at 1 excess cancer case per 100,000 exposed [4]. Therefore, the wipe samples were compared to EPA's clean-up standard or spill cleanup criteria for PCBs of 10 ug/100cm^2. In general, if a contaminant's maximum concentration is greater than its CV, then the contaminant is evaluated further. Contaminants detected at concentrations that exceed their respective CVs, do not necessarily represent a health threat.

Exposure Assessment

In order for any contaminant to be a health concern, the contaminant must be present at a high enough concentration to cause potential harm, and there must be a completed route of exposure to people. Exposures could occur through incidental ingestion (swallowing/eating), inhalation (breathing in), and/or dermal (skin) contact with dust. Completed exposure pathways exist at the site; the buildings have a variety of uses such as residential, office, storage, and warehouse space. Therefore, DOH will evaluate exposures based on area usage. For residential areas, DOH will evaluate exposures for adults and children. For offices, storage, and warehouse areas, DOH will only evaluate exposures for adult workers because these areas are expected to be a minimal source of exposure for visitors (adults or children). For the former exterior stairwell area, DOH will evaluate exposures for adults and children.

Residential Areas

Table 1 shows the results of residential sampling. PCBs in indoor air samples were not detected at the analytical detection limit; however, the analytical method detection limit was above the CREG. Therefore, DOH will further evaluate the indoor air pathway. Wipe samples in the residential areas were below the EPA regulatory clean-up standard or spill cleanup criteria for PCBs of 10 ug/100cm^2. Therefore, DOH will not further evaluate results of the wipe samples.

Results from vacuum dust samples showed that PCBs (Aroclor 1254 and 1260) were found at concentrations ranging from 1.4 ppm to 15.6 ppm. To assess possible non-cancer health concerns, DOH used a health protective approach and compared the results to ATSDR's Aroclor 1254 soil EMEG for children (1 ppm) and for adults (14 ppm). This CV is a generic, non-site specific guideline.

There is not an ATSDR cancer CREG for soil specifically for Aroclor 1254 or 1260. However, there is an ATSDR PCB cancer CREG for soil of 0.35 ppm based on mixtures of Aroclors. Therefore, DOH compared results to the cancer CV (based on a child's exposure) to assess possible cancer health concerns. PCBs in dust samples were above the CVs for soil. Therefore, DOH will further evaluate the PCBs in dust from residential areas.

Table 1. Concentration range of polychlorinated biphenols (PCBs) detected in residential areas at Rainier Commons, Seattle, King County, Washington.

Indoor Sample Type	PCB* Concentration Range	Comparison Value	Comparison Value Reference	Contaminant of Concern (COC)**
Air	0.015U – 0.025U (ug/m^3)	0.01(ug/m^3)	Air CREG	Yes
Surface Wipes	14.1 – 713 (ug/m^2)	10 (ug/100cm^2) which equals 1000 (ug/m^2)	EPA - Spill Clean-up Criteria	No
Vacuum dust	1.4 – 15.6 ppm	1 ppm	EMEG (soil)	Yes
		0.35 ppm	CREG (soil)	

CREG - ATSDR's Cancer Risk Evaluation Guide (chronic child)
EMEG - ATSDR's Environmental Media Evaluation Guide (chronic child)
Aroclor 1254 value was used as a surrogate for PCBs.
ppm – parts per million
ug/m^2 - micrograms per square meter
ug/m^3 - micrograms per cubic meter
ug/100 cm^2 - micrograms per one hundred square centimeter
UJ = The associated sample quantitation limit is estimated.
U = The analyte was not detected at this level.
EPA – Environmental Protection Agency
* Aroclor 1254 and 1260
** Contaminants of concern (COC) do not necessarily represent a health threat; a COC "Yes" means further evaluation is needed. See the Screening Evaluation section for more information.

Office Areas

Table 2 shows results of office sampling where PCBs were detected above the CV for air. Therefore, DOH will further evaluate indoor air. Wipe samples were below the EPA regulatory clean-up standard or spill cleanup criteria for PCBs of 10 ug/100cm^2. Therefore, DOH will not evaluate the results of the wipe samples any further.

Results from vacuum dust samples showed that PCBs (Aroclor 1254 and 1260) were found at concentrations ranging from 3.7 ppm to 10.9 ppm in office areas. To be protective, DOH compared results to ATSDR's soil EMEG (adults) for Aroclor 1254 to assess possible non-cancer health concerns. ATSDR's EMEG of 14 ppm for adults is a generic, non-site specific guideline.

There is not an ATSDR cancer CV for soil (specifically for Aroclors 1254 or 1260). However, there is an ATSDR cancer CREG of 0.35 ppm for PCBs based on mixtures of Aroclors. Therefore, DOH compared results to ATSDR's soil CV for children to assess possible cancer health concerns. PCBs in dust samples were above the CVs for soil. Therefore, DOH will further evaluate PCBs in dust for office areas.

Table 2. Concentration range of PCBs detected in offices spaces at Rainier Commons, Seattle, King County, Washington.

Indoor Sample Type	PCB* Concentration Range	Comparison Value	Comparison Value Reference	Contaminant of Concern (COC)**
Air	0.01- 0.028 (ug/m^3)	0.01(ug/m^3)	Air CREG	Yes
Surface Wipes	17.22 UJ – 344 UJ (ug/m^2)	10 (ug/100cm^2) which equals 1000 (ug/m^2)	EPA - Spill Clean-up Criteria	No
Vacuum dust	3.7 – 10.9 ppm	1 ppm	EMEG (soil)	Yes
		0.35 ppm	CREG (soil)	

CREG - ATSDR's Cancer Risk Evaluation Guide (chronic child)
EMEG - ATSDR's Environmental Media Evaluation Guide (chronic child) Aroclor 1254 value was used as a surrogate for PCBs
ppm – parts per million
ug/m^2 - micrograms per square meter
ug/m^3 - micrograms per cubic meter
ug/100 cm^2 - micrograms per one hundred square centimeter
UJ = The associated sample quantitation limit is estimated.
EPA – Environmental Protection Agency
* Aroclor 1254 and 1260
** Contaminants of concern (COC) do not necessarily represent a health threat; a COC "Yes" means further evaluation is needed. See the Screening Evaluation section for more information.

