Health Consultation

Evaluation of Contaminants in Adjacent Streets and Residential Soils in South Park Site South Seattle, King County, Washington

July 28, 2010

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

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

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

Elmer Diaz
Washington State Department of Health
Office of Environmental Health Assessments
P.O. Box 47846
Olympia, WA 98504-7846
360-236-3376
FAX 360-236-2251
1-877-485-7316
Website: 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 call 711).

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

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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 theoretical risk for developing cancer if exposed to a substance every day for 70 years (a lifetime exposure) based on an average daily exposure over a lifetime. 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**].
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

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 **oral reference dose**].
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
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 on a daily basis into the body (i.e., dose) over the course of a lifetime 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) /Parts per trillion (ppt)	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. 1 ounce of TCE in 1 trillion ounces of water is 1 ppt.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The RMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
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].
Toxic Equivalent (TEQ)	Is defined as the sum of the products of the concentration of each compound (e.g., dioxin and furan compound) multiplied by its Toxic Equivalent Factor (TEF) value.

Toxic Equivalency Factors (TEFs)	It is an estimate of the toxicity of the compound relative to 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD). Each dioxin/furan is multiplied by a TEF to produce the dioxin TEQ. The TEQs for each chemical are then summed to give the overall 2,3,7,8-tetrachlorodibenzo-*p*-dioxin TEQ.

Summary

Introduction:
The Department of Health's (DOH) top priority for South Park site residents is to ensure that the community has the best information possible to safeguard its health. The Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) asked DOH to conduct this investigation. The purpose of this health consultation is to evaluate contaminant data (i.e., surface soil) from the South Park site in Seattle, King County, Washington and make recommendations for actions that ensure the public's health is protected.

Conclusions: DOH reached two important conclusions in this health consultation:

Conclusion 1

DOH concludes that touching, breathing, or accidentally eating soil from streets and yards at the South Park site for approximately 350 days per year, over 30 years is not expected to harm people's health. The levels are below those where we would expect to see health effects.

Basis for decision:

Based on exposure assumptions and calculations, PCB and dioxin levels present in the streets and residential yards at the South Park site are below levels known to result in harmful non-cancer health effects.

Conclusion 2

DOH concludes that touching, breathing, or accidentally eating soil that contains dioxins and PCBs is not likely to produce harmful cancer health effects for residents during a 30 year lifetime exposure at the South Park site.

Basis for decision:

Based on cancer risk estimates and review of the toxicological literature, PCBs and dioxins in surface soil are considered below levels of health concern. The overall potential health risks associated with exposure to dioxins and PCBs in the surface soil at the South Park site are considered very low under most scenarios where the primary exposure pathway is incidental ingestion through direct exposure to soil. However, the true or actual risk is unknown and could be as low as zero.

Next Steps:

1. DOH will coordinate with staff from the City of Seattle, the EPA, and Seattle and King County Public Health (KCPH) Department to develop education materials.

    a. DOH is in the process of developing a fact sheet for the general public. This fact

sheet has been sent out for review and comments. DOH expects to have a final report by July 2010.

b. On May 6, 2010, DOH staff commented on Seattle's KCPH and EPA's general fact sheet on dioxins and PCBs.

c. Copies of a general fact sheet were distributed at a community meeting on June 17, 2010.

2. DOH will provide copies of this health consultation to Ecology, EPA, stakeholders, and other concerned parties.
   a. Final copies will be distributed in the summer of 2010 when the final report is approved.

3. DOH will coordinate with Ecology and EPA on public health action plans and next steps.
   a. DOH staff participated in a community meeting in South Park on June 17, 2010.

For More Information:
Please feel free to contact Elmer Diaz at 360-236-3357 or 1-877-485-7316, if you have any questions about this health consultation.

Statement of Issues

The Washington State Department of Health (DOH) has prepared this health consultation at the request of the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA). The purpose of this health consultation is to evaluate the potential human health risks posed by contaminants in surface soil at the South Park [a] site, King County, Washington. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

The Lower Duwamish Waterway (LDW) site was added to the EPA's National Priorities List as a Superfund site on September 13, 2001. Terminal 117 (T-117) is located on the west side of the LDW at approximately river mile 3.5 to 3.7 (Figure 1). T-117 is a contaminated area within the boundaries of the larger Lower Duwamish Waterway Superfund site and is scheduled for cleanup because of high levels of polychlorinated biphenyls (PCBs). The upland portions of the Early Action Area's (EAA) west shore include the Port of Seattle's T-117 and surrounding properties, including the former Malarkey Asphalt Company site. In 1999, the Port of Seattle acquired the inland parcels that make up the former Malarkey Early Action Area, between the shoreline parcel and Dallas Avenue South. These properties were consolidated to form the present-day T-117. Adjacent properties include the Basin Oil Company on the west side of Dallas Avenue, the Boeing Company to the south, and the South Park Marina to the north/northwest. T-117 covers approximately 5.5 acres including a 50-foot wide section of land adjacent to the shoreline owned by the Port of Seattle as successor in interest to a Duwamish commercial waterway district.

As part of the City of Seattle's (City) source-tracing program for the LDW, sediment samples were collected from catch basins, manholes, and street dirt. These samples were collected at various locations in south Seattle in 2004 and 2005. The samples were analyzed for dioxin/furan congeners. This analysis revealed the presence of dioxin and furans at two locations near T-117. Based on these source-tracing samples, uncertainty emerged regarding the presence of dioxin and furans throughout the T-117 EAA.[1]

In 2005, the City conducted interim action activities that included remediation of PCB contaminated soil in streets and residential yards adjacent to the T-117 EAA.[2] Any PCB contamination that remained within the right-of-ways (ROWs) after the City completed their interim action activities was covered with asphalt-concrete pavement or clean gravel to prevent human exposure and is pending final cleanup action.[3] PCB concentrations in soils have been extensively investigated and delineated within the adjacent streets as part of the City's

[a] The South Park site refers to the residential yards bounded by Dallas Avenue South, South Donovan Street, and 14th Avenue South. The South Park area is located in the immediate vicinity of T-117.

2004/2005 interim action and the non-time-critical removal action (NTCRA).[4] However, dioxin/furans sampling was not conducted as part of the interim action.

The City has been conducting investigational sampling in the South Park area in the immediate vicinity of T-117. The state and city health departments are also working closely on the program.

Additional environmental investigations were necessary due to uncertainty regarding chemicals of potential concern and the extent of contamination from the T-117 site. The T-117 EAA consists of three defined areas: the sediment study area within the LDW, the T-117 Upland Area, and the adjacent streets (City ROWs) and yards. Samples were collected in all three areas to determine the presence and concentrations of dioxins and furans and the extent at which PCB concentrations exceeded the Washington State Sediment Quality Standards (SQS).

In 2008, the City conducted a preliminary soil investigation near the T-117/Malarkey site (T-117). Dallas Avenue and South Cloverdale Streets are located west of T-117. Adjacent streets comprise the street ROWs along sections of 16th and 17th Avenue South, Dallas Avenue South, and South Donovan Street. The T-117 Upland Area, the South Park Marina, and residential properties to the south and west border the adjacent streets; the adjacent streets also surround, but do not include, the former Basin Oil property (Figure 1).

Analytical results for this investigation indicated the presence of PCBs and dioxin/furans in the southern end of T-117 and upland portions of the property. PCBs and dioxin/furans were also found in streets along Dallas Avenue South, Donovan Street, in residential yards along the north side of South Cloverdale Street, and the south side of Dallas Avenue South between 14th and 16th Avenue South. Some values were above the Washington State Model Toxics Control Act (MTCA) Method A soil cleanup level for PCB mixtures, which is one part per million (ppm) and MTCA Method B cleanup level of 0.000011 ppm (11 parts per trillion) (ppt) for dioxin/furans. Some PCBs and dioxin/furan levels were also above the ATSDR screening level of 1 ppm for PCB mixtures (Aroclor 1254 Environmental Media Evaluation Guide (EMEG) value is used as a surrogate for total PCB mixtures) and 0.00005 ppm (50 ppt) for dioxin and dioxin-like compounds (2,3,7,8- tetrachlorodibenzo-p-dioxin EMEG value is used as a surrogate for total dioxins) (Appendix A, Tables A8 and Table A12).[5]

In 2009, the City conducted additional surface soil sampling to continue characterizing the extent of the soil contamination. This sampling event consisted of two phases (Phase 1 and Phase 2). Please see more information in the Sample collection and analysis section.

In 2005, DOH conducted a health evaluation of PCBs, metals, and petroleum compounds in surface soils on and adjacent to the side streets of the Dallas Avenue site. DOH focused mainly on potential health impacts related to exposures to PCBs in residential soils. Some contaminants were also found on residential properties at levels of potential health concern.[6] This health evaluation will focus mainly on 2008 and 2009 sampling data for dioxin/furans and PCBs.

The current data selection will be restricted to residential community member's exposures and not street maintenance workers or other such working population's exposures. The purpose of

this document is to evaluate potential exposures (i.e., how might residents be exposed to site-related contamination, e.g., by ingesting soil, inhaling it, or through direct skin contact) to residents of South Park.

Data selection will also include currently accessible soils. Contaminants that are still present and have not been superseded by later sampling results are considered for this analysis. If they are under an asphalt cap (due to previous cleanup actions at the site), they are not considered currently accessible with respect to area residents. Thus, only accessible surface soils (depth of 0.0 to 0.5 feet (ft), and/or 0.0 to 6 inches) in adjacent streets and residential properties near the T-117/Malarkey site (Figure 1) are considered for this analysis.

Potential Sources

In general, there are many potential sources for dioxins. Overall, urban areas present higher levels of dioxins than suburban areas. Many sources (e.g., cars, diesel emissions, atmospheric deposition, etc.), local sources (e.g., incinerators, hazardous chemical wastes, etc.), and property-specific sources (e.g., burning wood, fireplaces, ash in yards, etc.) can contribute to regional background levels of dioxins in the environment.[7,8,9,10,11,12] Dioxins are also known to occur as an unintended byproduct from the manufacture of PCBs, and elevated dioxins have been reported from soil samples at the T-117 upland site. Hauling soil and/or sediment with PCBs, the burning of PCB-containing waste oils, and general oil-fueled boiler emissions are possible dioxin sources associated with historic T-117 operations. Evaluations of the contributions from T-117 operations to contamination in nearby streets and yards are not conclusive. Based on comparisons to other urban soil data sets in the literature, the total dioxins in yards near T-117 appear to be higher than expected, but the overall apportionment between T-117 and non-T-117 sources remains uncertain.

Under an EPA Order, the City and Port of Seattle are working with EPA and Ecology to identify the appropriate removal actions to take at this time. The City, Port, Ecology, the Puget Sound Clean Air Authority, Duwamish River Cleanup Coalition (DRCC), and People for Puget Sound have also submitted a grant application for additional regional air and soil sampling for dioxin and furans. However, EPA and Ecology anticipate no further investigations at this time.

Environmental Investigations

Sample collection and analysis

City of Seattle

From June through September of 2008, the City and Port of Seattle collected surface soil samples (0 to 0.5 feet) on and adjacent to the city streets, ROWs, and residential yards and analyzed them for PCBs and dioxin/furans (Figure 2). Samples of T-117 and Duwamish Waterway sediments were also collected. Soil samples were analyzed for the presence of dioxin/furans and total PCBs. A number of the samples contained PCBs (mainly Aroclor 1260; few samples contained Aroclor 1254) and dioxin/furans above the MTCA cleanup levels (i.e., Method A soil cleanup

levels for PCBs and Method B soil cleanup levels for dioxin/furans). The yard samples were collected as three discrete samples (a, b, and c), which were composited and analyzed for dioxin and furans.

In April 2009 (Phase 1), the City and Ecology conducted additional surface soil sampling and in July/August 2009 (Phase 2), the City conducted surface soil sampling to continue characterizing the extent of the soil contamination (Figures 3 and 4). Phase 1 sampling consisted of both individual and multi-increment samples (MIS) [b] (composites of 30+ samples)[c]. Samples were collected in the streets and yards and analyzed for PCBs and dioxin/furans [d]. Phase 2 sampling consisted of both individual and MIS samples. Phase 2 sampling also included collecting dioxin/furan samples, which are currently archived [e]. Samples were collected in the streets and yards and analyzed only for PCBs. Soil samples were collected 0.0 to 0.2 feet (0 to 2.4 inches) below ground surface (bgs) and 0.2 to 0.5 feet (2.4 to 6 inches) bgs. Some soil samples were also collected 0.5 feet to 5 feet (or 6 to 60 inches) bgs to determine the vertical extent of contamination. The samples from these additional sampling rounds were predominantly analyzed for dioxin/furans and Aroclors. Aroclors 1260 [f] and 1254 were the only Aroclors detected during these additional sampling rounds, and some of the detected Aroclor levels in residential yards and streets were above MTCA Method A soil cleanup levels (Appendix A, Tables A9, A10, A11, and A12). As mentioned before, the MTCA Method A cleanup level for PCBs mixtures is 1 ppm. Dioxin/furan concentrations are expressed as the toxic equivalent (TEQ) concentration of 2,3,7,8-tetrachlorodibenzo-*p*- dioxin (TCDD). Total dioxin TEQs were also detected above the ATSDR comparison value and MTCA Method B soil cleanup level (Appendix A, Tables A7 and A8).

The soil sampling collection methods for streets and residential yards are described in the quality assurance project plan (QAPP).[3] Methods, results, and data validation were verified according to criteria and procedures described in the QAPP. All laboratory procedures for the sample analyses followed the methods and procedures identified in the QAPPs. The results presented are of good quality and are acceptable for use.

As was determined by this evaluation, the laboratory followed the specified analytical method.

[b] MIS consists of collecting a large number of individual soil samples (increments) from within an area delineated for decision making, called a Decision Unit (DU), and aggregating the increments to form a single composite MIS for that DU. The MIS is then analyzed to provide an average chemical concentration for soil in the DU.

[c] Some 3:1 composite yard samples were later analyzed as individual subsamples (i.e., a, b, and c subsamples) forming the composite based on archived materials.

[d] Not all Phase 1 2009 MIS yard and street samples were analyzed for dioxins.

[e] None of the Phase 2 2009 MIS samples have been analyzed for dioxins.

[f] Aroclor 1260 was the only Aroclor detected in samples analyzed from the residential yards, with the exception of a few samples in which Aroclor 1254 was detected.

