Health Consultation

Kenmore Area of Lake Washington and Sammamish River
Evaluation of Sediment, Surface Water, and Groundwater
King County, Washington

June 27, 2013

Prepared by

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

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Foreword

The Washington State Department of Health (DOH) has prepared this health consultation with funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous substances.

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

This health consultation was prepared in accordance with ATSDR methodologies and guidelines. However, the report has not been reviewed and cleared by ATSDR. The findings in this report are relevant to conditions at the site during the time the report was written. It should not be relied upon if site conditions or land use changes in the future.

Use of trade names is for identification only and does not imply endorsement by state or federal health agencies.

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For persons with disabilities this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (voice) or 1-800-833-6388 (TTY/TDD).

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

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Summary

Introduction

The Washington State Department of Health (DOH) prepared this health consultation to address the concerns raised by some members of the Kenmore community. They are concerned about swimmers and boaters potential exposure to contaminated sediments at two public access areas in Kenmore, King County, Washington: Log Boom Park at the north end of Lake Washington and the motor boat launch area near the mouth of the Sammamish River. The community members are also concerned that swimmers and boaters might be exposed to contaminated sediments in three areas with limited public access in the Kenmore area: the navigation channel, Harbour Village Marina, and sediments and groundwater near the Kenmore Industrial Park (KIP) site. DOH prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

DOH reached two important conclusions about sediment, groundwater, and surface water:

Conclusion 1
Touching, breathing, or accidentally eating sediment from public access areas, as well as areas with limited public access, is not expected to harm people's health.

Basis for Decision

Public access areas include Log Boom Park and the motor boat launch areas and limited public access areas included Kenmore Harbor, Kenmore Navigation Channel, Sammamish Navigation Channel, Harbour Village Marina, and KIP. The levels of contaminants found in sediments are below levels of health concern. Exposure to sediments in these areas is not expected to cause non-cancer health effects. The estimated cancer risk associated with exposure to the sediments is considered low to insignificant and is based on lifetime exposures (72 to 78 years). Cancer risks are estimated and should not be taken to represent actual or likely risks for the public. The risks could be as low as zero.

Conclusion 2

Swimming or accidentally ingesting groundwater discharging from the KIP site or surface water tested by the City of Kenmore near Log Boom Park is not expected to harm people's health.

Basis for Decision

The maximum level of contaminants found in groundwater at the edge of the KIP site and surface water near Log Boom Park pose an insignificant cancer risk and are not expected to cause non-cancer health effects.

Next Steps

DOH will provide copies of this health consultation to the following:

- City of Kenmore
- Washington State Department of Ecology
- City of Lake Forest Park
- Washington State Department of Transportation
- Washington State Department of Fish and Wildlife
- Washington State Department of Natural Resources
- United States Army Corps of Engineers
- Public Health Seattle and King County
- Kenmore Industrial Park
- Harbour Village Marina
- North Lake Marina
- 41st Legislative District Delegation: Senator David Frockt; Representative Jessyn Farrell; Representative Gerry Pollet
- Community repositories for the public health consultation and related fact sheets will be established at the following:
    - Kenmore Public Library; 6531 NE 181 Street; Kenmore, Washington 425-486-8747
    - DOH web site –http://www.doh.wa.gov/consults

For More Information

If you have any questions about this health consultation contact Lenford O'Garro 360-236-3376, Barbara Trejo 360-236-3373, or 1-877-485-7316 at Washington State Department of Health. For more information about ATSDR, contact the Center for Disease Control and Prevention (CDC) Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

Purpose and Statement of Issues

The Washington State Department of Health (DOH) prepared this health consultation to address the concerns raised by some members of the Kenmore community. They are concerned about swimmers and boaters potential exposure to contaminated sediments at two public access areas in Kenmore, King County, Washington: Log Boom Park at the north end of Lake Washington and the motor boat launch area near the mouth of the Sammamish. The community members are also concerned that swimmers and boaters might be exposed to contaminated sediments in three areas with limited public access in the Kenmore area: the navigation channel, Harbour Village Marina, and sediments and groundwater near the Kenmore Industrial Park (KIP) site. DOH prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Site Background

The City of Kenmore is located on the northern end of Lake Washington (Figure 1). The Sammamish River flows through Kenmore and enters Lake Washington adjacent to the KIP site (Figure 2). Historically, activities in the area consisted of lumber shipping and log booming. Past sediment testing indicates the presence of dioxins/furans (dioxins), polychlorinated biphenyls (PCBs), metals, and other contaminants [1].