Storage and Warehouse Areas

Table 3 shows results of the storage and warehouse area sampling. Although PCBs in indoor air samples were not detected at the analytical detection limit, the analytical method detection limit was above the CREG. Therefore, DOH will further evaluate the indoor air pathway. Wipe samples were below the EPA regulatory clean-up standard or spill cleanup criteria for PCBs of 10 ug/100cm^2. Therefore, DOH will not evaluate the wipe samples any further.

Results from vacuum dust samples showed that PCBs (Aroclor 1254 and 1260) were found at concentrations ranging from 3.4 ppm to 36.0 ppm. To be protective when assessing the possible non-cancer health concerns, DOH used the ATSDR Aroclor 1254 soil EMEG for adults to assess possible non-cancer health concerns. This ATSDR soil CV of 14 ppm for adults is a generic, non-site specific guideline.

There is not an ATSDR cancer CV for soil (specifically for Aroclor 1254 or 1260). However, based on mixtures of Aroclors there is a soil cancer CREG of 0.35 ppm. Therefore, DOH compared results to the soil cancer CV for children to assess possible cancer health concerns. PCBs in dust samples were above the soil CVs. Therefore, DOH will further evaluate PCBs in dust for storage and warehouse areas.

Table 3. Concentration range of PCBs detected at storage and warehouse areas in Rainier Commons, Seattle, King County, Washington.

Indoor Sample Type	PCB* Concentration Range	Comparison Value	Comparison Value Reference	Contaminant of Concern (COC)**
Air	0.008U – 0.013U (ug/m^3)	0.01(ug/m^3)	Air CREG	Yes
Surface Wipes	17.22 UJ – 344 UJ (ug/m^2)	10 (ug/100cm^2) which equals 1000 (ug/m^2)	EPA - Spill Clean-up Criteria	No
Vacuum dust	3.4 – 36 ppm	1 ppm	EMEG (soil)	Yes
		0.35 ppm	CREG (soil)	

CREG - ATSDR's Cancer Risk Evaluation Guide (chronic child)
EMEG - ATSDR's Environmental Media Evaluation Guide (chronic child) Aroclor 1254 value was used as a surrogate for PCBs
ppm – parts per million
ug/m^2 - micrograms per square meter
ug/m^3 - micrograms per cubic meter
ug/100 cm^2 - micrograms per one hundred square centimeter
UJ = The associated sample quantitation limit is estimated.
U = The analyte was not detected at this level.
EPA – Environmental Protection Agency
* Aroclor 1254 and 1260
** Contaminants of concern (COC) do not necessarily represent a health threat; a COC "Yes" means further evaluation is needed. See the Screening Evaluation section for more information.

Former Exterior Stairwell Area

Table 4 shows the results of the stairwell sampling. PCBs were detected in the indoor air samples above the CREG. Therefore, DOH will further evaluate the indoor air.

Wipe sample results from the stairwell were above the EPA regulatory clean-up standard or spill cleanup criteria for PCBs of 10 ug/100cm^2. The EPA estimated that cancer risk from inhalation of PCBs at 10 ug/100cm^2 would result in 1 estimated cancer case per 1,000,000 exposed ($1x\ 10^{-6}$) [4]. Similarly, EPA estimated that cancer risk from dermal contact with PCBs at 10 ug/100cm^2 would result in 1 estimated cancer case per 100,000 exposed [4]. Therefore, based on EPA's estimated risk and toxicological principles, the risk for inhalation would be less than 2 estimated cancer cases per 1,000,000 people exposed, and the risk for dermal contact would be less than 2 estimated cancer cases per 100,000 people exposed.

The building owners (Rainier Commons LLC) posted signs on the stairwell doors requesting tenants not use the interior stairwell until its cleanup was complete. Removal of the PCB paints on the interior stairwell has begun. Rainier Commons has largely completed paint removal activities associated with the stairwell area. According to EPA, the goal of complete paint removal based on a defined method of visual evaluation has been met. However, Rainier Commons will have to go back to "touch up" some areas in between cracks in the bricks. Therefore, DOH will not evaluate this pathway any further.

Aroclors 1254 and 1260 were found at a concentration of 470 ppm in the stairwell dust samples. To be protective, DOH compared results to ATSDR's Aroclor 1254 soil EMEG for children to assess possible non-cancer health concerns. ATSDR's generic, non-site specific soil CV for Aroclor 1254 are 1 ppm for children and 14 ppm for adults.

There is not an ATSDR soil cancer CV available specifically for Aroclors 1254 or 1260. However, soil PCBs cancer CREG of 0.35 ppm based on mixtures of Aroclors. Therefore, DOH compared the results to the soil CV for children to assess possible cancer health concerns. PCBs in dust samples were above the CVs for soil. Therefore, DOH will further evaluate PCB dust in the stairwell.

Table 4. Concentration of PCBs detected in the former exterior stairwell in Rainier Commons, Seattle, King County, Washington.

Indoor Sample Type	PCB* Concentration	Comparison Value	Comparison Value Reference	Contaminant of Concern (COC)**
Air	0.052UJ (ug/m^3)	0.01(ug/m^3)	Air CREG	Yes
Surface Wipes	1722 UJ (ug/m^2)	10 (ug/100cm^2) which equals 1000 (ug/m^2)	EPA - Spill Clean-up Criteria	No
Vacuum Dust	470 ppm	1 ppm	EMEG (soil)	Yes
		0.35 ppm	CREG (soil)	

CREG - ATSDR's Cancer Risk Evaluation Guide (chronic child)
EMEG - ATSDR's Environmental Media Evaluation Guide (chronic child) Aroclor 1254 value was used as a surrogate for PCBs
ppm – parts per million
ug/m^2 - micrograms per square meter
ug/m^3 - micrograms per cubic meter
ug/100 cm^2 - micrograms per one hundred square centimeter
UJ = The associated sample quantitation limit is estimated.
EPA – Environmental Protection Agency
* Aroclor 1254 and 1260
** Contaminants of concern (COC) do not necessarily represent a health threat; a COC "Yes" means further evaluation is needed. See the Screening Evaluation section for more information.