Accuracy was acceptable as demonstrated by the surrogate, laboratory control sample/laboratory control sample duplicate (LCS/LCSD), matrix spikes/matrix spike duplicates (MS/MSD), and percent recovery values. Precision was also acceptable as demonstrated by the relative percent difference values for the MS/MSD and LCS/LCSD analyses. Data were qualified as non-detected at elevated reporting limits due to matrix interference.

Discussion

Given the data selection criteria (i.e., current conditions and accessible surface soils) described previously (Background section), Tables 1 - 2 summarize maximum concentrations of total PCBs and dioxin/furans found in the streets and residential yards at the South Park site. Figures 2 - 5 describe sampling locations and total dioxin/furans and PCB results for residential yards and streets. Appendix A, Tables A1-A12 provides more detailed data related to the levels of total PCBs and dioxin/furans found in street soils and residential yards of the South Park site.

Table 1. Maximum surface and subsurface soil concentrations of total PCBs and total dioxin TEQ data, June-September 2008, April and July/August 2009, South Park Site, Seattle, King County, Washington.

Location	Contaminant	Sample Depth Feet (ft) below ground surface (bgs)	Maximum Concentration (ppm)[a]	COC (residential scenario)	ATSDR comparison value (ppm)
Street Soil & ROW soil	Total PCBs	0.0 – 0.2 ft * 0.2 – 0.5 ft † 0.1 – 1.0 ft ††	**5.7** **8.1** **21**	**Yes**	**1.0** [c]
	Total dioxins TEQ	0.0 – 0.2 ft * 0.2 – 0.5 ft † 0.1 – 1.0 ft ††	**0.000051** 0.000039 **0.000084 J**	**Yes**	**0.00005** [b 5]
Residential yard Properties	Total PCBs	0.0 – 0.2 ft * 0.2 – 0.5 ft †	**2.1** **1.74**	**Yes**	**1.0** [c]
	Total dioxins TEQ	0.0 – 0.2 ft * 0.2 – 0.5 ft †	**0.000050** 0.000038	**Yes**	**0.00005** [b 5]

BOLD – values exceed comparison values
ROW - Right-of-way
COC: Contaminants of concern
J – Estimated value; the analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample.
[a] Maximum concentrations were determined from samples representing the most current conditions on-site. 2008 data that were superseded by 2009 data were not included.
[b] ATSDR's – EMEG - The minimal risk level (MRL) - based on Environmental Media Evaluation Guide (child). This value corresponds to 2,3,7,8-Tetrachlorodibenzo-*p*- dioxin (TCDD).
[c] ATSDR's – EMEG - Environmental Media Evaluation Guide (child). Aroclor 1254 EMEG value was used as a surrogate for total PCBs.
TEQ (Toxic Equivalent) dioxin
* Surface 1 samples range from 0.0 - 0.2 ft bgs.

† Surface 2 samples range from 0.2 – 0.5 ft bgs.
†† Subsurface depth corresponds to 0.1 – 1.0 ft bgs; the value corresponds to a sample collected in 2008. No update was necessary for this location.

Table 2. Total dioxin TEQs and total PCB concentrations detected in surface soil, June-September 2008, April and July/August 2009 from the South Park Site – Seattle, King County, Washington.

Location	Contaminant	Maximum Concentration (ppm)	Range of Concentration (ppm)	EPA Cancer Class	ATSDR comparison value (ppm)	MTCA Method A Cleanup level (ppm)
Street soil	Total Dioxins TEQ	**0.000084 J**	0.000000495 J – 0.000084 J	B2	**0.000050** [a]	**0.000011**[c]
Residential yard soil		**0.000050**	0.000005 J – 0.000050			
Street soil	Total PCB Aroclors	**8.1**	0.055 – 8.1	B2	**1.0** [b]	**1.0**
Residential yard soil		**2.1**	0.043 – 2.1			

BOLD – values exceed comparison values
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
[a] EMEG - ATSDR's Environmental Media Evaluation Guide (child). This value corresponds to 2,3,7,8-Tetrachlorodibenzo-*p*- dioxin (TCDD).
[b] ATSDR's – EMEG - Environmental Media Evaluation Guide (child). Aroclor 1254 EMEG value was used as surrogate
[c] Corresponds to MTCA Method B cleanup level
J - Indicates an estimated value
MTCA – Model Toxics Control Act

Contaminants of Concern

DOH used a conservative approach to evaluate whether contaminated soils at the South Park site pose a possible health concern (Appendix B). Contaminants of concern (COC) in soil were determined by employing a screening process. Maximum soil contaminant levels were first compared to health-based soil comparison values. In general, if a contaminant's maximum concentration is greater than its comparison value, then the contaminant is evaluated further. Several types of health-based comparison or screening values were used during this process: cancer risk evaluation guide (CREG), environmental media evaluation guide (EMEG), and reference dose media evaluation guide (RMEG) [see the glossary for descriptions]. Comparison values such as the CREG and EMEG 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 comparison values are levels that represent a theoretical increase in the risk of cancer by about one case for every million people exposed.

DOH uses ATSDR comparison values whenever available to make health based decisions. In the absence of ATSDR comparison or screening values, DOH may also use legal standards such as the cleanup levels specified in the Washington State MTCA and EPA's Preliminary Remediation Goals (PRGs) regional screening levels.[13] In this health evaluation, total dioxins and total PCBs were compared to ATSDR screening and MTCA cleanup values. Agencies, such as Ecology and EPA, use these types of comparison values (which gives a quantitative risk assessment and provides a numeric estimate of theoretical risk or hazard) when evaluating a site. These agencies focus on current and potential future exposures and consider all contaminated media regardless of whether exposures are occurring or are likely to occur. These types of values are used for regulatory purposes and often form the basis for site cleanup actions; risk estimates in the context of community health concerns may differ.

Based on the screening results summarized in Tables 1 - 2, the following chemicals will be carried out for further evaluation: total dioxins and total PCBs. The following discussion will address the exposure routes and potential health risks associated with these contaminants currently present in the surface soil at the South Park site.

Exposure Routes and Pathways at the South Park Site

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. A completed exposure pathway exists when there is direct evidence of a strong likelihood that people have in the past or are presently coming in contact with site-related contaminants.

A completed exposure pathway for soil currently exists at the South Park site. As mentioned before, the City conducted interim cleanup actions in 2005 that included remediation of PCB contaminated soil in streets and residential yards adjacent to the T-117 EAA[g]. Contaminants that are still present in the street soils, but are covered with asphalt do not present a current health risk for area residents. Frequent and long-term exposures are more likely to occur from residential soils. Thus, this document will focus on potential health impact related to exposures to PCBs and dioxins in soils that are currently accessible to the general population (i.e., residential soils and adjacent or unpaved streets [h] where contaminants are still present).

Human use patterns and site-specific conditions were considered in the evaluation of exposure to total PCBs and total dioxins TEQ at the South Park site. Exposure to contaminants in the soil can occur through the following pathways and routes:

[g] The extent of 2005 cleanup actions was limited in comparison to the current site area (see Figure 1).
[h] There are still some unpaved alleys between S. Cloverdale St. and S. Donovan St., and between S. Cloverdale St. and Dallas Ave. S. which have not been sampled.

Ingestion exposure (swallowing)

Most people inadvertently swallow small amounts of sediments, soil, and dust (and any contaminants they contain). Young children often put hands, toys, pacifiers, and other things in their mouths, and these may have dirt or dust on them that can be swallowed. Adults may ingest sediments, soil, and dust through activities such as gardening, mowing, construction work, dusting, and in this case, residential yard related work and/or recreational activities.

Inhalation exposure (breathing)

Although people can inhale suspended sediment, soil or dust, airborne sediment usually consists of relatively large particles that are trapped in the nose, mouth, and throat and are then swallowed, rather than breathed into the lungs.

Dermal exposure (skin contact)

Dirt particles that can adhere to the skin may cause additional exposure to contaminants through dermal absorption. Although human skin is an effective barrier for many environmental contaminants, some chemicals can move easily through the skin.

Exposure scenarios

The following discussion addresses human use patterns and site-specific conditions that were considered when evaluating potential exposures to total PCBs and total dioxin TEQ in soil from the South Park site. The pathways and routes include:

- Inadvertent soil ingestion, dust particle inhalation, and dermal absorption of contaminants in soil during gardening and/or playing activities.

Appendix B provides calculated exposure doses and assumptions used for chemicals in soil from the South Park site. An exposure scenario was developed to model exposures that might occur. These scenarios were devised to represent residential exposures for a child and an adult living at a residential area 350 days per year over 30 years. The scenario assumes that residents take a two week vacation each year.

Although everyone is exposed to low levels of PCBs and dioxin/furans, certain people may have higher levels of PCB and dioxin/furan exposure because of their eating habits or activities. Most human exposure comes from dietary sources. For example, people who eat more fish than the general population may be exposed to more PCBs because fish are a common dietary source of PCBs. It is likely that frequent and long-term exposure to contaminants in soils may occur in residential yards rather than streets. Consequently, the people who live in residential areas and/or near the right-of-ways and/or adjacent streets to the South Park site could be exposed to total PCBs and total dioxins through direct contact. Total PCBs and total dioxins in yard and garden soils might also be tracked into homes where exposure may continue through direct contact with house dust. Residents can also be exposed to contaminated soil during gardening and/or playing

activities. See Appendix B for exposure doses and assumptions used to evaluate soil contaminants at the South Park site.

As mentioned in the Background section, street maintenance worker exposures will not be considered for analysis in this evaluation. The levels of dioxin and PCBs are well below levels expected to cause health effects and do not represent a pathway of concern for maintenance workers at the South Park site.

Indoor dust sampling

Potential exposures due to indoor dust were conducted by DOH in 2005. DOH collected indoor dust samples at two residences near Dallas Avenue South Soil Removal site. PCBs were detected in house dust at levels ranging from 0.756 – 1.57 ppm (dust loading range from 2.18 – 16.67 g/m^2) indicating that some PCBs were transported into the home from exterior sources (Dallas Avenue Road dust). The majority of the dust collected in the home was trapped in area rugs. In 2005, DOH concluded that PCBs in house dust were below levels of health concern.[14] Based on the results of the 2005 evaluation, DOH believes it is not necessary to recommend indoor dust sampling.

Characterization of exposure

Exposure estimates such as rate, frequency, and duration of activities that could result in exposure to site-related contaminants are not likely to differ between PCBs, dioxin-like compounds (DLCs), and other contaminants. However, site-specific considerations (e.g., readily accessible soils such as surface versus subsurface soil, concentrations, frequency of exposure, etc.) may influence the impact of exposure to PCBs and dioxins in soil.

One of the factors that determine the potency of dioxin toxicity from soils is the efficiency of absorption into the bloodstream from ingested soil or from soil adhering to skin. The efficiency of this absorption process is referred to as "bioavailability" and is affected by specific characteristics of the contaminated soil.[15] A critical factor in determining bioavailability is the organic content of the contaminated soil. Soil with high organic content (e.g., >10% total organic carbon) has a lower bioavailability than soil with low organic content (<1% total organic carbon). In addition, dioxins in soil appear to be less bioavailable by at least a factor of two when compared to studies where 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is given in an oil matrix.[16] The dosing method used in the critical study for the chronic MRL value derivation[17] involved dissolving TCDD in oil and adding to the diet. It is likely that the relative bioavailability of TCDD in a dietary matrix would be less than expected from oil alone. However, without site-specific soil bioavailability measurements, data are insufficient to make default bioavailability adjustments for dioxins in soil.

For the general population not occupationally exposed to PCBs, dioxins, and DLCs, the predominant exposure pathway is from dietary sources. Therefore, the evaluation of exposure to site-related dioxins and DLCs represents an incremental increase in exposure above background levels. To provide some context for the characterization of exposure to dioxins and dioxin-like

compounds in soils, it may be useful to compare the estimated site-related daily intake levels with the average daily intake that all populations are likely to experience. If sufficient information is available, estimates could be made of the contribution of site-specific intakes to overall body burden for populations of concern.

Dioxins – General Occurrence and Toxicity

Chemical Specific Toxicity

Below are general summaries of COC health effects. The public health implications of exposure to these COCs from soils are discussed in the next section.

Dioxins and furans

Dioxins and furans (dioxins) consist of about 210 structural variations of dioxin congeners, which differ by the number and location of chlorine atoms on the chemical structure. The primary sources of dioxin releases to the environment are the combustion of fossil fuels and wood; the incineration of municipal, medical, and hazardous wastes; and certain pulp and paper processes. Dioxins also occur at very low levels from naturally occurring sources and can be found in food, water, air, and cigarette smoke.

The most toxic of the dioxin congeners, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin can cause chloracne (a condition of acne-like lesions on the face and neck). Exposure to high levels of dioxins can cause liver damage, developmental effects, and impaired immune function.[18] Long-term exposure to dioxins could increase the likelihood of developing cancer. Studies reveal that rats and mice exposed to TCDD developed thyroid and liver cancer.[19] EPA considers TCDD to be a probable human carcinogen and developed a cancer slope factor of 1.5×10^{5} mg/kg/day^{-1}.[20,21]

Dioxins and Furans, TEQ concentrations

Dioxins are a group of chemicals with similar structures and biological effects. The most toxic of these compounds is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (commonly referred to as TCDD or dioxin). There are many forms of dioxins and "dioxin-like compounds" (DLCs) that share most, if not all, of the toxic potential of TCDD although nearly all are considerably less potent. Included in the list of DLCs are chlorinated forms of dibenzofurans and certain polychlorinated biphenyls (PCBs). Although several dioxin and furan congeners were analyzed in the soil, only a single value called a dioxin toxic equivalent (TEQ) was used to determine non-cancer health threat and cancer risks. Each dioxin/furan is multiplied by a Toxic Equivalency Factor (TEF) to produce the dioxin TEQ. The TEQs for each chemical are then summed to give the overall 2,3,7,8-tetrachlorodibenzo-*p*-dioxin TEQ. The TEQ approach is based on the premise that many dioxins/furans and in general dioxin-like PCB congeners are structurally and toxicologically similar to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. TEFs are used to account for the different potency of dioxins/furans relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, and are available for ten chlorinated dibenzofurans and seven chlorinated dibenzodioxins using the World Health Organization (WHO) methodology.[22]

PCBs – General Occurrence and 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 U.S. in 1977 because of evidence that it could build up in the environment and cause toxic 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 made before PCB use was stopped, old microscope oil, and old hydraulic oil. Prior to 1977, PCBs entered the environment (soil, water, and air) during the manufacture and use of PCBs. Today, although no longer manufactured, 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.[23] Common sources of PCBs include some paints and building materials.