Current commercial and industrial activities identified in the Kenmore area of Lake Washington include recreational marinas, commercial float plane operations, maritime operations, and concrete and asphalt batch plant. Residential and recreational properties (e.g. park and boat launch) are also located in the area.

The KIP site is an active 45-acre industrial property. In the past, the property was used as a demolition debris landfill [1, 2]. There have been reports that hazardous wastes were disposed in the landfill. However, environmental investigations conducted at the site have not confirmed this. The western fourteen acres of this property are currently being used for constructing anchors, bridge deck, and other components for the State Route (SR) 520 Bridge Replacement Project.

The City of Kenmore (City) and Washington State Department of Ecology (Ecology) conducted sediment sampling at public access areas and near the KIP site in November 2012 in response to community concerns. This sampling was added to an existing plan for sediment sampling in the Kenmore Navigation Channel, which is a U.S. Army Corps of Engineers (USACE) facility. The navigation channel sampling was being planned, in order to evaluate the sediment conditions for potential maintenance dredging that would be conducted by the USACE. Limited surface water sampling was also conducted during this time. Prior to the sampling, DOH participated in some of the City and Ecology planning meetings and discussions. DOH also reviewed and provided input on the draft sampling and analysis plan [3]. The public was also provided an opportunity to review and comment on the plan.

Community Health Concerns

Several community members are concerned that swimmers and boaters could potentially be exposed to contaminated sediments at the following public access areas:

- Log Boom Park,
- Harbour Village Marina, and
- Motor boat launch area near the mouth of the Sammamish River below the Juanita Drive – 68th Avenue NE bridge.

They are also concerned about potential swimmer and boater exposure to contaminated sediments in Lake Washington and mouth of the Sammamish River near the navigation channel and near the KIP site. Additionally, concerns were raised about potential exposure to contaminated groundwater discharging from the KIP site.

Sample Collection and Analysis

The City of Kenmore and Ecology conducted sediment sampling in northeast Lake Washington and Sammamish River in areas identified in the sampling and analysis plan in November 2012[a]. Limited surface water sampling was also conducted near Log Boom Park [1].

In public access areas, sediment grab samples or hand trowel samples were collected from depths of 0 to 10 centimeter (cm). Sediment core samples from the navigation channel were collected from 0 to 25 cm[b]. Surface water from Lake Washington was collected from 0.5 to 3 feet below surface [1]. Groundwater sampling was done at the KIP site in October 2012.

Sediment, surface water, and groundwater samples were analyzed for semivolatile organic compounds (SVOCs) and metals [1, 4]. Sediments were also analyzed for some volatile organic compounds (as part of the SVOC's using EPA Method 8270 and EPA Method 8081), tributyltins, pesticides, PCBs (aroclor), and dioxins [1, 4]. Appendix B, Tables B1 - B9 provides a summary of the detected and non-detected chemical results for each location evaluated in this health consultation report [4].

For more information about sample collection and processing methods, please refer to the sampling and analysis plan, Kenmore Sediment and Water Characterization [1]. Methods, results, and data validation are summarized in Ecology's Kenmore Area Sediment & Water Characterization Environmental Evaluation Report, publication #13-09-174.

[a] Sediment samples were also collected at North Lake Marina, Creek 0056, and Lyon Creek Park in Lake Forest Park. These results were not included in this health consultation report because Lyon Creek Park is located outside of City of Kenmore and no public access is available at North Lake Marina or the portion of Creek 0056 where the sediment samples were collected.

[b] The sediment testing in the navigation channel is intended to support the City's ongoing work with the U.S. Army Corps of Engineers (USACE) to support a request for federal funding for USACE maintenance dredging Channel (Figure 2).

Figure 1. Washington State map showing location of Kenmore, King County, Washington.