Chemical Specific Toxicity

PCBs are a mixture of man-made organic chemicals. There are no known natural sources of PCBs in the environment. The manufacture of PCBs stopped in the United States (U.S.) in 1977 because evidence showed that they could build up in the environment and cause health effects. Although no longer manufactured, PCBs can still be found in certain products such as old fluorescent lighting fixtures, electrical devices or appliances containing PCB capacitors that were made before the use of PCBs was banned, old microscope oil, old hydraulic oil, paint, caulking, sealants and other building materials. Prior to 1977, PCBs entered the environment (soil, water, air) during the manufacture and use of PCBs. Today, PCBs can still enter the environment from poorly maintained hazardous waste sites; illegal or improper dumping of PCB wastes, such as old hydraulic oil; leaks from electrical transformers that contain PCB oils; and disposal of old consumer products that contain PCBs[5].

PCBs entered the environment as mixtures. There are 209 structural variations of PCBs, referred to as congeners, which differ in the number and location of chlorine atoms in the chemical structure. Most PCBs commercially produced in the U.S. were standard mixtures called Aroclors. The conditions for producing each Aroclor favor the synthesis of certain congeners,

giving each Aroclor a unique pattern based on its congener composition. No Aroclor contains all 209 congeners. Once in the environment, PCBs do not breakdown easily and may stay in the soil for months or years. PCBs can also be transported globally in emitted into the atmosphere from combustion or evaporation. PCBs stick to soil and sediment and do not usually move deep into the soil with rainfall. As a result, PCBs are found worldwide. Small amounts of PCBs can be found in almost all outdoor and indoor air, soil, sediments, surface water, and animals. PCBs bioaccumulate in the food chain and are stored in the fatty tissue of organisms. For humans, the major dietary source of PCBs is fish. PCBs are also found in meats and dairy products [5]. Since the 1980s, human PCB concentrations have generally followed a decreasing trend [6, 7].

Most direct exposure to PCBs can occur by ingestion, inhalation, and dermal (skin) contact. Some PCBs that enter the body are metabolized and excreted within a few days; others stay in the body fat and liver for months and even years. PCBs collect in milk fat and can enter the bodies of infants through breast-feeding [5]. Skin irritation, vomiting, nausea, diarrhea, abdominal pain, eye irritation, and liver damage can occur in people exposed to high levels of PCBs [5]. However, health effects relevant to low-level environmental exposures are immunological effects in monkeys (Aroclor 1254, oral reference dose (RfD) of 0.00002 mg/kg/day) and developmental effects in kids exposed to PCBs in the womb from mothers eating PCB contaminated fish [5].

Evaluating non-cancer hazards

In order to evaluate the potential for non-cancer adverse health effects that may result from exposure to contaminated media (i.e., soil (dust), air, and water), a dose is estimated for each COC. These doses are calculated for situations (scenarios) in which a person might be exposed to the contaminated media. The estimated dose for each scenario is then compared to the minimal risk level (MRL). The MRL is an estimate of the daily human exposure to a substance at or below a level that is unlikely to cause a measurable risk of harmful health effects over a specified amount of time. In the absence of MRLs, DOH uses the EPA's RfD. RfDs are doses below which non-cancer adverse health effects are not expected to occur. MRLs and/or RfDs are derived from observed effect levels obtained from human population and laboratory animal studies. These observed effect levels can be classified as either the Lowest Observed Adverse Effect Level (LOAEL) or No Observed Adverse Effect Level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse health effect is seen, while the NOAEL is the highest dose that does not result in any adverse health effects. If the exposure dose exceeds the MRL, further evaluation is needed. If the exposure dose is lower than the MRL, no health effects are expected.

MRLs and RfDs are not available for all PCB mixtures. However, ATSDR has derived a chronic MRL for Aroclor 1254 of 0.00002 mg/kg/day for an exposure of one year or longer. The MRL is based on the lowest observed adverse effect level (LOAEL) of 0.005 mg/kg/day for immunological effects in monkeys. Similarly, the EPA has an established RfD of 0.00002 mg/kg/day [5]. The MRL was calculated by dividing the LOAEL by an uncertainty factor of 300 (10 for extrapolation from a LOAEL to a NOAEL, 3 for extrapolation from monkeys to humans and 10 for human variability). If a dose exceeds the MRL or RfD, it does not mean that adverse health effects will occur. When the MRL or RfD is exceeded, further toxicological evaluation is

needed. The further evaluation includes comparing the site-specific estimated dose to doses from animal and human studies that showed either an effect level or a no effect level. This comparison, combined with other toxicological information, such as sensitive groups or chemical metabolism is used to determine the risk of specific harmful effects. A MRL or RfD is exceeded whenever the Hazard Quotient (HQ) is greater than one. See Appendices A, B and C for the hazard quotient equation.

As indicated in Tables 1 - 4, levels of Aroclor 1254 and 1260 in dust and air exceed the screening value. It is important to note that exceedance of a soil or air CV does not mean that people will become sick. It does indicate that further evaluation of the chemical is necessary. Therefore, DOH calculated exposure doses based on site-specific exposure scenarios and compared results to ATSDR's MRL. Exposure assumptions for estimating contaminant doses from PCB exposures are found in Appendices A, B, and C (Tables A1, B1 and C1). Appendix A is based on a five-year exposure of 350 days per year for residential and 250 days per year for workers. Appendix B is based on a residential exposure of 350 days per year for 30-years and a worker exposure of 250 days per year for 25-years. Appendix C is based on a residential exposure in the stairwell of 52 days per year for five years.

Based on DOH's site-specific exposure estimates, people in residential areas are not likely to experience adverse non-cancer health effects from exposure to PCBs (Appendices A and B, Tables A2, A3, B2 and B3). Similarly, workers in office areas are not likely to experience adverse non-cancer health effects from exposure to PCBs (Appendices A and B, Tables A6, A7, B6 and B7). Also, workers in storage and warehouse areas are not likely to experience adverse non-cancer health effects from exposure to PCBs (Appendices A and B, Tables A10, A11, B10 and B11). This is because the estimated exposure dose in scenarios for residential, office, and storage and warehouse areas did not exceed the MRL.