PCBs enter the environment as mixtures of individual components known as congeners. There are 209 structural variations of PCBs, which differ on the number and location of chlorine atoms on the chemical structure. Once in the environment, PCBs do not easily breakdown and can be transferred between air, water, and soil. As a result, PCBs are found worldwide. PCBs stick to soil and sediment and will not usually be carried deep into the soil with rainwater. They do not easily break down in soil and may stay in the soil for months or years. Generally, the more chlorine atoms that the PCBs contain, the more slowly they break down. Evaporation appears to be an important way by which the lighter PCBs leave the soil. As a gas, PCBs can accumulate in the leaves and aboveground parts of plants and food crops. 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 fat tissue. The major dietary source of PCBs is fish. PCBs are also found in meats and dairy products.[23]

Most PCBs commercially produced in the U.S. are made up of 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. Traditionally, PCB analysis has focused on identifying and quantifying Aroclor levels in a sample using Gas Chromatography/Electron Capture Detector (GC/ECD) (EPA Method 8082). This method, which was used at the South Park site, is quick and relatively inexpensive and provides an estimate of the total PCBs as a sum of the Aroclors. The Aroclor is identified by comparison to Aroclor standards. However, when released into the environment Aroclors undergo weathering, which can alter their physical and chemical composition. Weathering can make it difficult to match an environmental sample with an Aroclor pattern, leading to difficulties in identification and quantification of PCBs.[24]

Exposures to these chemicals usually occur from mixtures rather than from individual PCBs. PCBs were analyzed in the soil as total PCBs. PCB congener analysis was not addressed in this investigation, because PCB congener analysis is complex and expensive. Therefore, in the absence of this information DOH focused its evaluation on the results provided by the analytical laboratory for total PCBs, particularly on Aroclor 1260, which was the predominant PCB mixture found at the South Park site.

Our understanding of the adverse human health effects of exposure to PCBs is limited by available animal research and occupational exposure data. Concerns about health effects from PCB exposure arose from studies of wildlife communities that showed reproductive, developmental, endocrine, immunological, and carcinogenic effects.[25,26,23]

If PCBs get into a person's body, the body can change them into other related chemicals called metabolites. Because PCBs bioaccumulate as a person ages, the blood PCB levels tend to increase with age. Some metabolites of PCBs have the potential to be just as harmful as the PCBs to which the person was originally exposed. Some of the metabolites may leave your body in the feces in a few days; others may remain in your body fat for months. Unchanged PCBs may also remain in your body and be stored for years, mainly in the fat and liver, but smaller amounts can be found in other organs as well. PCBs collect in milk fat and can enter the bodies of infants through breast-feeding.[23]

It is difficult to predict how PCBs will affect someone. Different types of PCBs may produce effects by different mechanisms. Amounts that cause serious health problems for some people may have no effect on others. Other factors such as diet, genes, lifestyle, preexisting illness, or exposure to other chemicals can influence how people get sick. Certainly, exposure to the PCB-contaminated soils at the South Park site could potentially increase the health risks of residents that live in this area.

Little is known about the long-term health effects of PCBs in humans, so it is important to keep our exposure to these chemicals as low as possible. Most of what is known about the possible human health risks of PCBs comes from animal studies and accidental human exposures to high levels of these chemicals in the workplace.[12] Health effects have been observed in humans who have been accidentally exposed to high levels of PCBs either by the consumption of contaminated rice oil in Japan and Taiwan, consumption of contaminated fish, or general environmental exposure.[23]

Because the health effects of environmental mixtures of PCBs are difficult to evaluate, most of the information provided in ATSDR's toxicological profile is about seven types of PCB mixtures (i.e., Aroclors) that were commercially produced in the U.S.[23]

Chronic and acute exposure to PCBs has shown to produce a wide array of toxic effects in animals including neurobehavioral, immunological, and developmental deficits in newborns exposed to PCBs in utero.[27,23]

Other toxic effects in humans include:

- Swelling of the upper eyelids
- Numbness in the arms and/or legs
- Weakness
- Discoloring of the nails and the skin
- Muscle spasms

- Chronic bronchitis
- Problems with the nervous system and thyroid metabolism

The PCB levels found at the South Park site are not likely to produce these health effects because levels are below chronic and acute exposures.

Evaluating non-cancer hazards

Exposure assumptions for estimating contaminant doses from soil exposure are found in Appendix B, Table B1. In order to evaluate the potential for non-cancer adverse health effects that may result from exposure to contaminated media (i.e., air, water, soil, and sediment), 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 contaminant under each scenario is then compared to ATSDR Minimal Risk Levels (MRLs). MRLs are an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified duration of exposure. MRLs are based only on non-carcinogenic effects. In the absence of MRLs, DOH uses the EPA's oral reference dose (RfD). RfDs are doses below which non-cancer adverse health effects are expected to occur ("safe" doses). MRLs and/or RfDs are derived from toxic effect levels obtained from human population and laboratory animal studies.

Because of data uncertainty, the toxic effect level is divided by "safety factors" to produce the lower and more protective MRL. If a dose exceeds the MRL, this indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded. If the estimated exposure dose is only slightly above the MRL, then that dose will fall well below the observed toxic effect level. The higher the estimated dose is above the MRL, the closer it will be to the actual observed toxic effect level. This comparison is called a hazard quotient (HQ). See Appendix B for the hazard quotient equation.

These toxic effect levels can be either the lowest-observed adverse effect level (LOAEL) or a 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 hazard quotient is above one, DOH evaluates the contaminant further and compares the estimated dose to the LOAEL and/or NOAEL.

Evaluation for PCBs in street soil and residential yards

Based on exposure estimates quantified in Appendix B, a child (ages 0 to 15 yrs old) or adult is not likely to experience adverse non-cancer health effects if they are exposed to total PCBs in the street soil at the South Park site. A child could potentially receive an exposure dose of 0.000174 mg/kg-day. Although the exposure dose did exceed EPA's oral RfD of 0.00002 mg/kg/day for Aroclor 1254 (Appendix B, Table B2), this dose did not exceed the chronic LOAEL of 0.005 mg/kg/day for PCBs. The estimated dose is 29 times below the LOAEL. This number is based on clinical observations of monkeys exposed to 0.005 – 0.08 mg/kg/day of Aroclor 1254 during the first 37 months of the study. Health effects of decreased antibody response and eyelid and

toe/fingernail changes were observed in female Rhesus monkeys chronically exposed to these levels.[28]

Similarly, child and adult exposures to total PCBs in residential yards are 0.000047 mg/kg/day and 0.0000044 mg/kg/day, respectively, which are below the LOAEL (Appendix B, Table B2). The chronic dose is likely to be much less given the conservative approach of using the maximum environmental values.

Evaluation for dioxins in street soil and residential yards

Based on exposure estimates, a child is not likely to experience adverse non-cancer health effects if they are exposed to dioxins in the street soils from the South Park site. A child could potentially receive an exposure dose of 0.0000014 ug/kg/day. Although the exposure dose did slightly exceed ATSDR's chronic MRL of 0.000001 ug/kg/day for 2,3,7,8-TCDD, this dose did not exceed the chronic LOAEL for dioxins of 0.00012 ug/kg/day (i.e., the estimated dose is 86 times below the LOAEL). This number is based on studies conducted in monkeys exposed to a dietary concentration of 5 ppt of 2,3,7,8-TCDD during 16.2 months of exposure. The authors of the study estimated that the total maternal intake during the 16.2 months of exposure was 59.6 ng/kg (ppt). Behavioral patterns (play behavior, displacement, and self-directed behavior) were observed in the 2,3,7,8-TCDD exposed offspring monkeys.[29]

Similarly, child and adult exposures to dioxins in residential yards (0.00000084 ug/kg/day and 0.000000075 ug/kg/day, respectively) are below the MRL (Appendix B, Table B2). Health effects from exposure to residential soil are not expected. The chronic dose is likely to be much less given the conservative approach of using the maximum environmental values.

Evaluating Cancer Risk

Some chemicals have the ability to cause cancer. Theoretical cancer risk is estimated by calculating a dose similar to that described above 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 low-level exposures. This process involves much uncertainty.

Current regulatory practice assumes there is no "safe dose" of a carcinogen. Any dose of a carcinogen will result in some additional cancer risk. Theoretical cancer risk estimates are, therefore, not yes/no answers but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat 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.[30]

This health consultation report describes theoretical cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight, and no significant increase in theoretical 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 1 cancer case per 10,000 persons exposed over a lifetime. A very low estimate might result in 1 cancer case per 100,000 exposed over a lifetime and a slight estimate would require an exposed population of 1,000,000 to result in a single case. DOH considers theoretical cancer risk insignificant when the estimate results in less than 1 cancer per 1,000,000 exposed over a lifetime. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population.

Theoretical Cancer Risk

Theoretical 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 one quarter to one third (1/4 to 1/3) of people living in the United States will develop cancer at some point in their lives.[31]

Evaluation for dioxins in street soil and residential yards

Exposure doses were calculated for a child and an adult over a year exposure period with 350 days of exposure per year over 30 years in 1 residence at the South Park site. Theoretical cancer risk estimates for exposure to dioxins in street soil due to frequent exposure are 3 excess cancers estimated per 100,000 people exposed (Appendix B, Table B3). Exposure to dioxins in residential yard soil is 1 excess cancer estimated per 100,000 people exposed (Appendix B, Table B3). In general, these theoretical cancer risk estimates are considered very low.

Evaluation for PCBs in street soil and residential yards

Exposures to total PCBs in street soil are 4 excess cancers estimated per 100,000 people exposed (Appendix B, Table B3). Exposures to total PCBs in residential yard soil are 9 excess cancers estimated per 1,000,000 people exposed (Appendix B, Table B3). In general, these theoretical cancer risk estimates range from very low to slight.

The overall potential health risks associated with exposure to dioxins and PCBs in the surface soil at the South Park site are considered very low under most scenarios where the primary

exposure pathway is incidental ingestion through direct exposure to soil. However, the true or actual risk is unknown and could be as low as zero.

Uncertainty of actual risks posed by dioxins in the environment

There is uncertainty about the actual risk posed by low levels of dioxin in the environment. Decisions by environmental and public health agencies about the lowest allowable levels of dioxin in soil are not purely scientific, but involve policy decisions that take this uncertainty into account. Different agencies make different policy choices (e.g., whether to regulate dioxin on the basis of dioxin's non-cancer or cancer effects, the maximum allowable cancer risk posed by dioxin, etc.) that lead to differences in allowable dioxin soil levels. EPA and Ecology regulate dioxin based on cancer risk. The Ecology state soil cleanup standard for unrestricted land use is 11 parts per trillion based on a human health risk level of 1 additional case of cancer per 1,000,000 individuals over the course of a lifetime (though this risk level could be slightly higher than or as low as zero additional cases of cancer). The federal (EPA) cleanup level for dioxin was set at 1000 parts per trillion in residential soils based on a human health risk level of 100 additional cases of cancer per 1,000,000 individuals over the course of a lifetime. EPA is proposing revised dioxin preliminary remediation goals (PRGs) of 72 ppt for residential soil and 950 ppt for industrial soil. EPA's revised PRGs are based on a human health risk level of 1 additional case of cancer for 100,000 individuals over the course of a lifetime, which is within EPA's protective risk range of $1x10^{-4}$ to $1x10^{-6}$.

DOH and ATSDR evaluates the non-cancer health effects as well as cancer endpoints of dioxin to estimate the potential hazards of exposure. DOH assesses the likelihood of outcomes on a population and site-specific basis by evaluating variables such as route, duration, and frequency of exposure.

Children's Health Concerns

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 in adults. The following factors contribute to this vulnerability:

- Children are more likely to play outdoors in contaminated areas by disregarding signs and wandering onto restricted locations.
- Children often bring food into contaminated areas, resulting in hand-to-mouth activities.
- Children are smaller and receive higher doses of contaminant exposures per body weight.
- Children are shorter than adults; therefore, they have a higher possibility of breathing in dust and soil.
- Fetal and child exposure to contaminants can cause permanent damage during critical growth stages.

These unique vulnerabilities of infants and children demand special attention in communities that have contamination of their water, food, soil, or air. 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.

Conclusions

In general, there are uncertainties in evaluating low-level environmental exposures to dioxins and PCBs in surface soil. Thus, the true risk to the public depends on a number of factors such as the chemical sensitivity, concentration of chemicals, ingestion, dermal, and inhalation rates, frequency and duration of exposure, and the genetic susceptibility of an individual. Based on the information provided above, DOH concludes the following:

- Touching, breathing, or accidentally eating soil from streets and yards at the South Park site for approximately 350 days per year over 30 years is not expected to harm people's health. The levels are below those where we would expect to see health effects. Based on exposure assumptions and calculations, PCB and dioxin levels present in the streets and residential yards at the South Park site are below levels known to result in harmful non-cancer health effects.

- Touching, breathing, or accidentally eating soil that contains dioxins and PCBs is not likely to produce harmful cancer health effects for residents during a 30 year lifetime exposure at the South Park site. Based on cancer risk estimates and review of the toxicological literature, PCBs and dioxins in surface soil are considered below levels of health concern. The overall potential health risks associated with exposure to dioxins and PCBs in the surface soil at the South Park site are considered very low under most scenarios where the primary exposure pathway is incidental ingestion through direct exposure to soil. However, the true or actual risk is unknown and could be as low as zero.

Recommendations

1. DOH recommends conducting appropriate public health activities such as health education for the residents of the South Park site affected by levels of contaminants in residential yards and streets until cleanup has been completed.

2. DOH recommends as a prudent public health practice to follow general advice on ways people can minimize exposure to contaminants in surface soil at the South Park site.

General Advice

Ways to Minimize Exposure to PCBs and Dioxins in Soils from the South Park site

Exposure to contaminants present in surface soil at the South Park site can be reduced if children and adults follow the safety guidelines below.