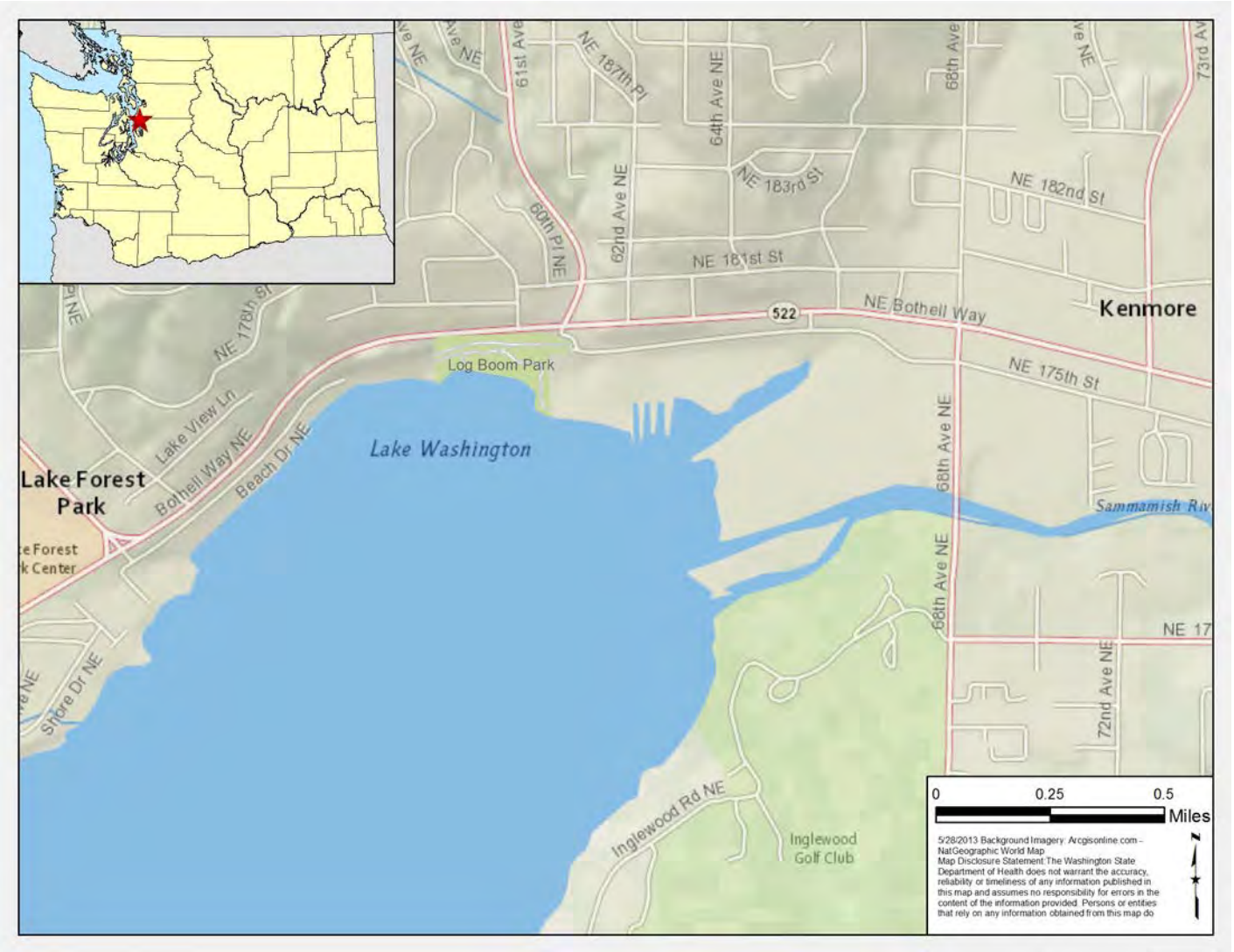

Figure 2. Area map of Kenmore sample collection location on Lake Washington, King County, Washington.

Discussion

Contaminants were found in sediment and water samples. Exposure to these chemicals can occur through:

- Ingestion (accidentally swallowing water or eating contaminated sediment),
- Inhalation (breathing in contaminated sediment or water), and
- Dermal contact (skin contact with contaminated sediment or water).

However, there are many factors that determine if an exposure will cause health effects. These factors include:

- Dose (how much),
- Duration (how long), and
- How someone comes in contact with the chemicals (touching, ingesting, or breathing in the chemical).

A person's age and the number of chemicals they are exposed to are a few other factors that may determine if exposure will cause health effects.

The following exposure routes were evaluated for this health consultation:

- Water Exposure Scenario: Accidental water ingestion and dermal absorption of contaminants in water when wading or swimming.
- Sediment Exposure Scenario: Accidental sediment ingestion and dermal absorption of contaminants in sediment when wading or inhalation of dust particles along the shoreline.