Based on DOH's site-specific residential exposure estimates for PCBs in the stairwell, the highest estimated dose for a child (0 to 5 years old) is 0.0000266 mg/kg/day (Appendix C, Tables C2 and C3). This exceeds the MRL for PCBs of 0.00002 mg/kg/day, but is 188 times below the LOAEL of 0.005 mg/kg/day. However, the highest estimated dose for an older child (6 to 15 years old) (0.0000049 mg/kg/day) and adult (0.0000014 mg/kg/day) did not exceed the MRL (Appendix C, Tables C2 and C3). Therefore, it is unlikely that adverse non-cancer health effects from exposure to PCB will occur.

Evaluating cancer hazards

Some chemicals have the ability to cause cancer. Cancer risk is estimated by calculating a dose similar to those used for evaluating non-cancer hazards and multiplying it by a cancer potency factor, also known as the cancer slope factor. Some cancer potency factors are derived from human population data. Others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data requires extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty.

Current regulatory practice assumes there is no "safe dose" of a carcinogen and that any dose of a carcinogen will result in some additional cancer risk. Therefore, estimated cancer risk estimates are not yes/no answers, but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries an associated risk. The validity of the "no safe dose" assumption for all 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. For such chemicals, risk estimates are not appropriate. Recent guidelines on cancer risk from EPA reflect the potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise [8].

This document describes estimated cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight, and no significant increase in estimated cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands exposed over a lifetime, and a slight estimate would require an exposed population of several hundreds of thousands to result in a single case. DOH considers estimated cancer risk insignificant when the estimate results in less than one cancer per one million exposed over a lifetime. Estimated cancer risks quantified in this document are an upper-bound estimate; actual risks are likely to be much lower. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population.

Estimated Cancer Risk

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

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

Cancer is a common illness and its occurrence in a population increases with the age of the population. There are many different forms of cancer resulting from a variety of causes; not all are fatal. Approximately 1 in 3 to 1 in 2 people living in the United States will develop cancer at some point in their lives [9].

DOH also calculated estimated cancer risk estimates based on site-specific exposure doses (Appendix A, B and C). For residential areas, the cancer risk estimate for children is about 4 excess cancers per 1,000,000 children exposed. For older children, cancer risk ranges from 2 excess cancers per 1,000,000 children exposed to 4 excess cancers per 1,000,000 children exposed. The cancer risk estimate for adult's ranges from 1 excess cancer per 1,000,000 adults exposed to 3 excess cancers per 1,000,000 adults exposed. In a worst-case scenario, exposure to the current highest levels of PCBs would increase a person's lifetime estimated cancer risk by about one excess cancer in a population of one hundred thousand people exposed (Appendix B, Tables B4 and B5). The cancer risks ranged from very low to slight.

For office areas, the cancer risk estimate for adults ranges from five excess cancers per 10,000,000 adults exposed to three excess cancers per 1,000,000 adults exposed. In a worst-case scenario, exposure to the highest levels of PCBs currently found would increase a person's lifetime estimated cancer risk by about three excess cancers in a population of a million people exposed (Appendix A and B, Tables A8, A9, B8 and B9). The cancer risks ranged from slight to insignificant.

For storage and warehouse areas, the cancer risk estimate for adults ranges from seven excess cancers per 10,000,000 adults exposed to three excess cancers per 1,000,000 adults exposed. In a worst-case scenario, exposure to the highest levels of PCBs currently found would increase a person's lifetime estimated cancer risk by about three excess cancers in a population of a million people exposed (Appendix A and B, Tables A12, A13, B12 and B13). The cancer risks ranged from slight to insignificant.

For the stairwell, the cancer risk estimate for children is about four excess cancers per 1,000,000 children exposed and for older children it is about one excess cancer per 1,000,000 children exposed. Also, the cancer risk estimate for adults is about six excess cancers per 10,000,000 adults exposed (Appendix C, Tables C4 and C5). The cancer risks ranged from slight to insignificant.

All estimated cancer risks ranged from very low to insignificant and fall within the range of cancer risks considered acceptable by the EPA (one cancer estimated per 10,000 exposed ($1x\ 10^{-4}$) to one cancer estimated per 1,000,000 exposed ($1x\ 10^{-6}$)). The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population.

Children's Health Considerations

The potential for exposure and subsequent adverse health effects often increases for younger children compared with older children or adults. ATSDR and DOH recognize that children are susceptible to developmental toxicity that can occur at levels much lower than those causing other types of toxicity. The following factors contribute to this vulnerability:

- Children are smaller and receive higher doses of chemical exposure per body weight.
- Children's developing bodies or systems are more vulnerable to toxic exposures, especially during critical growth stages in which permanent damage may occur.

Children's health was considered in the writing of this health consultation, and the exposure scenarios treated children as the most sensitive population being exposed. Doses calculated for PCBs are not expected to result in adverse health effects for children or adults based on comparison with MRL and RfD values. The assessment did find that chronic exposure to PCBs over many years (for example, 30 years) indicate an insignificant to very low increased estimated cancer risk.

Conclusions

DOH concludes that touching, breathing or accidentally ingesting PCBs in dust and air in the Rainier Commons buildings is not expected to harm people's health. The amount of PCBs that people could come into contact with at Rainier Commons' apartments, offices, stairwells, and storage and warehouse areas are below levels known to harm people's health. DOH estimated an increase in cancer risk that is insignificant to very low.

Recommendations

DOH recommends the following:

1. Rainier Commons LLC remove all paint containing PCBs above 50 parts per million (ppm) from the Rainier commons buildings.

2. Take steps to avoid tracking PCB contamination from Rainer Commons paint from outside the buildings to indoor spaces by removing or wiping shoes before entering homes or work areas.

3. Vacuum carpets and rugs frequently using a HEPA filter vacuum, use a wet/damp cloth or mop on other surfaces, and dispose of the cloth/mop and cleaning solution.

4. Follow (Rainier Commons LLC) Washington State Department of Labor and Industries rules and regulations and the regulations at 40 Code of Federal Regulations (C.F.R.) Part 761 for specific requirements relating to PCBs and PCB-containing materials regarding workers' rights.

Public Health Action Plan

Action Planned

DOH will provide copies of this health consultation to the EPA, Ecology, Public Health-Seattle and King County, tenants, and the owners of the Rainier Commons buildings.