- Wash your hands and face after playing or working outside, especially before eating
- Use a scrub brush to clean dirt from under your nails
- Use plenty of soap and water
- Wash heavily soiled clothing separately
- Wash children's toys, bedding, and pacifiers frequently
- Prevent children from eating dirt

Mop, dust, and vacuum

- Wash anything that has come in contact with soils before entering your home
- Implement regular damp mopping to avoid breathing indoor house dust
- Vacuum carpets and rugs frequently [i] and dust all other surfaces in your home with a wet rag
- Remove shoes before entering your home to avoid tracking soil into your house

Keep pets clean

- Wipe down pets before you let them inside
- Brush and bathe them regularly
- Restrict your pets to areas of your home that are free from carpeting and upholstery. Give pets their own sleeping spots

Eat a healthy diet

- Eat healthy. Foods that contain the daily recommended amounts of nutrients (e.g., calcium, iron, non-fat protein, etc.) can help you to protect against disease

Public Health Action Plan

Actions Planned

1. DOH will coordinate with staff from the City of Seattle, the EPA, and Seattle and King County Public Health (KCPH) Department to develop education materials.

[i] You may consider using a vacuum that has a hepa filter.

a. DOH is in the process of developing a fact sheet for the general public. This fact sheet has been sent out for review and comments. DOH expects to have a final report by July 2010.

b. On May 6, 2010, DOH staff commented on Seattle's KCPH and EPA's general fact sheet on dioxins and PCBs.

c. Copies of a general fact sheet were distributed at a community meeting on June 17, 2010.

2. DOH will provide copies of this health consultation to Ecology, EPA, stakeholders, and other concerned parties.
   a. Final copies will be distributed in the summer of 2010 when the final report is approved.

3. DOH will coordinate with Ecology and EPA on public health action plans and next steps.
   a. DOH staff participated in a community meeting in South Park on June 17, 2010.

Author
Elmer Diaz
Washington State Department of Health
Office of Environmental Health, Safety, and Toxicology
Site Assessment Section

Designated Reviewer

Dan Alexanian, Manager
Site Assessment Section
Office of Environmental Health, Safety, and Toxicology
Washington State Department of Health

ATSDR Technical Project Officer

Audra Henry
Cooperative Agreement and Program Evaluation Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Figures

Figure 1: Site overview map of Early Action Area, South Park soil site, South Seattle, King County, Washington.

Figure 2: Soil sample types and locations at South Park site, 2008 and 2009, South Seattle, King County, Washington.

Figure 3. Dioxin TEQ concentrations in dry weight (ng/kg) in surface soil (0.0 – 0.5 feet) in residential yards and streets, 2009, South Park site, King County, Seattle, Washington.

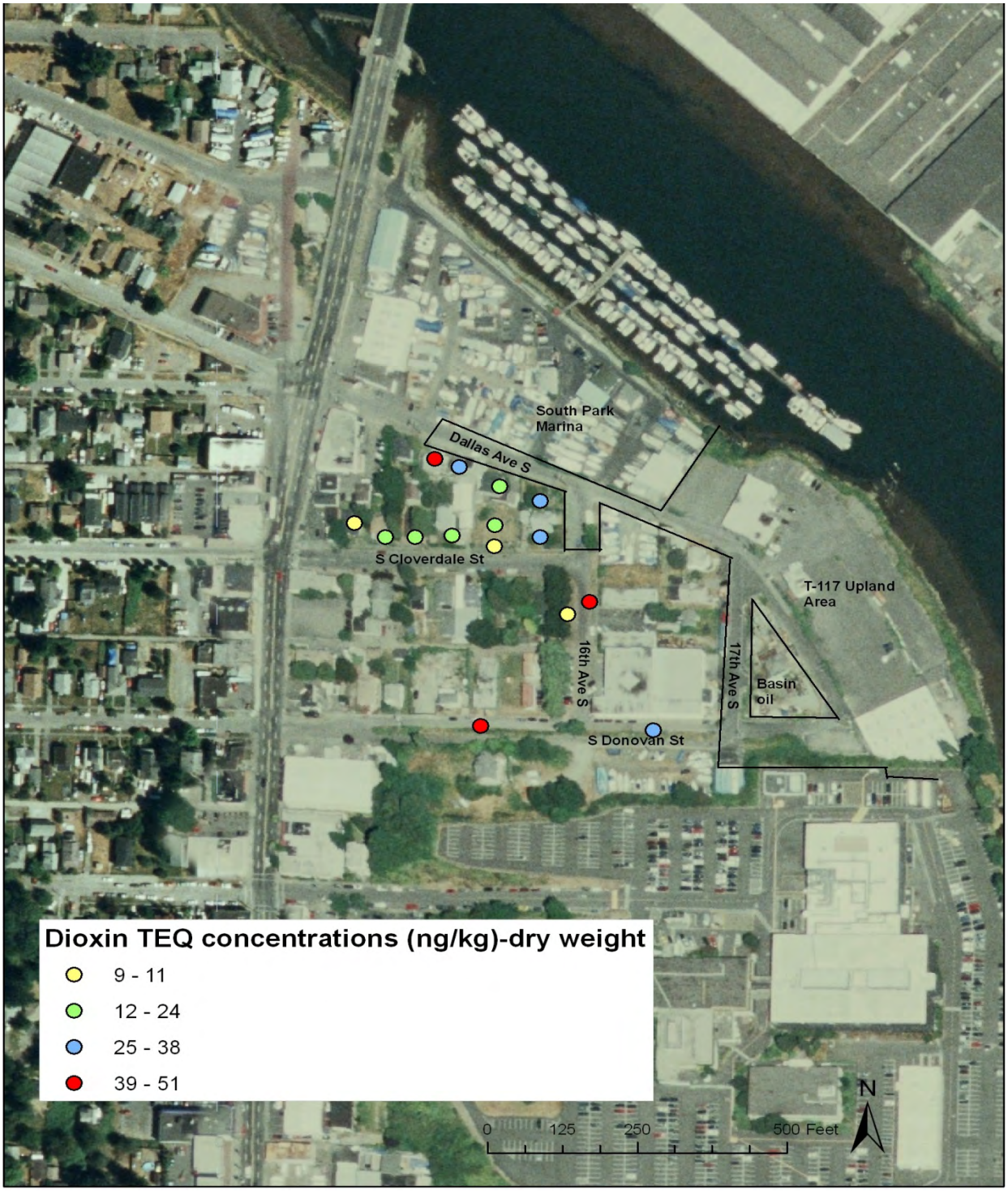

Figure 4. Total PCB concentrations in dry weight (ppm) in surface soil (0.0 – 0.5 feet) in residential yards and street soils, South Park site, 2009, Seattle, King County, Washington.

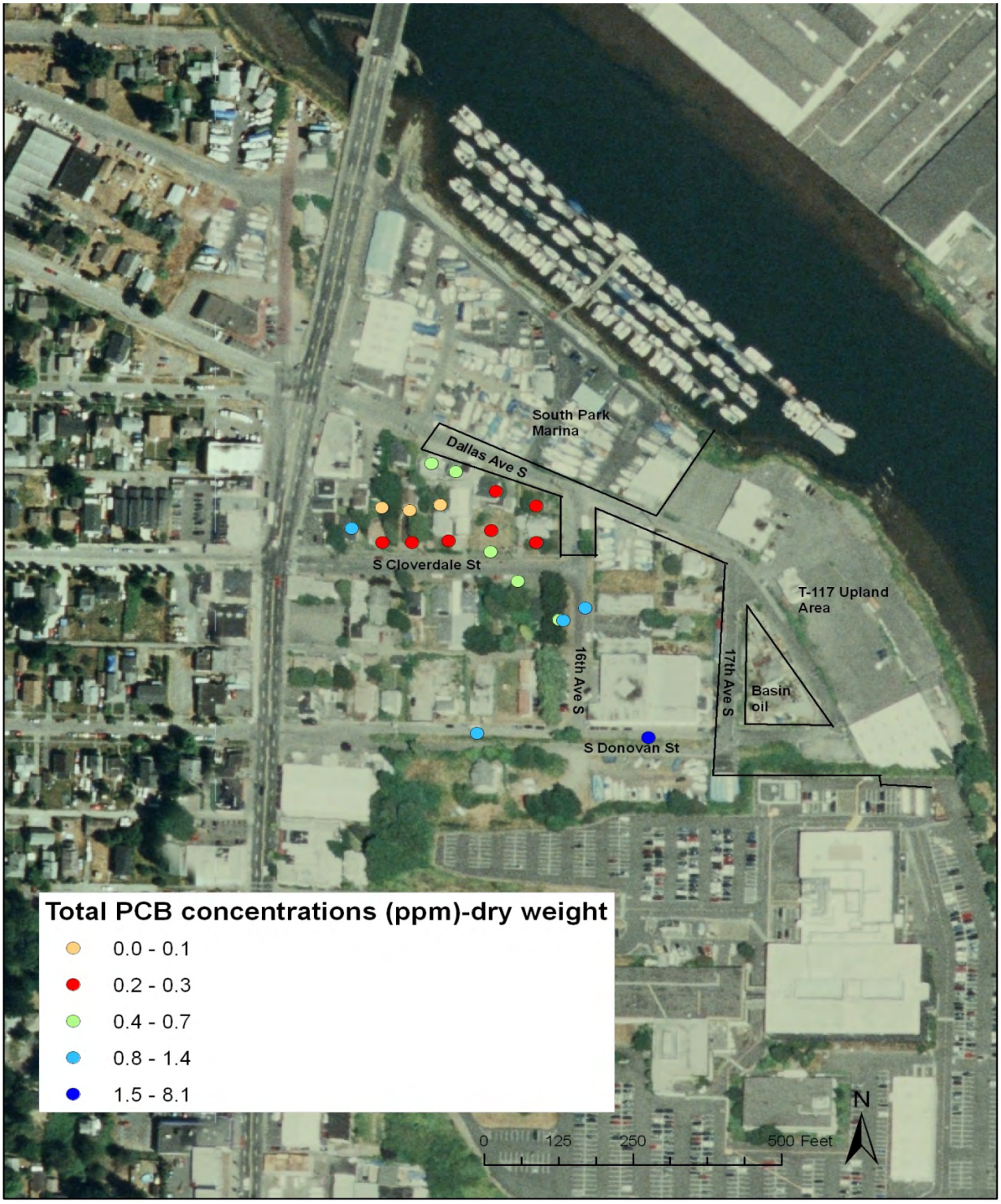

Figure 5. Dioxin TEQ concentrations in dry weight (ng/kg) in surface soil (0.1 – 1 feet) at the streets, South Park site, 2008, Seattle, King County, Washington.

Appendix A

Dioxin and furans abbreviations

HpCDD - heptachlorodibenzo-*p* -dioxin
HpCDF - heptachlorodibenzofuran
HxCDD - hexachlorodibenzo-*p* -dioxin
HxCDF – hexachlorodibenzofuran
OCDF - octachlorodibenzofuran
PCDD - polychlorinated dibenzo-*p* -dioxin
PCDF - polychlorinated dibenzofuran
PeCDD - pentachlorodibenzo-*p* -dioxin
PeCDF - pentachlorodibenzofuran
TCDD - tetrachlorodibenzo-*p* -dioxin
TCDF - tetrachlorodibenzofuran
OCDD - octachlorodibenzo-*p* -dioxin

Table A1. Surface soil dioxin/furan congeners at South Park site, South Seattle, King County, Washington.

Congener	DU 01 TEQ (pg/g) (0.0 – 0.2 ft)	DU 01 TEQ (pg/g) (0.2 – 0.5 ft)	DU 02 TEQ (pg/g) (0.0 – 0.2 ft)	DU 02 TEQ (pg/g) (0.2 – 0.5 ft)	DU 03 TEQ (pg/g) (0.0 – 0.2 ft)	DU 03 TEQ (pg/g) (0.2 – 0.5 ft)
2,3,7,8-TCDD	7.1	0 Q	1.6	5.5	0.72	1.3
1,2,3,7,8-PeCDD	8.6	9.1	6.5	5.5	2.1	3.4
1,2,3,4,7,8-HxCDD	0.83	0.81	0.65	0.54	0.21	0.39
1,2,3,6,7,8-HxCDD	4.6 B	1.9 B	1.8 B	1.8 B	0.79 B	1.1 B
1,2,3,7,8,9-HxCDD	2.3 B	1.6 B	1.2 B	1.4 B	0.48 B	0.91 B
1,2,3,4,6,7,8-HpCDD	10 EB	3.2 B	3.1 B	3.3 B	1.5 B	2.1 B
OCDD	3.0 EGB	0.78 EGB	0.75 EGB	0.78 EB	0.39 EB	0.51 EB
2,3,7,8-TCDF	1.5 CON B	1.6 CON B	1.3 G CON B	1.1 CON B	0.36 CON B	0.84 CON B
1,2,3,7,8-PeCDF	0.26 B	0.33 B	0.2 B	0.18 B	0.057 B	0.10 B

2,3,4,7,8-PeCDF	4.8	7.5	6.0	3.3	1.0	2.1
1,2,3,4,7,8-HxCDF	1.9 B	2.1 B	1.7 B	1.1 B	0.34 B	1.0 B
1,2,3,6,7,8-HxCDF	1.6 B	2.9 B	2.2 B	0.95 B	0.35 B	0.71 B
2,3,4,6,7,8-HxCDF	1.8 B	3.5 B	2.5 B	1.0 B	0.35 B	0.55 B
1,2,3,7,8,9-HxCDF	0.06 JB	0.047 JB	0.026 JB	0.048 JB	0.015 JB	0.018 JB
1,2,3,4,6,7,8-HpCDF	1.6 B	1.2 B	1.0 B	0.75 B	0.34 B	0.54 B
1,2,3,4,7,8,9-HpCDF	0.088 B	0.067 B	0.056 B	0.046 B	0.022 B	0.036 B
OCDF	0.1	0.048 B	0.048 B	0.048 B	0.025 B	0.03
Total TEQ	**50**	**37**	**31**	**27**	**9.0**	**16**

B Indicates the associated analyte that is found in the method blank, as well as in the sample
J Indicates an estimated value – used when the analyte concentration is below the method-reporting limit (MRL) and above the estimated detection limit (EDL).
E Estimated result; result concentration exceeds the calibration range
G Elevated reporting limit. The reporting limit is elevated due to matrix interference
CON – Confirmation analysis
DU = discrete unit
pg/g = picograms per gram
TEQ = toxic equivalent

Table A2. Surface soil dioxin/furan congeners at South Park site, South Seattle, King County, Washington.