Contaminants of Concern

To identify chemicals that might be of health concern or contaminants of concern (COC), DOH compared the maximum level of each chemical to ATSDR health-based comparison values (CVs) (Appendix B, Tables B1 to B9). COC in sediment or water below *CVs are levels of chemicals that are unlikely to result in adverse health effect. This is done to be protective of the most sensitive individuals (e.g., children or pregnant women). It is also done to account for our lack of certainty regarding the adverse health effects of low levels of chemical exposure.* When a chemical was noted as below a detection limit, DOH used the detection limit when comparing the chemical to the CV.

Several types of ATSDR CVs are used during this process, cancer risk evaluation guide (CREG), environmental media evaluation guide (EMEG), and reference dose media evaluation guide (RMEG). Soil and water CVs in this health consultation represent residential exposures, which occur more often than recreational exposures. DOH uses CVs because they offer a high degree of protection. Therefore, DOH does not expect chemicals below the CV to pose a health threat. When these ATSDR CVs are not available, comparisons are made with other health-based standards including the Washington State Model Toxics Control Act (MTCA) cleanup levels or the U.S. Environmental Protection Agency's Regional Screening Levels (RSLs).

For this evaluation, when a chemical is present, but did not exceed the CV, no further evaluation of that chemical was necessary. When a chemical is found to be above a CV, or no health based CV is available, further evaluation of that chemical was performed. However, it is important to note that just because a chemical was found above the CV does not necessarily mean that adverse health effects will occur if people are exposed.

Dioxins and polycyclic aromatic hydrocarbons (PAHs) in sediment were the only two groups of compounds that exceeded their respective CVs (see Table 1) and are evaluated further below. Additionally, because two chemicals, calcium and magnesium (which are common minerals found in sediment and water) had no CV, they were also evaluated further.

Table 1. Summary of location-specific contaminants of concern, maximum concentrations detected in sediments, Kenmore, King County, Washington.

Location	Compounds	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Log Boom Park	Total cPAH (BaP-EQ)	1.09	0.1	B2	CREG	Yes
Kenmore Navigation Channel	Total cPAH (BaP-EQ)	0.80	0.1	B2	CREG	Yes
Harbour Village Marina	Total cPAH (BaP-EQ)	1.23	0.1	B2	CREG	Yes
	Total Dioxin TEQ	7.1E-5	5.0E-5	B2	EMEG	
Kenmore Harbor	Total cPAH (BaP-EQ)	1.48	0.1	B2	CREG	Yes

ATSDR - Agency for Toxic Substances and Disease Registry
CREG - ATSDR's Cancer Risk Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
EPA - Environmental Protection Agency
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million

Water Exposure Scenario

Contact with water at the park or other areas is expected to be seasonal and to occur infrequently. Exposure to contaminants in water can occur primarily by swallowing it (ingestion exposure) or getting it on the skin (dermal exposure). However, inhalation of water is not considered a likely route of exposure because water droplets usually consist of relatively large particles that are trapped in the nose, mouth, and throat and are then swallowed rather than breathed into the lungs.

The chemical contaminants evaluated in the Lake Washington water samples collected for this study are below their respective drinking water ATSDR CVs or other drinking water screening

values. Additionally, DOH evaluated the same chemicals in KIP groundwater samples and found that they are also below their respective CVs (see Appendix B, Tables B1 and B2). Since surface water and groundwater contaminant levels are all below the CVs, these chemicals do not pose a health concern. As a result, no further assessment of exposure to surface water or groundwater is needed.

Sediment Exposure Scenario

Contact with sediments at the park and other areas where boaters and swimmers might come into contact with them are typically seasonal and occur infrequently. Exposure to contaminants in sediment can occur by swallowing it (ingestion exposure), breathing it (inhalation exposure), or getting it on the skin (dermal exposure).

Ingestion exposure (swallowing)

People may accidentally swallow small amounts of sediments when swimming or boating (and any contaminants they contain). Young children often put hands, toys, pacifiers, and other things in their mouths, and these may have sediment on them that can be swallowed.

Inhalation exposure (breathing)

Although people can inhale suspended sediment, it 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. As a result, inhalation is not considered a route of exposure.

Dermal exposure (skin)

Sediment 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.

The following evaluation addresses dioxins and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) as contaminants of potential concern (COCs) in sediments (see Table 1 and Appendix B, Tables B3 – B9). Standard human health assessment for cancer and non-cancer risk was carried out using the formulas in Appendix C and results are shown in Tables C3 and C5.