Report Preparation

This Health Consultation for the Rainier Commons building was prepared by the Washington State Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

Author
Lenford O'Garro
Toxicologist
Washington State Department of Health
Site Assessment and Toxicology Section
Office of Environmental Health, Safety, and Toxicology

State Reviewers
Joanne Snarski, Principal Investigator
Erin Kochaniewicz, Public Health Educator
Marilyn Hanna, Editorial Review

ATSDR Reviewers

Division of Community Health Investigations

Audra Henry, Technical Project Officer
Alan Yarbrough, State Cooperative Agreement Coordinator
Cassandra Smith, Western Branch Chief
Lynn Wilder, Acting Associate Director for Science
Tina Forrester, Acting Division Director

References

1. United States Environmental Protection Agency: EPA Region 10, PCB Compliance Inspection report – Rainier Commons, LLC. United States Environmental Protection Agency, Office of Compliance and Enforcement, April 2009.

2. Washington State Department of Health. Letter Health Consultation of Rainier Commons LLC Polychlorinated Biphenyls (PCBs) Paint Contamination, Seattle, King County, Washington. March 10, 2010 Available at: http://www.doh.wa.gov/ehp/oehas/pubs/rainiercom0310.pdf

3. Draft health and safety plan for the paint removal pilot test on building 13 Rainer Commons Facility 3100 Airport Way S. Seattle, Washington, Prepared by CDM for Rainer Commons LLC, October 5, 2009.

4. Part III, Environmental Protection Agency: Polychlorinated Biphenyls Spill Cleanup Policy, Final Rule, 52 Federal Register. 10688-10710 (April 2, 1987) (40 C.F.R. pt.761).

5. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for Polychlorinated Biphenyls (PCBs) (update) PB/2000/108027. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.pdf

6. Patterson DG Jr, Wong LY, Turner WE, Caudill SP, DiPietro E, McClure C, Cash TP, Osterloh JD, Pirkle JL, Sampson EJ, Needham LL. Levels in the U.S. Population of those Persistent Organic Pollutants (2003-2004) Included in the Stockholm Convention or in other Long-Range Transboundary Air Pollution Agreements. Environ. Sci. Technol., 2009, 43 (4), 1211-1218.

7. Centers for Disease Control and Prevention. *Fourth National Report on Human Exposure to Environmental Chemicals*. http://www.cdc.gov/exposurereport/. December 2009.

8. U.S. Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment (2005). U.S. Environmental Protection Agency, Washington, DC, EPA/630/P-03/001F. Available at internet: http://www.epa.gov/raf/publications/pdfs/CANCER_GUIDELINES_FINAL_3-25-05.PDF

9. Cancer. American Cancer Society. Cancer Facts & Figures 2010. Atlanta: American Cancer Society; 2010.

10. National Center for Environmental Assessment. Exposure Factors Handbook Volume 1 – General Factors EPA/600/P-95/002Fa: U.S. Environmental Protection Agency; August 1997.

Appendix A

This section provides calculated exposure doses and assumptions used for exposure to PCBs in dust and air from the Rainier Commons buildings in Seattle, Washington. This exposure scenario was developed to model exposures that might occur based on a five-year exposure of 350 days per year for residential and 250 days per year for workers. The following exposure parameters and dose equations were used to estimate exposure dose from direct contact with PCBs. As with any scenario, there are uncertainties.

Exposure to PCBs in dust and air through ingestion, inhalation, and dermal absorption

Total dose $_{\text{(non-cancer)}}$ = Ingested dose + inhaled dose + dermally absorbed dose

Ingestion Route

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{C \times CF \times IR \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{C \times CF \times IR \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Dermal Route

$$\text{Dermal Transfer (DT)} = \frac{C \times AF \times ABS \times AD \times CF}{ORAF}$$

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{DT \times SA \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Inhalation Route

$$\text{Dose}_{\text{non-cancer (mg/kg-day)}} = \frac{Ca \times IHR \times EF \times ED \times IHCF}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{Ca \times IHR \times EF \times ED \times CPF \times IHCF}{BW \times AT_{\text{cancer}}}$$

Table A1. Assumptions used for exposure to PCB dust and air from the Rainier Commons buildings, Seattle, King County, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	mg/kg	Maximum detected value
Concentration in air (Ca)	Variable	mg/m3	Maximum detected value
Conversion Factor (CF)	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion Rate (IR) – adult	3.1*	mg/day	Exposure Factors [10]
Ingestion Rate (IR) – older child	3.1*		
Ingestion Rate (IR) - child	3.1*		
Exposure Frequency (EF)	350	Days/year	Average days per year minus two week vacation
	250		Average working days per year
Exposure Duration (ED)	5	years	Number of years at location 2007 -2011
Body Weight (BW) - adult	72	kg	Adult mean body weight
Body Weight (BW) – older child	41		Older child (6 - 15 years old) mean body weight
Body Weight (BW) - child	15		0-5 year-old child average body weight
Surface area (SA) - adult hand	840	cm^2	Exposure Factors [10]
Surface area (SA) – older child hand	400		
Surface area (SA) – child hand	400		
Averaging $Time_{non\text{-}cancer}$ (AT)	1825	days	Equal to Exposure Duration
Averaging $Time_{cancer}$ (AT)	27375	days	75 years
Dermal Transfer (DT) - child	4.37E-7	mg/cm^2-day	Based on DT equation with C = 15.6
Dermal Transfer (DT) – older child	4.37E-7		Based on DT equation with C = 15.6
Dermal Transfer (DT) - adult	1.53E-7		Based on DT equation with C = 15.6
Dermal Transfer (DT) - adult	1.1E-7		Based on DT equation with C = 10.9
Dermal Transfer (DT) - adult	3.5E-7		Based on DT equation with C = 36
Cancer Potency Factor (CPF)	2	$mg/kg\text{-}day^{-1}$	Source: EPA (Chemical Specific) PCBs
24 hr. absorption factor (ABS)	0.14	unitless	Source: EPA (Chemical Specific) PCBs
Oral route adjustment factor (ORAF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Adherence duration (AD)	1	days	Source: EPA
Adherence factor (AF)	0.2	mg/cm^2	Child, older child
	0.07		Adult
Inhalation Conversion Factor (IHCF)	0.001	mg/ug	Converts contaminant concentration from milligrams (mg) to micrograms (ug)
Inhalation rate (IHR) - adult	15.2	m^3/day	Exposure Factors [10]
Inhalation rate (IHR) – older child	14		
Inhalation rate (IHR) – child 0-5	8.3		
Inhalation rate (IHR) - worker	10.4		

*Assumes 31 mg of dust adhering to the hands (based on average soil adherence to palm [10]) and 10 percent of the total adherence of soil is ingested.