Congener	DU 03 DUP TEQ (pg/g) (0.2 – 0.5 ft)	DU 05 TEQ (pg/g) (0.0 – 0.2 ft)	DU 05 TEQ (pg/g) (0.2 – 0.5 ft)	DU 07 TEQ (pg/g) (0.0 – 0.2 ft)	DU 07 TEQ (pg/g) (0.2 – 0.5 ft)	DU 09 TEQ (pg/g) (0.0 – 0.2 ft)
2,3,7,8-TCDD	0.95	1.7 B	2.2	4.9	5.9	3.2
1,2,3,7,8-PeCDD	2.3	5.6	5.2	4.6	4.3	3.6
1,2,3,4,7,8-HxCDD	0.28	0.65	0.56	0.6 B	0.48 B	0.35
1,2,3,6,7,8-HxCDD	0.78 B	1.7 B	1.4	2.0 B	1.1 B	1.4 B
1,2,3,7,8,9-HxCDD	0.58 B	1.5 B	1.5	0.96 B	0.8 B	0.99 B
1,2,3,4,6,7,8-HpCDD	1.5 B	3.4 B	3.0 B	3.4 B	2.2 B	2.4 B
OCDD	0.36 EB	0.78 EGB	0.57 EB	0.75 EB	0.48 EB	0.54 EB
2,3,7,8-TCDF	0.6 CON B	1.1 G CON B	1.2 CON B	0.78 CON B	0.86 CON B	0.7 CON B
1,2,3,7,8-PeCDF	0.081 B	0.17 B	**0.18 B**	0.14 B	0.14 B	0.12 B
2,3,4,7,8-PeCDF	1.6	2.8	3.0 B	2.1	2.2	1.8
1,2,3,4,7,8-HxCDF	0.81 B	1.4 B	1.3 B	0.66 B	0.63 B	0.72 B
1,2,3,6,7,8-HxCDF	0.52 B	0.98 B	0.9 B	0.61 B	0.52 B	0.48 B
2,3,4,6,7,8-HxCDF	0.40 B	0.82 B	0.8 B	0.58 B	0.54 B	0.51 B
1,2,3,7,8,9-HxCDF	0.022 JB	0.025 JB	0.028 JQB	0.03 JB	0.035 JB	0.0 JQB
1,2,3,4,6,7,8-HpCDF	0.37 B	1.1 B	1.2 B	0.54 B	0.41 B	0.47 B
1,2,3,4,7,8,9-HpCDF	0.026 B	0.065 B	0.053 B	0.033 B	0.028 B	0.029 B
OCDF	0.023 B	0.084 B	0.066 B	0.029 B	0.022 B	0.025 B
Total TEQ	**11**	**24**	**23**	**23**	**21**	**17**

B Indicates the associated analyte that is found in the method blank, as well as in the sample
J Indicates an estimated value – used when the analyte concentration is below the method-reporting limit (MRL) and above the estimated detection limit (EDL).
E Estimated result; result concentration exceeds the calibration range
G Elevated reporting limit. The reporting limit is elevated due to matrix interference
Q Estimated maximum possible concentration
CON – Confirmation analysis
DU = discrete unit
pg/g = picograms per gram
TEQ = toxic equivalent

Table A3. Surface soil dioxin/furan congeners at South Park site, South Seattle, King County, Washington.

Congener	DU 10 TEQ (pg/g) (0.0 – 0.2 ft)	DU 10 TEQ (pg/g) (0.2 – 0.5 ft)	DU 11 TEQ (pg/g) (0.0 – 0.2 ft)	DU 11 TEQ (pg/g) (0.2 – 0.5 ft)	DU 12 TEQ (pg/g) (0.0 – 0.2 ft)	DU 12 TEQ (pg/g) (0.2 – 0.5 ft)
2,3,7,8-TCDD	1.7	1.4	1.3	0.91	0.8	0.76
1,2,3,7,8-PeCDD	5.2	4.4	5.4	4.5	2.7	3.0
1,2,3,4,7,8-HxCDD	0.5 B	0.42 B	0.5	0.37 B	0.28 B	0.32 B
1,2,3,6,7,8-HxCDD	1.2 B	1.0 B	1.2 B	0.91 B	0.69 B	0.78 B
1,2,3,7,8,9-HxCDD	0.74 B	0.71 B	1.1	0.61 B	0.44 B	0.46 B
1,2,3,4,6,7,8-HpCDD	2.1 B	1.6 B	1.8 B	1.3 B	1.4 B	1.5 B
OCDD	0.48 EB	0.36 EB	0.33 EB	0.28 EB	0.36 EB	0.3 EB
2,3,7,8-TCDF	1.2 CON B	1.1 CON B	1.4 CON B	1.0 CON B	0.71 CON B	0.72 CON B
1,2,3,7,8-PeCDF	0.2 B	0.17 B	0.24 B	0.19 B	0.11 B	0.11 B
2,3,4,7,8-PeCDF	3.6	3.0	4.5 B	3.3	1.9	2.0
1,2,3,4,7,8-HxCDF	1.0 B	0.82 B	1.4 B	0.97 B	0.51 B	0.51 B
1,2,3,6,7,8-HxCDF	1.1 B	0.88 B	1.3 B	0.92 B	0.43 B	0.47 B
2,3,4,6,7,8-HxCDF	1.2 B	1.0 B	1.4 B	0.93 B	0.45 B	0.55 B
1,2,3,7,8,9-HxCDF	0.0 JQB	0.034 JB	0.062 JB	0.051 JB	0.019 JB	0.0 JQB
1,2,3,4,6,7,8-HpCDF	1.8 B	0.89 B	0.93 B	0.64 B	0.39 B	0.46 B
1,2,3,4,7,8,9-HpCDF	0.043 B	0.036 B	0.074 B	0.029 B	0.025 B	0.073 B
OCDF	0.051 B	0.029 B	0.039 B	0.033 B	0.028 B	0.03 B
Total TEQ	**22**	**18**	**23**	**17**	**11**	**12**

B Indicates the associated analyte that is found in the method blank, as well as in the sample
J Indicates an estimated value – used when the analyte concentration is below the method-reporting limit (MRL) and above the estimated detection limit (EDL).
E Estimated result; result concentration exceeds the calibration range
G Elevated reporting limit. The reporting limit is elevated due to matrix interference
Q Estimated maximum possible concentration
CON – Confirmation analysis
DU = discrete unit
pg/g = picograms per gram
TEQ = toxic equivalent

Table A4. Surface soil dioxin/furan congeners at South Park site, South Seattle, King County, Washington.

Congener	DU 13 TEQ (pg/g) (0.0 – 0.2 ft)	DU 13 TEQ (pg/g) (0.2 – 0.5 ft)	DU 14 TEQ (pg/g) (0.0 – 0.2 ft)	DU 16 TEQ (pg/g) (0.0 – 0.2 ft)	DU 16 TEQ (pg/g) (0.2 – 0.5 ft)	DU 17 TEQ (pg/g) (0.0 – 0.2 ft)
2,3,7,8-TCDD	2.9	2.0	4.5	0.51 Q	0.68	1.9
1,2,3,7,8-PeCDD	5.1	5.8	6.4	1.9	2.7	7.6
1,2,3,4,7,8-HxCDD	0.57	0.64 B	0.75	0.24	0.35	0.96
1,2,3,6,7,8-HxCDD	1.5	1.5 B	1.8	0.68	1.1	5.1
1,2,3,7,8,9-HxCDD	0.9	1.1 B	1.7	0.56	0.76	2.2
1,2,3,4,6,7,8-HpCDD	3.7 EB	2.9 B	3.7 B	1.7 B	3.2 B	10.0 EB
OCDD	0.81 EB	0.57 EB	0.75 EB	0.42 EB	1.0 EB	2.4 EB
2,3,7,8-TCDF	1.1 CON B	0.91 CON B	1.1 CON B	0.39 G CON B	0.6 B CON	0.91 B CON
1,2,3,7,8-PeCDF	0.24 B	0.27 B	0.21 B	0.069 B	0.087 B	0.25 B
2,3,4,7,8-PeCDF	3.9 B	4.5	3.6 B	1.3 B	1.7 B	4.5 B
1,2,3,4,7,8-HxCDF	1.6 B	2.6 B	1.9 B	0.59 B	0.81 B	2.7 B
1,2,3,6,7,8-HxCDF	1.3 B	1.7 B	1.2 B	0.38 B	0.54 B	1.7 B
2,3,4,6,7,8-HxCDF	1.5 B	2.2 B	1.3 B	0.33 B	0.51 B	1.4 B
1,2,3,7,8,9-HxCDF	0.067 JB	0.11 B	0.052 JB	0.02 JQB	0.015 JB	0.068 JB
1,2,3,4,6,7,8-HpCDF	1.4 B	1.2 B	1.3 B	0.41 B	0.81 B	1.9 B
1,2,3,4,7,8,9-HpCDF	0.086 B	0.094 B	0.081 B	0.03 B	0.049 B	0.096 B
OCDF	0.048 B	0.042 B	0.054 B	0.03 B	0.09 B	0.054 B
Total TEQ	**27**	**28**	**30**	**9.6**	**15**	**44**

B Indicates the associated analyte that is found in the method blank, as well as in the sample
J Indicates an estimated value – used when the analyte concentration is below the method-reporting limit (MRL) and above the estimated detection limit (EDL).
E Estimated result; result concentration exceeds the calibration range
G Elevated reporting limit. The reporting limit is elevated due to matrix interference
Q Estimated maximum possible concentration
CON – Confirmation analysis
DU = discrete unit
pg/g = picograms per gram
TEQ = toxic equivalent

Table A5. Surface soil dioxin/furan congeners at South Park site, South Seattle, King County, Washington.

Congener	DU 17 TEQ (pg/g) (0.2 – 0.5 ft)	DU 18 TEQ (pg/g) (0.0 – 0.2 ft)	DU 18 TEQ (pg/g) (0.2 – 0.5 ft)	DU 19 TEQ (pg/g) (0.0 – 0.2 ft)	DU 19 TEQ (pg/g) (0.2 – 0.5 ft)	DU 19 DUP TEQ (pg/g) (0.2 – 0.5 ft)
2,3,7,8-TCDD	1.4 B	2.2	1.6 B	1.9 B	2.4 B	1.7 B
1,2,3,7,8-PeCDD	4.0	8.0	6.5	10.0	11	8.0
1,2,3,4,7,8-HxCDD	0.48	1.2	0.89	1.1	0.91	0.78
1,2,3,6,7,8-HxCDD	2.2 B	7.6	3.8 B	3.3 B	4.0 B	2.9 B
1,2,3,7,8,9-HxCDD	1.2 B	3.2	1.9 B	2.4 B	2.0 B	1.5 B
1,2,3,4,6,7,8-HpCDD	4.2 EB	14 DB	6.1 DB	5.9 EB	4.5 EB	3.6 EB
OCDD	1.1 EGB	3.3 DB	1.3 DB	1.2 EB	0.9 EB	0.78 EB
2,3,7,8-TCDF	0.56 CON B	1.2 CON B	0.92 CON B	1.2 CON GB	1.3 G CON B	0.92 CON B
1,2,3,7,8-PeCDF	0.12 B	0.22 B	0.17 B	0.17 B	0.2 B	0.14 B
2,3,4,7,8-PeCDF	2.2	3.9 B	3.0	4.8	5.1	3.9
1,2,3,4,7,8-HxCDF	1.2 B	2.0 B	1.4 B	2.1 B	2.7 B	2.2 B
1,2,3,6,7,8-HxCDF	0.77 B	1.3 B	1.0 B	1.2 B	1.3 B	0.98 B
2,3,4,6,7,8-HxCDF	0.68 B	1.1 B	0.85 B	1.0 B	0.96 B	0.7 B
1,2,3,7,8,9-HxCDF	0.04 JB	0.049 QJB	0.039 JB	0.028 JB	0.045 JB	0.032 JB
1,2,3,4,6,7,8-HpCDF	1.1 B	1.5 B	0.83 B	1.1B	1.2 B	0.84 B
1,2,3,4,7,8,9-HpCDF	0.053 B	0.11 B	0.067 B	0.12 B	0.17 B	0.13 B
OCDF	0.045 B	0.12 DB	0.057 DB	0.072 B	0.078 B	0.054
Total TEQ	**21**	**51.0**	**30.4**	**37.6**	**38.8**	**29.2**

B Indicates the associated analyte that is found in the method blank, as well as in the sample
J Indicates an estimated value – used when the analyte concentration is below the method-reporting limit (MRL) and above the estimated detection limit (EDL).
E Estimated result; result concentration exceeds the calibration range
G Elevated reporting limit. The reporting limit is elevated due to matrix interference
Q Estimated maximum possible concentration
D Result was obtained from the analysis of a dilution
CON – Confirmation analysis
DU = discrete unit
pg/g = picograms per gram.
TEQ = toxic equivalent

Table A6. Surface soil dioxin/furan congeners at South Park site, South Seattle, King County, Washington.

Congener	DU 64 TEQ (pg/g) (0.0 – 0.2 ft)	DU 74 TEQ (pg/g) (0.0 – 0.2 ft)	DU 74 TEQ (pg/g) (0.2 – 0.5 ft)
2,3,7,8-TCDD	3.4	2.4	1.5
1,2,3,7,8-PeCDD	5.9	6.0	3.9
1,2,3,4,7,8-HxCDD	0.76	0.8	0.42 B
1,2,3,6,7,8-HxCDD	1.9	2.1	0.94 B
1,2,3,7,8,9-HxCDD	1.3	1.7	0.76 B
1,2,3,4,6,7,8-HpCDD	3.6 EB	4.0 EB	1.8 B
OCDD	0.84 EB	0.87 EB	0.42 EB
2,3,7,8-TCDF	1.1 CON B	1.3 CON B	0.6 CON B
1,2,3,7,8-PeCDF	0.21 B	0.24 B	0.12 B
2,3,4,7,8-PeCDF	3.9 B	4.5 B	2.1
1,2,3,4,7,8-HxCDF	2.2 B	2.6 B	0.86 B
1,2,3,6,7,8-HxCDF	1.3 B	1.5 B	0.64 B
2,3,4,6,7,8-HxCDF	1.5 B	1.7 B	0.71 B
1,2,3,7,8,9-HxCDF	0.072 JB	0.078 JB	0.029 JB
1,2,3,4,6,7,8-HpCDF	1.3 B	1.5 B	0.63 B
1,2,3,4,7,8,9-HpCDF	0.086 B	0.1 B	0.034 B
OCDF	0.063 B	0.069 B	0.033 B
Total TEQ	**29**	**31**	**15**

B Indicates the associated analyte that is found in the method blank, as well as in the sample
J Indicates an estimated value – used when the analyte concentration is below the method-reporting limit (MRL) and above the estimated detection limit (EDL).
E Estimated result; result concentration exceeds the calibration range
CON – Confirmation analysis
DU = discrete unit
pg/g = picograms per gram
TEQ = toxic equivalent

Table A7. Summary of total dioxin concentrations in surface soils sampled at residential yards at the South Park site in May 2009, South Seattle, King County, Washington.