Hazard Quotient formula:

$$HQ = \frac{\text{Estimated Dose (mg/kg-day)}}{\text{MRL (mg/kg-day)}}$$

Chemicals with a HQ less than 1 are not considered a health concern.

PCB Residential Dust Exposure Route – Non-cancer

Table A2. Non-cancer hazard calculations resulting from exposure to PCBs in dust from residential areas at the Rainier Commons buildings Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	15.6	Child	3.09E-6	1.12E-5	2.0E-5	0.72
		Older Child	1.13E-6	4.09E-6		0.26
		Adult	6.44E-7	1.71E-6		0.12

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Residential Air Exposure Route – Non-cancer

Table A3. Non-cancer hazard calculations resulting from exposure to PCBs in air from residential areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.025U	Child	1.33E-5	2.0E-5	0.67
		Older Child	8.19E-6		0.41
		Adult	5.06E-6		0.25

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.
* - MRL is for Aroclor 1254

PCB Residential Dust Exposure Route – Cancer

Table A4. Cancer hazard calculations resulting from exposure to PCBs in dust from residential areas at Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	15.6	2	Child	4.12E-7	1.49E-6	1.90E-6
			Older Child	1.51E-7	5.45E-7	6.96E-7
			Adult	8.59E-8	2.28E-7	3.14E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Residential Air Exposure Route – Cancer

Table A5. Cancer hazard calculations resulting from exposure to PCBs in air from residential areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.025U	2	Child	1.77E-6
			Older Child	1.09E-6
			Adult	6.75E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.

Lifetime cancer risk (Child): 1.90E-6 + 1.77E-6 = 3.67E-6
Lifetime cancer risk (Older Child): 6.96E-7 + 1.09E-6 = 1.79E-6
Lifetime cancer risk (Adult): 3.14E-7 + 6.75E-7 = 9.89E-7

PCB Office Dust Exposure Route – Non-cancer

Table A6. Non-cancer hazard calculations resulting from exposure to PCBs in dust from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	10.9	Adult	3.21E-7	8.54E-7	2.0E-5	0.06

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Office Air Exposure Route – Non-cancer

Table A7. Non-cancer hazard calculations resulting from exposure to PCBs in air from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.028	Adult	2.77E-6	2.0E-5	0.14

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Office Dust Exposure Route – Cancer

Table A8. Cancer hazard calculations resulting from exposure to PCBs in dust from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	10.9	2	Adult	4.29E-8	1.14E-7	1.57E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Office Air Exposure Route – Cancer

Table A9. Cancer hazard calculations resulting from exposure to PCBs in air from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.028	2	Adult	3.69E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

Lifetime cancer risk: 1.57E-7 + 3.69E-7 = 5.26E-7

PCB Storage/Warehouse Dust Exposure Route – Non-cancer

Table A10. Non-cancer hazard calculations resulting from exposure to PCBs in dust from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	36	Adult	1.06E-6	2.82E-6	2.0E-5	0.19

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Storage/Warehouse Air Exposure Route – Non-cancer

Table A11. Non-cancer hazard calculations resulting from exposure to PCBs in air from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.013U	Adult	1.29E-6	2.0E-5	0.07

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.
* - MRL is for Aroclor 1254

PCB Storage/Warehouse Dust Exposure Route – Cancer

Table A12. Cancer hazard calculations resulting from exposure to PCBs in dust from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	36	2	Adult	1.42E-7	3.76E-7	5.17E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Storage/Warehouse Air Exposure Route – Cancer

Table A13. Cancer hazard calculations resulting from exposure to PCBs in air from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.013U	2	Adult	1.71E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.

Lifetime cancer risk: 5.17E-7 + 1.71E-7 = 6.88E-7

Appendix B

This section provides calculated exposure doses and assumptions used for exposure to PCBs in dust and air from the Rainier Commons building in Seattle, Washington. This exposure scenario was developed to model exposures that might occur based on a residential exposure of 350 days per year for 30 years and a worker exposure of 250 day per year for 25 years. The following exposure parameters and dose equations were used to estimate exposure dose from direct contact with PCBs. As with any scenario, there are uncertainties.

Exposure to PCBs in dust and air through ingestion, inhalation, and dermal absorption

Total dose $_{\text{(non-cancer)}}$ = Ingested dose + inhaled dose + dermally absorbed dose

Ingestion Route

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{C \times CF \times IR \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{C \times CF \times IR \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Dermal Route

$$\text{Dermal Transfer (DT)} = \frac{C \times AF \times ABS \times AD \times CF}{ORAF}$$

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{DT \times SA \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Inhalation Route

$$\text{Dose}_{\text{non-cancer (mg/kg-day)}} = \frac{Ca \times IHR \times EF \times ED \times IHCF}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{Ca \times IHR \times EF \times ED \times CPF \times IHCF}{BW \times AT_{\text{cancer}}}$$

Table B1. Assumptions used for exposure to PCBs in dust and air from the Rainier Commons buildings, Seattle, King County, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	mg/kg	Maximum detected value
Concentration in air (Ca)	Variable	mg/m3	Maximum detected value
Conversion Factor (CF)	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion Rate (IR) – adult	3.1*	mg/day	Exposure Factors [10]
Ingestion Rate (IR) – older child	3.1*		
Ingestion Rate (IR) - child	3.1*		
Exposure Frequency (EF)	350	Days/year	Average days per year minus two week vacation
	250		Average working days per year
Exposure Duration (ED)	30 (5,10,15)	years	Number of years at one residence (child, older child, adult years)
	25		Number of years at work
Body Weight (BW) - adult	72	kg	Adult mean body weight
Body Weight (BW) – older child	41		Older child mean body weight
Body Weight (BW) - child	15		0-5 year-old child average body weight
Surface area (SA) - adult hand	840	cm^2	Exposure Factors [10]
Surface area (SA) – older child hand	400		
Surface area (SA) – child hand	400		
Averaging $Time_{non\text{-}cancer}$ (AT)	Variable	days	Equal to Exposure Duration
Averaging $Time_{cancer}$ (AT)	27375	days	75 years
Dermal Transfer (DT) - child	4.37E-7	mg/cm^2-day	Based on DT equation with C = 15.6
Dermal Transfer (DT) – older child	4.37E-7		Based on DT equation with C = 15.6
Dermal Transfer (DT) - adult	1.53E-7		Based on DT equation with C = 15.6
Dermal Transfer (DT) - adult	1.1E-7		Based on DT equation with C = 10.9
Dermal Transfer (DT) - adult	3.5E-7		Based on DT equation with C = 36
Cancer Potency Factor (CPF)	2	$mg/kg\text{-}day^{-1}$	Source: EPA (Chemical Specific) PCBs
24 hr. absorption factor (ABS)	0.14	unitless	Source: EPA (Chemical Specific) PCBs
Oral route adjustment factor (ORAF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Adherence duration (AD)	1	days	Source: EPA
Adherence factor (AF)	0.2	mg/cm^2	Child, older child
	0.07		Adult
Inhalation Conversion Factor (IHCF)	0.001	mg/ug	Converts contaminant concentration from milligrams (mg) to micrograms (ug)
Inhalation rate (IHR) - adult	15.2	m^3/day	Exposure Factors [10]
Inhalation rate (IHR) – older child	14		
Inhalation rate (IHR) – child 0-5	8.3		

*Assumes 31 mg of dust adhering to the hands (based on average soil adherence to palm [10]) and 10 percent of the total adherence is ingested.

Hazard Quotient formula:

$$HQ = \frac{\text{Estimated Dose (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

Chemicals with an HQ less than 1 are not considered a health concern.

PCB Residential Dust Exposure Route – Non-cancer

Table B2. Non-cancer hazard calculations resulting from exposure to PCBs in dust from residential areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	15.6	Child	3.09E-6	1.12E-5	2.0E-5	0.72
		Older Child	1.13E-6	4.09E-6		0.26
		Adult	6.44E-7	1.71E-6		0.12

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Residential Air Exposure Route – Non-cancer

Table B3. Non-cancer hazard calculations resulting from exposure to PCBs in air from residential areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.025U	Child	1.33E-5	2.0E-5	0.67
		Older Child	8.19E-6		0.41
		Adult	5.06E-6		0.25

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.
* - MRL is for Aroclor 1254

PCB Residential Dust Exposure Route – Cancer

Table B4. Cancer hazard calculations resulting from exposure to PCBs in dust from residential areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	15.6	2	Child	4.12E-7	1.49E-6	1.90E-6
			Older Child	3.02E-7	1.09E-6	1.39E-6
			Adult	2.58E-7	6.84E-7	9.42E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Residential Air Exposure Route – Cancer

Table B5. Cancer hazard calculations resulting from exposure to PCBs in air from residential areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.025U	2	Child	1.77E-6
			Older Child	2.18E-6
			Adult	2.02E-6

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.

Lifetime cancer risk: 1.90E-6 + 1.39E-6 + 9.42E-7 + 1.77E-6 + 2.18E-6 + 2.02E-6 = 1.02E-5

PCB Office Dust Exposure Route – Non-cancer

Table B6. Non-cancer hazard calculations resulting from exposure to PCBs in dust from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	10.9	Adult	3.21E-7	8.54E-7	2.0E-5	0.06

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Office Air Exposure Route – Non-cancer

Table B7. Non-cancer hazard calculations resulting from exposure to PCBs in air from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.028	Adult	2.77E-6	2.0E-5	0.14

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Office Dust Exposure Route – Cancer

Table B8. Cancer hazard calculations resulting from exposure to PCBs in dust from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	10.9	2	Adult	2.14E-7	5.69E-7	7.83E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Office Air Exposure Route – Cancer

Table B9. Cancer hazard calculations resulting from exposure to PCBs in air from office areas at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.028	2	Adult	1.85E-6

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

Lifetime cancer risk: 7.83E-7 + 1.85E-6 = 2.63E-6

PCB Storage/Warehouse Dust Exposure Route – Non-cancer

Table B10. Non-cancer hazard calculations resulting from exposure to PCBs in dust from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	36	Adult	1.06E-6	2.82E-6	2.0E-5	0.19

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254

PCB Storage/Warehouse Air Exposure Route – Non-cancer

Table B11. Non-cancer hazard calculations resulting from exposure to PCBs in air from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.013U	Adult	1.29E-6	2.0E-5	0.07

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.
* - MRL is for Aroclor 1254

PCB Storage/Warehouse Dust Exposure Route – Cancer

Table B12. Cancer hazard calculations resulting from exposure to PCBs in dust from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	36	2	Adult	7.08E-7	1.88E6	2.59E-6

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Storage/Warehouse Air Exposure Route – Cancer

Table B13. Cancer hazard calculations resulting from exposure to PCBs in air from storage/warehouse at the Rainier Commons buildings, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.013U	2	Adult	8.57E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
U = The analyte was not detected at this level.

Lifetime cancer risk: 2.59E-6 + 8.57E-7 = 3.45E-6

Appendix C - Stairwell

This section provides calculated exposure doses and assumptions used for exposure to PCBs in dust and air from the stairwell at the Rainier Commons building in Seattle, Washington. This exposure scenario was developed to model exposures that might occur based on residential exposure in the stairwell of 52 days per year for 5 years. The following exposure parameters and dose equations were used to estimate the exposure dose from direct contact with PCBs. As with any scenario, there are uncertainties.