SAMPLE LOCATION	SAMPLE ID	APPROXIMATE SAMPLE INTERVAL (ft bgs)	TOTAL Dioxin TEQ (ppt dry wgt)	MTCA Method B Cleanup level (ppt)
MIS Yard Samples				
DU01	DU01-0.0-0.2	0.0-0.2	50.0	
	DU01-0.2-0.5	0.2-0.5	38.0	
DU02	DU02-0.0-0.2	0.0-0.2	31.0	
	DU02-0.2-0.5	0.2-0.5	27.0	
DU03	DU03-0.0-0.2	0.0-0.2	9.0	
	DU03-0.0-0.2	0.0-0.2	NA	
	DU03-0.2-0.5	0.2-0.5	16.0	
Lab Duplicate	DU03-0.2-0.5	0.2-0.5	11.0	
DU04	DU04-0.0-0.2	0.0-0.2	NA	
	DU04-0.2-0.5	0.2-0.5	NA	
DU05	DU05-0.0-0.2	0.0-0.2	24.0	
	DU05-0.2-0.5	0.2-0.5	23.0	
DU06	DU06-0.0-0.2	0.0-0.2	NA	
	DU06-0.2-0.5	0.2-0.5	NA	
DU07	DU07-0.0-0.2	0.0-0.2	23.0	
	DU07-0.2-0.5	0.2-0.5	21.0	11.0
DU08	DU08-0.0-0.2	0.0-0.2	NA	
	DU08-0.2-0.5	0.2-0.5	NA	
DU09	DU09-0.0-0.2	0.0-0.2	17.0	
	DU09-0.2-0.5	0.2-0.5	NA	
DU10	DU10-0.0-0.2	0.0-0.2	22.0	
	DU10-0.2-0.5	0.2-0.5	18.0	
DU11	DU11-0.0-0.2	0.0-0.2	23.0	
	DU11-0.0-0.2	0.0-0.2	NA	
	DU11-0.2-0.5	0.2-0.5	17.0	
	DU11-0.2-0.5	0.2-0.5	NA	
DU12	DU12-0.0-0.2	0.0-0.2	11.0	
	DU12-0.2-0.5	0.2-0.5	12.0	
DU13	DU13-0.0-0.2	0.0-0.2	27.0	
	DU13-0.2-0.5	0.2-0.5	28.0	
DU14	DU14-0.0-0.2	0.0-0.2	30.0	
	DU14-0.2-0.5	0.2-0.5	NA	
MIS field replicate	DU64-0.0-0.2	0.0-0.2	29.0	
MIS field replicate	DU64-0.2-0.5	0.2-0.5	NA	
MIS field replicate	DU74-0.0-0.2	0.0-0.2	31.0	
MIS field replicate	DU74-0.2-0.5	0.2-0.5	15.0	
DU16	DU16-0.0-0.2	0.0-0.2	9.6	
	DU16-0.2-0.5	0.2-0.5	15.0	
DU17	DU17-0.0-0.2	0.0-0.2	44.0	
	DU17-0.2-0.5	0.2-0.5	21.0	
DU18	DU18-0.0-0.2	0.0-0.2	51.0	

	DU18-0.2-0.5	0.2-0.5	30.0	11.0 *
DU19	DU19-0.0-0.2	0.0-0.2	38.0	
	DU19-0.2-0.5	0.2-0.5	39.0	
	DU19-0.0-0.2	0.0-0.2	NA	
	DU19-0.2-0.5	0.2-0.5	29.0	

Toxic equivalents (TEQs) were calculated using the mammalian dioxin and furan Toxic Equivalent Factors (TEFs) from Van den Berg et al. (2006) and one-half the reporting limit (RL) for undetected congeners [32]
MIS – Multi-incremental sampling
Bgs – below ground surface
Ft – feet
DU – discrete unit
LDUP – laboratory MIS processing duplicate sample
NA – not available
ppt dry wgt – parts per trillion dry weight
***** MTCA Method B Cleanup level

Table A8. Summary of total dioxin concentrations in surface soils sampled for streets and residential yards at the South Park Site in August 2008, South Seattle, King County, Washington.

SAMPLE LOCATION (Streets)	SAMPLE ID	APPROXIMATE SAMPLE INTERVAL (ft bgs)	TOTAL Dioxin TEQ (ppt dry wgt)	MTCA Method B Cleanup level (ppt)
Streets				11.0
HA1	HA1	0.0 – 1.0	11.5 J	
P100	P100	0.4 – 1.0	30 J	
P 88	P88	0.2 – 1.0	11.4 J	
P89	P89	0.3 – 1.0	15.9 J	
P90	P90	0.4 – 1.0	21.4 J	
P91	P91	0.2 – 1.0	12.2 J	
P92	P92	0.2 – 1.0	4.53 J	
P93	P93	0.2 – 1.0	7.3 J	
P94	P94	0.1 – 1.0	84.0 J	
P95	P95	0.1 – 1.0	32.4 J	
P96	P96	0.4 – 1.0	3.65 J	
P97	P97	0.1 – 1.0	4.91 J	
P98	P98	0.3 – 1.0	1.79 J	
P99	P99	0.3 – 1.0	0.495 J	

Toxic equivalents (TEQs) were calculated using the mammalian dioxin and furan Toxic Equivalent Factors (TEFs) from Van den Berg et al. (2006) and one-half the reporting limit (RL) for undetected congeners. [32]
ft bgs – feet below ground surface
dw – dry weight
J – estimated value
ppt – parts per trillion

SAMPLE LOCATION (Yards)	SAMPLE ID	APPROXIMATE SAMPLE INTERVAL (ft bgs)	TOTAL Dioxin TEQ (ppt dry wgt)	MTCA Method B Cleanup level (ppt)
YC02	YC02	0 – 0.5	27.1 J	11.0
YC03	YC03	0 – 0.5	50.0 J	
YC04	YC04	0 – 0.5	22.0 J	
YC05	YC05	0 – 0.5	12.4 J	
YC06	YC06	0 – 0.5	18.6 J	
YC07	YC07	0 – 0.5	27.9 J	
YC08 **	YC08a YC08 b YC09=8c YC08	0.2 – 0.5 0.2 – 0.5 0.1 – 0.5 0 – 0.5	2.4 J 14.4 J 21.6 J 395 J	
YC09	YC09	0 – 0.5	12.5 J	
YC10	YC10	0 – 0.5	15.6 J	
YC11	YC11	0 – 0.5	6.32 J	
YC12	YC12	0 – 0.5	16.0 J	
YC13	YC13	0 – 0.5	11.5 J	
YC14	YC14	0 – 0.5	13.4 J	
YC15	YC15	0 – 0.5	8.63 J	
YC16	YC16	0 – 0.5	4.69 J	
YC17	YC17	0 – 0.5	6.42 J	
YC18	YC18	0 – 0.5	6.6 J	
YC19	YC19	0 – 0.5	11.8 J	
YC20	YC20	0 – 0.5	7.88 J	

Toxic equivalents (TEQs) were calculated using the mammalian dioxin and furan Toxic Equivalent Factors (TEFs) from Van den Berg et al. (2006) and one-half the reporting limit (RL) for undetected congeners. [32]
ft bgs – feet below ground surface
dw – dry weight
J – estimated value
***** The 2008 data was not used for analysis in the residential yards. Instead, 2009 data was used for this analysis
****** This sample was a composite of three individual samples. The City analyzed the three individual samples that made up this composite and results ranged from 1.8 to 21.6 ppt. The value of 395 ppt was never confirmed

Table A9. Summary of surface soil detected Aroclors and total PCB Aroclor concentrations for residential yards at the South Park Site, sampled in April 2009, South Seattle, King County, Washington.

Sample Location	Sample ID	Approximate Sample Interval (ft bgs)	Detected Aroclors Aroclor 1221 (ppm dry wgt)	Detected Aroclor Aroclor 1254 (ppm dry wgt)	Detected Aroclors Aroclor 1260 (ppm dry wgt)	Preliminary Total PCB Aroclors (ppm dry wgt)
MIS Yard Samples						
DU01	DU01-0.0-0.2	0.0-0.2	ND	ND	0.740	0.740
	DU01-0.2-0.5	0.2-0.5	ND	ND	0.430	0.430
DU02	DU02-0.0-0.2	0.0-0.2	ND	ND	0.480	0.480
	DU02-0.2-0.5	0.2-0.5	ND	ND	0.340	0.340
DU03	DU03-0.0-0.2	0.0-0.2	ND	0.098	0.085	0.183
(LDUP)	DU03-0.0-0.2	0.0-0.2	ND	0.140	0.090	0.230
	DU03-0.2-0.5	0.2-0.5	ND	0.990	ND	0.990
(LDUP)	DU03-0.2-0.5	0.2-0.5	ND	0.890	ND	0.890
DU04	DU04-0.0-0.2	0.0-0.2	ND	ND	0.130	0.130
	DU04-0.2-0.5	0.2-0.5	ND	ND	0.100	0.100
DU05	DU05-0.0-0.2	0.0-0.2	ND	ND	0.200	0.200
	DU05-0.2-0.5	0.2-0.5	ND	ND	0.160	0.160
DU06	DU06-0.0-0.2	0.0-0.2	ND	ND	0.054	0.054
	DU06-0.2-0.5	0.2-0.5	ND	ND	0.078	0.078
DU07	DU07-0.0-0.2	0.0-0.2	ND	ND	0.160	0.160
	DU07-0.2-0.5	0.2-0.5	ND	ND	0.180	0.180
DU08	DU08-0.0-0.2	0.0-0.2	ND	ND	0.053	0.053
	DU08-0.2-0.5	0.2-0.5	ND	ND	0.048	0.048
DU09	DU09-0.0-0.2	0.0-0.2	ND	ND	0.140	0.140
	DU09-0.2-0.5	0.2-0.5	ND	ND	0.160	0.160
DU10	DU10-0.0-0.2	0.0-0.2	ND	ND	0.380	0.380
	DU10-0.2-0.5	0.2-0.5	ND	ND	0.220	0.220
DU11	DU11-0.0-0.2	0.0-0.2	ND	ND	0.140	0.140
(LDUP)	DU11-0.0-0.2	0.0-0.2	ND	ND	0.140	0.140
	DU11-0.2-0.5	0.2-0.5	ND	ND	0.160	0.160

(LDUP)	DU11-0.2-0.5	0.2-0.5	ND	ND	0.140	0.140
DU12	DU12-0.0-0.2	0.0-0.2	ND	ND	0.370	0.370
	DU12-0.2-0.5	0.2-0.5	ND	ND	0.360	0.360
DU13	DU13-0.0-0.2	0.0-0.2	ND	ND	0.390	0.390
	DU13-0.2-0.5	0.2-0.5	ND	ND	0.300	0.300
DU14	DU14-0.0-0.2	0.0-0.2	ND	ND	0.730	0.730
	DU14-0.2-0.5	0.2-0.5	ND	ND	0.170	0.170
MIS field replicate	DU64-0.0-0.2	0.0-0.2	ND	ND	0.910	0.910
MIS field replicate	DU64-0.2-0.5	0.2-0.5	ND	ND	0.180	0.180
MIS field replicate	DU74-0.0-0.2	0.0-0.2	ND	ND	**1.20**	**1.20**
MIS field replicate	DU74-0.2-0.5	0.2-0.5	ND	ND	0.190	0.190
Discrete Parking Strip Sample						
YS100	YS01-0.0-0.5	0.0-0.5	ND	ND	**1.40**	**1.40**
	YS01-0.5-1.0	0.5-1.0	ND	ND	0.330	0.330
	YS02-0.0-0.5	0.0-0.5	ND	ND	**1.90**	**1.90**
2008 Archive Samples						
YC06	YC06b-0.5-1.0	0.5-1.0	ND	ND	0.770	0.770
YC07	YC07c-0.5-1.0	0.5-1.0	ND	ND	0.620	0.620
YC09	YC09c-0.5-1.0	0.5-1.0	ND	ND	0.530	0.530
YC10	YC10c-0.5-1.0	0.5-1.0	ND	ND	0.770	0.770
YC14	YC14c-0.5-1.0	0.5-1.0	ND	ND	0.350	0.350
P88	P88-1.5-2.0	1.0-2.0	ND	ND	0.007	0.007
P90	P90-1.5-2.0	1.0-2.0	ND	ND	0.015	0.015
P91	P91-1.5-2.0	1.0-2.0	ND	ND	0.003	0.003
P93	P93-1.5-2.0	1.0-2.0	ND	ND	ND	ND
Street Borings						
P101	P101-0.0-1.0	0-1	ND	ND	**2.60**	**2.60**
(field duplicate)	P103-0.0-1.0	0-1	ND	ND	**2.50**	**2.50**
	P101-1.0-2.0	1-2	ND	ND	ND	ND
	P101-2.0-4.0	2-4	ND	ND	ND	ND
P102	P102-0.0-1.0 1	0-1	ND	ND	0.920	0.920
	P102-1.0-2.0	1-2	ND	ND	ND	ND
	P102-2.0-4.0	2-4	ND	ND	0.003	0.003

BOLD values – indicates that values exceeds MTCA Method A cleanup levels of 1.0 ppm
ND – non-detect

MIS – Multi-incremental sampling
Bgs – below ground surface
Ft – feet
DU – discrete unit
LDUP- laboratory MIS processing duplicate sample
YC – residential area composite sample

Table A10. Summary of total PCB concentrations in surface soil detected in residential yards, Dallas Ave S – West of 16th Ave S, and S. Cloverdale St., at the South Park Site, South Seattle, King County, Washington.

Sample Location	Sample Identification (feet bgs)	Location Description	Sample Date	Total PCBs (mg/kg dw)
DU01	DU01-0.0-0.2	8523 Dallas Ave S	4/20/2009	0.74
DU01	DU01-0.2-0.5	8523 Dallas Ave S	4/20/2009	0.43
DU01	DU51-0.0-0.2	8523 Dallas Ave S	7/31/2009	**1.1** [a]
DU01	DU51-0.2-0.5	8523 Dallas Ave S	7/31/2009	0.47
DU01	DU61-0.0-0.2	8523 Dallas Ave S	7/31/2009	**1.1** [a]
DU01	DU61-0.2-0.5	8523 Dallas Ave S	7/31/2009	0.50
DU02	DU02-0.0-0.2	8525 Dallas Ave S	4/21/2009	0.48
DU02	DU02-0.2-0.5	8525 Dallas Ave S	4/21/2009	0.34
DU10	DU10-0.0-0.2	8529 Dallas Ave S	4/23/2009	0.38
DU10	DU10-0.2-0.5	8529 Dallas Ave S	4/23/2009	0.22
DU11	DU11-0.0-0.2	8529 Dallas Ave S	4/24/2009	0.14
DU11	DU11-0.0-0.2-LDUP	Laboratory-generated MIS split of DU11-0.0-0.2	4/24/2009	0.14
DU11	DU11-0.2-0.5	8529 Dallas Ave S	4/24/2009	0.16
DU11	DU11-0.2-0.5-LDUP	Laboratory-generated MIS split of DU11-0.2-0.5	4/24/2009	0.14
DU12	DU12-0.0-0.2	8529 Dallas Ave S	4/24/2009	0.37
DU12	DU12-0.2-0.5	8529 Dallas Ave S	4/24/2009	0.36

Sample Location	Sample Identification (feet bgs)	Location Description	Sample Date	Total PCBs (mg/kg dw)
DU03	DU03-0.0-0.2	1410 S Cloverdale St	4/21/2009	0.18 [a]
DU03	DU03-0.0-0.2-LDUP	Laboratory-generated MIS split of DU03-0.0-0.2	4/21/2009	0.23 [a]
DU03	DU03-0.0-0.2	1410 S Cloverdale St	4/21/2009	0.99 [a]
DU03	DU03-0.2-0.5-LDUP	Laboratory-generated MIS split of DU03-0.2-0.5	4/21/2009	0.89 [a]
DU04	DU04-0.0-0.2	1412 S Cloverdale St	4/21/2009	0.13
DU04	DU04-0.2-0.5	1412 S Cloverdale St	4/21/2009	0.10
DU04	DU04-0.2-0.5-LDUP	Laboratory-generated MIS split of DU04-0.2-0.5	4/21/2009	0.12
DU05	DU05-0.0-0.2	1412 S Cloverdale St	4/29/2009	0.20
DU05	DU05-0.2-0.5	1412 S Cloverdale St	4/29/2009	0.16
DU06	DU06-0.0-0.2	1420 S Cloverdale St	4/23/2009	0.054
DU06	DU06-0.2-0.5	1420 S Cloverdale St	4/24/2009	0.078
DU07	DU07-0.0-0.2	1420 S Cloverdale St	4/23/2009	0.16
DU07	DU07-0.2-0.5	1420 S Cloverdale St	4/23/2009	0.18
DU08	DU08-0.0-0.2	1424 S Cloverdale St	4/20/2009	0.053
DU08	DU08-0.2-0.5	1424 S Cloverdale St	4/20/2009	0.048
DU09	DU09-0.0-0.2	1424 S Cloverdale St	4/20/2009	0.14
DU09	DU09-0.2-0.5	1424 S Cloverdale St	4/20/2009	0.16
DU13	DU13-0.0-0.2	1440 S Cloverdale St	4/22/2009	0.39
DU13	DU13-0.2-0.5	1440 S Cloverdale St	4/22/2009	0.30
DU14	DU14-0.0-0.2	1440 S Cloverdale St	4/22/2009	0.73
DU14	DU14-0.2-0.5	1440 S Cloverdale St	4/22/2009	0.17
DU14	DU64-0.0-0.2	1440 S Cloverdale St	4/22/2009	0.91

Sample Location	Sample Identification (feet bgs)	Location Description	Sample Date	Total PCBs (mg/kg dw)
DU14	DU64-0.2-0.5	1440 S Cloverdale St	4/22/2009	0.18
DU14	DU74-0.0-0.2	1440 S Cloverdale St	4/22/2009	**1.2**
DU14	DU74-0.2-0.5	1440 S Cloverdale St	4/22/2009	0.19
DU32	DU32-0.0-0.2	1445 S Cloverdale St	8/5/2009	**2.1**
DU32	DU32-0.2-0.5	1445 S Cloverdale St	8/5/2009	**1.4**
DU33	DU33-0.0-0.2	1445 S Cloverdale St	7/24/2009	0.59
DU33	DU33-0.2-0.5	1445 S Cloverdale St	7/24/2009	0.17
DU33	DU83-0.0-0.2	1445 S Cloverdale St	7/24/2009	0.68
DU33	DU83-0.2-0.5	1445 S Cloverdale St	7/24/2009	0.14
DU33	DU93-0.0-0.2	1445 S Cloverdale St	7/27/2009	0.30
DU33	DU93-0.2-0.5	1445 S Cloverdale St	7/27/2009	0.10
DU34	DU34-0.0-0.2	1429 S Cloverdale St	7/31/2009	0.24
DU34	DU34-0.0-0.2-LDUP	Laboratory-generated MIS split of DU34-0.0-0.2	7/31/2009	0.25
DU34	DU34-0.2-0.5	1429 S Cloverdale St	7/31/2009	0.40
DU34	DU34-0.2-0.5-LDUP	Laboratory-generated MIS split of DU34-0.2-0.5	7/31/2009	0.32
DU35	DU35-0.0-0.2	1425 S Cloverdale St	7/20/2009	0.84
DU35	DU35-0.2-0.5	1425 S Cloverdale St	7/20/2009	**1.7** [a]
DU36	DU36-0.0-0.2	1421 S Cloverdale St	7/20/2009	0.18
DU36	DU36-0.2-0.5	1421 S Cloverdale St	7/20/2009	0.17
DU37	DU37-0.0-0.2	1417 S Cloverdale St	7/20/2009	0.18
DU37	DU37-0.2-0.5	1417 S Cloverdale St	7/20/2009	0.14

Sample Location	Sample Identification (feet bgs)	Location Description	Sample Date	Total PCBs (mg/kg dw)
DU22	DU22-0.0-0.2	1442, 1446, 1450 S Donovan St.	8/5/2009	0.045
DU22	DU22-0.0-0.2-LDUP	Laboratory-generated MIS split of DU22-0.0-0.2	8/5/2009	0.043
DU22	DU22-0.2-0.5	1442, 1446, 1450 S Donovan St.	8/5/2009	0.072
DU22	DU22-0.2-0.5-LDUP	Laboratory-generated MIS split of DU22-0.2-0.5	8/5/2009	0.076
DU23	DU23-0.0-0.2	1430 S Donovan St	7/22/2009	0.62
DU23	DU23-0.2-0.5	1430 S Donovan St	7/22/2009	0.16
DU23	DU173-0.0-0.2	1430 S Donovan St	7/23/2009	0.78
DU23	DU173-0.2-0.5	1430 S Donovan St	7/23/2009	0.25
DU23	DU183-0.0-0.2	1430 S Donovan St	7/22/2009	0.89
DU23	DU183-0.2-0.5	1430 S Donovan St	7/22/2009	0.32
DU24	DU24-0.0-0.2	1426 S Donovan St	8/3/2009	0.060
DU24	DU24-0.2-0.5	1426 S Donovan St	8/3/2009	0.079
DU25	DU25-0.0-0.2	1418 S Donovan St	8/3/2009	0.81 [a]
DU25	DU25-0.2-0.5	1418 S Donovan St	8/3/2009	0.80 [a]
DU26	DU26-0.0-0.2	1412 S Donovan St	8/3/2009	0.13
DU26	DU26-0.2-0.5	1412 S Donovan St	8/3/2009	0.14

BOLD values – indicates that values exceeds MTCA Method A cleanup levels of 1.0 ppm
MIS – Multi-incremental sampling
DU – discrete unit
LDUP- laboratory MIS processing duplicate sample
bgs- below ground surface
[a]- Aroclor 1260 was the only Aroclor detected in all samples analyzed from the yards, with the exception of these samples footnoted. Aroclor 1254 was detected in these samples.

Table A11. Summary of total PCB concentrations in surface soil detected in adjacent streets, 16th Ave S. and S. Donovan St. (ROWs) at the South Park Site, South Seattle, King County, Washington.

Sample Location	Sample Identification	Location Description	Sample Date	Total PCBs (mg/kg dw)
DU15	DU15-0.0-0.2	16th Ave S, between S Cloverdale St and alleyway to the S	4/27/2009	0.46 [a]
DU15	DU15-0.2-0.5	16th Ave S, between S Cloverdale St and alleyway to the S	4/27/2009	0.37
DU16	DU16-0.0-0.2	16th Ave S, between S Cloverdale St and alleyway to the S (E of DU15)	4/28/2009	0.45
DU16	DU16-0.2-0.5	16th Ave S, between S Cloverdale St and alleyway to the S (E of DU15)	4/28/2009	**1.4** [a]
DU17	DU17-0.0-0.2	16th Ave S, eastern shoulder of right-of-way	4/27/2009	**1.3**
DU17	DU17-0.2-0.5	16th Ave S, eastern shoulder of right-of-way	4/27/2009	**1.1**
DU17	DU67-0.0-0.2	16th Ave S, eastern shoulder of right-of-way	7/27/2009	0.88
DU17	DU67-0.2-0.5	16th Ave S, eastern shoulder of right-of-way	7/27/2009	0.63
DU17	DU77-0.0-0.2	16th Ave S, eastern shoulder of right-of-way	7/27/2009	0.84
DU17	DU77-0.2-0.5	16th Ave S, eastern shoulder of right-of-way	7/27/2009	0.44
DU20	DU20-0.0-0.2	16th Ave S, between S Donovan St and alleyway to the N	8/5/2009	**1.1 J** [a]
DU20	DU20-0.0-0.2-LDUP	Laboratory-generated MIS split of DU20-0.0-0.2	8/5/2009	0.20 J
DU20	DU20-0.2-0.5	16th Ave S, between S Donovan St and alleyway to the N	8/5/2009	0.15
DU20	DU20-0.2-0.5-LDUP	Laboratory-generated MIS split of DU20-0.2-0.5	8/5/2009	0.13
DU21	DU21-0.0-0.2	16th Ave S, between S Donovan St and alleyway to the N (E of DU20)	7/28/2009	0.44
DU21	DU21-0.2-0.5	16th Ave S, between S Donovan St and alleyway to the N (E of DU20)	7/28/2009	0.86
DU21	DU71-0.0-0.2	16th Ave S, between S Donovan St and alleyway to the N (E of DU20)	7/28/2009	0.29
DU21	DU71-0.2-0.5	16th Ave S, between S Donovan St and alleyway to the N (E of DU20)	7/28/2009	0.65
DU21	DU81-0.0-0.2	16th Ave S, between S Donovan St and alleyway to the N (E of DU20)	7/28/2009	0.90
DU21	DU81-0.2-0.5	16th Ave S, between S Donovan St and alleyway to the N (E of DU20)	7/28/2009	**1.4**

BOLD values – indicates that values exceeds MTCA Method A cleanup levels of 1.0 ppm
J – Estimated value
PCB – Polychlorinated biphenyl

DU – Discrete Unit
[a] – Aroclor 1260 was the only Aroclor detected in samples analyzed from the adjacent streets, with the exception of these samples footnoted. Aroclor 1221 was detected in sample DU15-0.0 – 0.2 (0.028 mg/kg); and Aroclor 1254 was detected in samples DU16-0.2 – 0.5 (0.35 mg/kg) and DU20-0.0 – 0.2 (0.48 mg/kg)
MIS – Multi-incremental sampling

Sample Location	Sample Identification	Location Description	Sample Date	Total PCBs (mg/kg dw)
DU18	DU18-0.0-0.2	W end of Lower S Donovan St	4/29/2009	**1.2**
DU18	DU18-0.2-0.5	W end of Lower S Donovan St	4/29/2009	**1.4**
DU19	DU19-0.0-0.2	E end of Lower S Donovan St	4/29/2009	**5.7**
DU19	DU19-0.2-0.5	E end of Lower S Donovan St	4/29/2009	**8.1**
DU27	DU27-0.0-0.2	W end of Upper S Donovan St	7/23/2009	**1.5**
DU27	DU27-0.0-0.2-LDUP	Laboratory-generated MIS split of DU27-0.0-0.2	7/23/2009	**1.4**
DU27	DU27-0.2-0.5	W end of Upper S Donovan St	7/23/2009	**1.5**
DU27	DU27-0.2-0.5-LDUP	Laboratory-generated MIS split of DU27-0.2-0.5	7/23/2009	**1.6**
DU27	DU177-0.0-0.2	W end of Upper S Donovan St	7/23/2009	**1.3**
DU27	DU177-0.2-0.5	W end of Upper S Donovan St	7/23/2009	**1.5**
DU27	DU187-0.0-0.2	W end of Upper S Donovan St	7/24/2009	**1.4**
DU27	DU187-0.2-0.5	W end of Upper S Donovan St	7/24/2009	**1.7 J**
DU28	DU28-0.0-0.2	E end of Upper S Donovan St	7/21/2009	**1.3**
DU28	DU28-0.2-0.5	E end of Upper S Donovan St	7/21/2009	0.87
DU28	DU78-0.0-0.2	E end of Upper S Donovan St	7/21/2009	0.97
DU28	DU78-0.2-0.5	E end of Upper S Donovan St	7/21/2009	0.71
DU28	DU88-0.0-0.2	E end of Upper S Donovan St	7/22/2009	0.84
DU28	DU88-0.2-0.5	E end of Upper S Donovan St	7/22/2009	0.53
DU29	DU29-0.0-0.2	N side of Upper S Donovan St	8/4/2009	0.80
DU29	DU29-0.2-0.5	N side of Upper S Donovan St	8/4/2009	0.68
DU30	DU30-0.0-0.2	Upper S Donovan St, boat yard parking lot	8/4/2009	0.061
DU30	DU30-0.2-0.5	Upper S Donovan St, boat yard parking lot	8/4/2009	0.055
DU38	DU38-0.0-0.2	Upper S Donovan St, W of boat yard parking lot (1433 S Donovan St parking strip)	8/4/2009	0.21

DU38	DU38-0.2-0.5	Upper S Donovan St, W of boat yard parking lot (1433 S Donovan St parking strip)	8/4/2009	0.23

BOLD values – indicates that values exceeds MTCA Method A cleanup levels of 1.0 ppm
J – Estimated value
PCB – Polychlorinated biphenyl
DU – Discrete Unit
[a] – Aroclor 1260 was the only Aroclor detected in samples analyzed from the adjacent streets, with the exception of these samples footnoted. Aroclor 1221 was detected in sample DU15-0.0 – 0.2 (0.028 mg/kg); Aroclor 1254 was detected in samples DU16-0.2 – 0.5 (0.35 mg/kg) and DU20-0.0 – 0.2 (0.48 mg/kg).
MIS – Multi-incremental sampling

Table A12. Summary of total PCB concentrations in surface soil detected in residential yards, 16th Ave S and S. Cloverdale St at the South Park Site, South Seattle, King County, Washington.