Exposure to PCBs in dust and air through ingestion, inhalation, and dermal absorption

Total dose $_{\text{(non-cancer)}}$ = Ingested dose + inhaled dose + dermally absorbed dose

Ingestion Route

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{C \times CF \times IR \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{C \times CF \times IR \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Dermal Route

$$\text{Dermal Transfer (DT)} = \frac{C \times AF \times ABS \times AD \times CF}{ORAF}$$

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{DT \times SA \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Inhalation Route

$$\text{Dose}_{\text{non-cancer (mg/kg-day)}} = \frac{Ca \times IHR \times EF \times ED \times IHCF}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{Ca \times IHR \times EF \times ED \times CPF \times IHCF}{BW \times AT_{\text{cancer}}}$$

Table C1. Assumptions used for exposure to PCBs in paint chips from the stairwell at the Rainier Commons building in Seattle, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	mg/kg	Maximum detected value
Concentration in air (Ca)	Variable	mg/m3	Maximum detected value
Conversion Factor (CF)	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion Rate (IR) – adult	0.31*	mg/day	Exposure Factors [10]
Ingestion Rate (IR) – older child	0.31*		
Ingestion Rate (IR) - child	0.31*		
Exposure Frequency (EF)	52	Days/year	One day per week exposure
Exposure Duration (ED)	5	years	Number of years at location 2007 -2011
Body Weight (BW) - adult	72	kg	Adult mean body weight
Body Weight (BW) – older child	41		Older child mean body weight
Body Weight (BW) - child	15		0-5 year-old child average body weight
Surface area (SA) - adult hand	420	cm^2	Exposure Factors [10]
Surface area (SA) – older child hand	200		
Surface area (SA) – child hand	200		
Averaging $Time_{non\text{-}cancer}$ (AT)	1825	days	Equal to Exposure Duration
Dermal Transfer (DT) – child	1.32E-5	mg/cm^2-day	Based on DT equation
Dermal Transfer (DT) – older child	1.32E-5		
Dermal Transfer (DT) – adult	4.61E-5		
Averaging $Time_{cancer}$ (AT)	27375	days	75 years
Cancer Potency Factor (CPF)	2	$mg/kg\text{-}day^{-1}$	Source: EPA (Chemical Specific) PCBs
24 hr. absorption factor (ABS)	0.14	unitless	Source: EPA (Chemical Specific) PCBs
Oral route adjustment factor (ORAF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Adherence duration (AD)	1	days	Source: EPA
Adherence factor (AF)	0.2	mg/cm^2	Child, older child
	0.07		Adult
Inhalation Conversion Factor (IHCF)	0.001	mg/ug	Converts contaminant concentration from milligrams (mg) to micrograms (ug)
Inhalation rate (IHR) - adult	0.63	m^3/day	Based on 1 hour per day in stairwell Exposure Factors [10]
Inhalation rate (IHR) – older child	0.58		
Inhalation rate (IHR) – child 0-5	0.35		

*Assumes 31 mg of dust adhering to the hands (based on average soil adherence to palm [10]) and 10 percent of the total adherence of soil is ingested. However, only one percent (1%) of the total adherence of soil ingested is from the stairwell.

Hazard Quotient formula:

$$HQ = \frac{\text{Estimated Dose (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

Chemicals with an HQ less than one are not considered a health concern.

PCB Stairwell Dust Exposure Route – Non-cancer

Table C2. Non-cancer hazard calculations resulting from exposure to PCBs dust from stairwell at Rainier Commons building in Seattle, Washington.

Contaminant	Maximum Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)		MRL* (mg/kg/day)	Hazard Quotient
			Ingestion	Dermal		
PCB	470	Child	1.38E-6	2.50E-5	2.0E-5	**1.3**
		Older Child	5.06E-7	9.15E-6		0.48
		Adult	2.88E-7	3.83E-6		0.21

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
* - MRL is for Aroclor 1254
BOLD – hazard quotient exceed 1

PCB Stairwell Dust Air Exposure Route – Non-cancer

Table C3. Non-cancer hazard calculations resulting from exposure to PCBs in air from stairwell at Rainier Commons building in Seattle, Washington.

Contaminant	Maximum Concentration (ug/m3)	Scenarios	Estimated Dose (mg/kg/day)	MRL* (mg/kg/day)	Hazard Quotient
			Inhalation		
PCB	0.052UJ	Child	1.73E-7	2.0E-5	0.009
		Older Child	1.05E-7		0.005
		Adult	6.48E-8		0.003

MRL – minimal risk level
ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
UJ = The associated sample quantitation limit is estimated
* - MRL is for Aroclor 1254

PCB Stairwell Dust Exposure Route – Cancer

Table C4. Cancer hazard calculations resulting from exposure to PCBs in dust from the stairwell at Rainier Commons building Seattle, King County, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor (mg/kg-day)$^{-1}$	Scenario	Increased Cancer Risk		Total Cancer Risk
				Ingestion	Dermal	
PCB	470	2	Child	1.85E-7	3.33E-6	3.52E-6
			Older Child	6.75E-8	1.22E-6	1.29E-6
			Adult	3.84E-8	5.10E-7	5.49E-7

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day

PCB Stairwell Air Exposure Route – Cancer

Table C5. Cancer hazard calculations resulting from exposure to PCBs in air from the stairwell at Rainier Commons building, Seattle, King County, Washington.

Contaminant	Maximum Concentration (ug/m3)	Cancer Potency Factor (mg/kg-day)$^{-1}$	Scenario	Increased Cancer Risk
				Inhalation
PCB	0.052UJ	2	Child	2.30E-8
			Older Child	1.40E-8
			Adult	8.64E-9

ppm – parts per million
mg/kg/day - milligrams per kilogram body-weight per day
UJ = The associated sample quantitation limit is estimated

Lifetime cancer risk (Child): 3.52E-6 + 2.30E-8 = 3.54E-6
Lifetime cancer risk (Older Child): 1.29E-6 + 1.40E-8 = 1.30E-6
Lifetime cancer risk (Adult): 5.49E-7 + 8.64E-9 = 5.58E-7

Appendix D Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Risk	A estimated risk for developing cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil, or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor	A number assigned to a cancer-causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Comparison value	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.
Dermal Contact	Contact with (touching) the skin (see route of exposure).
Dose (for chemicals that are not radioactive)	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.

Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on ATSDR's *minimal risk level* (MRL).
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].
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.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].
Ingestion rate	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].
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.
Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
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.
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 that are not easily dissolved in water.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
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].