Sample Location	Sample Identification [b]	Location Description	Sample Date	Total PCBs (mg/kg dw)
YC06a	YC06a-0.2-0.5	1440 S Cloverdale St (front yard)	8/21/2008	0.61 U
YC06a	YC06a-0.2-0.5DUP	Field split of YC06a-0.2-0.5	8/21/2008	0.59 U
YC06c	YC06c-0.1-0.5	1440 S Cloverdale St (front yard)	8/21/2008	0.64 U
YC07a	YC07a-0.1-0.5	8529 Dallas Ave S (backyard facing S Cloverdale St)	8/21/2008	0.20
YC07b	YC07b-0.1-0.5	8529 Dallas Ave S (backyard facing S Cloverdale St)	8/21/2008	0.27
YC08a	YC08a-0.2-0.5	1424 S Cloverdale St (front yard)	8/26/2008	0.018
YC08a	YC08a-0.2-0.5DUP	Field split of YC08a-0.2-0.5	8/26/2008	0.020
YC08a	YC08a-0.5-1.0	1424 S Cloverdale St (front yard)	8/26/2008	0.12
YC08b	YC08b-0.2-0.5	1424 S Cloverdale St (front yard)	8/26/2008	**2.9**
YC08b	YC08b-0.5-1.0	1424 S Cloverdale St (front yard)	8/26/2008	**1.1**
YC09a	YC09a-0.1-0.5	1420 S Cloverdale St (front yard)	8/22/2008	0.13
YC09b	YC09b-0.1-0.5	1420 S Cloverdale St (front yard)	8/22/2008	0.19
YC10a	YC10a-0.2-0.5	1412 S Cloverdale St (front yard)	8/25/2008	0.34
YC10a	YC10a-0.2-0.5DUP	Field split of YC10a-0.2-0.5	8/25/2008	0.33
YC10b	YC10b-0.2-0.5	1412 S Cloverdale St (front yard)	8/25/2008	0.19
YC11a	YC11a-0.2-0.5	1410 S Cloverdale St (front yard)	8/25/2008	**1.5**

BOLD values – indicates that values exceeds MTCA Method A cleanup levels of 1.0 ppm

Sample Location	Sample Identification [b]	Location Description	Sample Date	Total PCBs (mg/kg dw)
YC11b	YC11b-0.2-0.5	1410 S Cloverdale St (front yard)	8/25/2008	0.46
YC12a	YC12a-0.1-0.5	1417 S Cloverdale St (front yard)	8/26/2008	0.13
YC12a	YC12a-0.1-0.5DUP	Field split of YC12a-0.1-0.5	8/26/2008	0.11
YC13a	YC13a-0.0-0.5	1421 S Cloverdale St (front yard)	8/25/2008	0.16
YC13b	YC13b-0.0-0.5	1421 S Cloverdale St (front yard)	8/25/2008	0.17
YC14a	YC14a-0.1-0.5	1425 S Cloverdale St (front yard)	8/22/2008	0.20
YC14b	YC14b-0.1-0.5	1425 S Cloverdale St (front yard)	8/22/2008	0.44 [a]
YC15a	YC15a-0.0-0.5	1429 S Cloverdale St (front yard)	8/25/2008	0.19
YC15c	YC15c-0.0-0.5	1429 S Cloverdale St (front yard)	8/25/2008	0.19
YC16c	YC16c-0.0-0.5	1445 S Cloverdale St (front yard)	8/20/2008	0.13 U
YC16b	YC16b-0.1-0.5	1445 S Cloverdale St (front yard)	8/20/2008	0.43 U
YC18a	YC18a-0.1-0.5	Vegetated area immediately south of boatyard at 8603 Dallas Ave S	8/20/2008	0.26
YC18b	YC18b-0.1-0.5	Vegetated area immediately south of boatyard at 8603 Dallas Ave S	8/20/2008	0.14
YC18c	YC18c-0.1-0.5	Vegetated area immediately south of boatyard at 8603 Dallas Ave S	8/20/2008	0.12
HA1	HA1-0.0-1.0	16th Avenue S, immediately south of intersection with South Donovan Street	8/21/2008	0.18

[a] Aroclor 1260 was the only Aroclor detected in samples analyzed from the yards, with the following exceptions: Aroclor 1254 was detected in samples YC14b-0.1 – 0.5 (0.18 mg/kg), and YC17c-0.0 – 0.5 (0.068 mg/kg)
U – Not detected at the reported limit
[b] Sample identification depth corresponds to 0.00 – 0.5 feet below ground surface (ft bgs), 0.1 – 0.5 ft bgs, 0.2 – 0.5 ft bgs, 0.0 – 1.0 ft bgs
DUP - Duplicate
PCB – Polychlorinated biphenyl

Appendix B

This section provides calculated exposure doses and assumptions used for exposure to chemicals currently present in accessible surface soils at the South Park site. An exposure scenario was developed to model exposures that might occur. These scenarios were devised to represent exposures for children (ages 0 to 15 years old) and an adult (exposure scenario). The following exposure parameters and dose equations were used to estimate exposure doses from direct contact with chemicals in soil.

Exposure to chemicals in soil via ingestion, inhalation, and dermal absorption

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

Ingestion Route

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

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

Dermal Route

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

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

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

Inhalation Route

$$Dose_{non\text{-}cancer\ (mg/kg\text{-}day)} = \frac{C \times SMF \times IHR \times EF \times ED \times 1/PEF}{BW \times AT_{non\text{-}cancer}}$$

$$Cancer\ Risk = \frac{C \times SMF \times IHR \times EF \times ED \times CPF \times 1/PEF}{BW \times AT_{cancer}}$$

Table B1. Exposure assumptions used for exposure to dioxins and PCBs in surface soil from South Park site, South Seattle, King County, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	mg/kg	Maximum detected value
Conversion Factor (CF)	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion Rate (IR) – adult	100	mg/day	Exposure Factors Handbook [33,34]
Ingestion Rate (IR) – older child	100		
Ingestion Rate (IR) - child	200		
Exposure Frequency (EF)	350	days/year	Average days in one residence [j]
Exposure Duration (ED)	30 (5, 10 and 15)	years	Number of years at one residence (child [age 0 to 5 yrs old], older child [age 6 to 15 yrs old], and adult yrs)
Body Weight (BW)	72	kg	Adult mean body weight
	41		Older child mean body weight
	15		0-5 year-old child average body weight
Surface area (SA) - adult	5700	cm^2	Exposure Factors Handbook [33,34]
Surface area (SA) – older child	2900		
Surface area (SA) - child	2900		
Averaging $Time_{non\text{-}cancer}$ (AT)	10950	days	30 years
Averaging $Time_{cancer}$ (AT)	27375	days	75 years
Cancer Potency Factor (CPF)	variable	$mg/kg\text{-}day^{-1}$	Source: EPA
24 hr. absorption factor (ABS)	Dioxin= 0.03 PCB = 0.14	unitless	Source: EPA (Chemical Specific) Total dioxin and 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 rate (IHR) - adult	15.2	m^3/day	Exposure Factors Handbook [33,34]
Soil matrix factor (SMF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Particulate emission factor (PEF)	1.20E+9	m^3/kg	Model Parameters

Hazard Quotient formula:

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

[j] It assumes residential exposures of 350 days per year with a two-week absence from the location if residents take vacation. In general, EPA recommends the central tendency for residential soil contact of 350 days/year and Reasonable Maximum Exposure (RME) for industrial scenarios of 250 days/year for workers. EPA suggests that exposure duration may be adjusted to reflect site-specific conditions. Thus, current exposure assumptions should represent conservative actual occurrences as accurately as possible.[35,36]

South Park Street and Residential Surface Soil Exposure Route –Non-cancer

Table B2. Non-cancer hazard calculations resulting from exposure to dioxins and PCBs in South Park site, South Seattle, King County, Washington.

Contaminant	Maximum concentration (ppm) (mg/kg)	Scenarios	Estimated Dose (mg/kg/day)			Total Dose (mg/kg/day)	MRL/ LOAEL * (mg/kg/day)	Total Dose/ MRL/ LOAEL)
			Incidental Ingestion of Soil	Dermal Contact with Soil	Inhalation of Particulates			
Total Dioxins TEQ Street soil	0.000084	Child	1.1E-9	9.3E-11	3.7E-14	1.2E-9	1.0E-9	**1.2**
		Older Child	2.0E-10	3.4E-11	2.3E-14	2.3E-10		0.2
		Adult	1.1E-10	1.3E-11	1.4E-14	1.2E-10		0.1
Total Dioxins TEQ Residential yard properties	0.000050	Child	6.4E-10	5.6E-11	2.2E-14	7.0E-10		0.7
		Older Child	1.2E-10	2.0E-11	1.4E-14	1.4E-10		0.1
		Adult	6.7E-11	8.0E-12	8.4E-15	7.5E-11		0.1
Total PCBs Street soil	8.1	Child	1.0E-4	4.2E-5	3.6E-9	1.4E-4	2.0E-5	**7.1**
		Older Child	1.9E-5	1.5E-5	2.2E-9	3.4E-5		**1.7**
		Adult	1.1E-5	6.0E-6	1.4E-9	1.7E-5		0.9
Total PCBs Residential yard soil	2.1	Child	2.7E-5	1.1E-5	9.3E-10	3.8E-5		**1.9**
		Older Child	4.9E-6	4.0E-6	5.7E-10	8.9E-6		0.4
		Adult	2.8E-6	1.6E-6	3.6E-10	4.4E-6		0.2

* ATSDR's Chronic Oral MRL for 2,3,7,8-Tetrachlorodibenzo –*p*- dioxin and Aroclor 1254 for total PCBs.
RfD/MRL/LOAEL – Reference dose/Minimal Risk Level/Lowest Observed Adverse Effect Level
BOLD – means values exceed hazard quotient of one

South Park Street and Residential Surface Soil Exposure Route – Cancer

Table B3. Cancer hazard calculations resulting from exposure to dioxins and PCBs in South Park site, South Seattle, King County, Washington.

Contaminant	Maximum concentration (ppm)	EPA Cancer Class	Cancer Potency Factor ($mg/kg\text{-}day^{-1}$)	Scenarios	Increased Cancer Risk			Total Cancer Risk
					Incidental Ingestion of Soil	Dermal Contact with Soil	Inhalation of Particulates	
Total Dioxins TEQ Street soil	0.000084	B2	1.5E+5	Child	1.1E-5	9.3E-7	3.7E-10	1.2E-5
				Older Child	3.9E-6	6.8E-6	4.6E-10	1.1E-5
				Adult	3.4E-6	4.0E-7	4.3E-10	3.8E-6
				Total †	1.8E-5	8.1E-6	1.3E-9	2.7E-5
Total Dioxins TEQ Residential yard soil	0.000050			Child	6.4E-6	5.6E-7	2.2E-10	7.0E-6
				Older Child	2.3E-6	4.1E-7	2.7E-10	2.7E-6
				Adult	2.0E-6	2.4E-7	2.5E-10	2.2E-6
				Total †	1.07E-5	1.2E-6	7.4E-10	1.2E-5
Total PCBs Street soil	8.1	B2	2.0	Child	1.4E-5	5.6E-6	4.8E-10	2.0E-5
				Older Child	5.1E-6	4.3E-6	5.9E-10	9.4E-6
				Adult	4.3E-6	2.4E-6	5.5E-10	6.7E-6
				Total †	2.3E-5	1.2E-5	1.6E-9	3.6E-5
Total PCBs Residential yard soil	2.1			Child	3.6E-6	1.5E-6	1.2E-10	5.1E-6
				Older Child	1.3E-6	1.1E-6	1.5E-10	2.4E-6
				Adult	1.1E-6	6.3E-7	1.4E-10	1.7E-6
				Total †	6.0E-6	3.2E-6	4.1E-10	9.2E-6

B2 – Probable human carcinogen – based on sufficient evidence of carcinogenicity in animals
Total † – refers to the30 year life time exposure

Appendix C

Theoretical cancer risks compared to MTCA and EPA

Theoretical cancer risks do exceed the Washington State Model Toxics Control Act or "MTCA" Method A for PCB mixtures and Method B for dioxins level of $1x10^{-6}$, which was established as a cleanup level for hazardous waste sites. The MTCA regulation establishes cleanup levels for contaminated sites. These cleanup levels are based on: (1) standard risk-based equations (i.e., an acceptable cancer risk level of one excess cancer risk per one million people exposed (1×10^{-6}), which is exceeded in some exposure scenarios (Appendix B, Table B3); (2) federal and state regulatory policies and procedures; and (3) consideration of cross media contamination.

DOH used health protective screening levels and a quantitative risk assessment, using site-specific exposure assumptions, to evaluate the health risks posed by contaminants currently present in the streets and residential surface soils at the South Park site. Some of those exposure assumptions may be different from those used by Ecology when conducting site cleanups under the Model Toxics Control Act (MTCA) cleanup regulation. Ecology risk levels may differ from those calculated by DOH.

It should be noted that EPA considers an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} as an acceptable range, meaning that regular exposure to a substance would lead to 1 additional case of cancer per 10,000 to 1 additional case of cancer per 1,000,000 people exposed.

Certification

The Washington State Department of Health prepared this Health Consultation 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 the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Audra Henry
Technical Project Officer, CAPEB, DHAC
Agency for Toxic Substances & Disease Registry

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

Alan W. Yarbrough
Team Lead, CAPEB, DHAC
Agency for Toxic Substances & Disease Registry

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