The major direct contact sediment exposures in this health consultation are expected to occur mainly along Log Boom Park. DOH used very conservative exposure assumptions for someone being exposed to the maximum concentration for a lifetime from a baby to 78 years. The assumptions used in calculating the non-cancer and cancer risk estimates in this health consultation are “conservative” (protective of health) to “extremely conservative” (highly protective of health). Therefore, cancer risks should not be taken to represent actual or likely risks for users to the site. Also, direct contact exposures to in-water or submerged sediment are unlikely or negligible (due to sediment washing off and sediment sample location or depth). However, in-water or submerged sediments were evaluated as if they were exposed beach sediments with the same “conservative” to “extremely conservative” assumptions for calculating risk estimates.

While dioxins and PAHs were found above their respective CVs, it is important to note that sediment samples from Kenmore Harbor (SG-14) and Kenmore Navigation Channel sediment were collected from the lake bottom under 15 feet or more of water. Similarly, sediment samples from Sammamish Navigation Channel were collected offshore at 3 feet under water and Harbour Village Marina sediment samples were collected from the lake bottom under 4 feet or more of water. Sediment samples from near the Kenmore Industrial Park were collected from 1.9 feet to 10 feet below water. Submerged or in-water sediments, like these, are not considered to be a direct contact (i.e., ingestion and dermal contact) exposure risk for humans. This is because of their location and depth in the lake, and the water will wash off sediments that get on the skin. Additionally, these areas consist of active boat docks and boat navigation channels; therefore, it is unlikely that there is a completed route of exposure to people. However, in the event there is a completed route of exposure to people (someone diving to depth and collecting sediment barehanded), dioxins and cPAHs were conservatively evaluated the same way as the public access areas (see Table 1).

Dioxins and Furans

Dioxins and furans (dioxins) consist of congeners, which differ in the number and location of chlorine atoms on the chemical structure. The primary sources of dioxin releases to the environment are from burning fossil fuels and wood during the incineration of municipal, medical, and hazardous waste. They also are the result of 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.

2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic of the dioxin congeners and can cause chloracne (a condition of acne like lesions on the face and neck) at high levels. Exposure to high levels of dioxins can also cause liver damage, developmental effects, and impaired immune function [5]. Long-term exposure to dioxins could increase the likelihood of developing cancer. Studies in rats and mice exposed to TCDD resulted in thyroid and liver cancer [6]. EPA considers TCDD to be a probable human carcinogen and developed a cancer slope factor of 1.5×10^{5} per mg/kg/day [7, 8].

Although several dioxin and furan congeners were analyzed, only a single value, called a dioxin Toxic Equivalent (TEQ) is used in this health consultation. The TEQ approach is based on the premise that many dioxins/furans are structurally and toxicologically similar to 2,3,7,8-tetrachlorodibenzo-p-dioxin. Each dioxin/furan is multiplied by a Toxic Equivalency Factor (TEF) then added together to equal dioxin TEQ. TEFs are used to account for the different potency of dioxins and 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 [9,10]. The TEQs for each chemical are then summed to give the overall 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are generated by the incomplete burning of organic matter, including oil, wood, and coal. They are found in materials such as creosote, coal, coal

tar, and used motor oil. Based on structural similarities, metabolism, and toxicity, PAHs are often grouped together when evaluating their potential for adverse health effects. EPA has classified some PAHs as probable human carcinogens (B2), called carcinogenic polycyclic aromatic hydrocarbons (cPAHs) as a result of sufficient evidence of carcinogenicity in animals and inadequate evidence in humans [11].

Dietary sources make up a large percentage of PAH exposure in the U.S. population. Smoked or barbecued meats and fish contain relatively high levels of PAHs. The majority of dietary exposure to PAHs for the average person comes from eating vegetables and grains (cereals)[12].

Non -carcinogenic polycyclic aromatic hydrocarbons (PAHs)

Non-cancer adverse health effects associated with PAH exposure has been observed in animals, but generally not in humans (with the exception of effects to the skin and blood) [11]. The skin is prone to PAH effects in both humans and animals. Because the observed effect level for carcinogenic endpoints is much lower than that of the non-cancer endpoints, it is routine to focus on the potential cancer effects of PAHs instead.

Carcinogenic polycyclic aromatic hydrocarbons (cPAHs)

Benzo(a)pyrene (BaP) is the only cPAH for which EPA has derived a cancer slope factor. In a manner similar to deriving the toxic equivalent (TEQ) for dioxin/furan compounds, each cPAH found in the sediment is multiplied by a Relative Potency Factor (RPF) based on BaP (Appendix C, Table C2) [11, 13, 14]. The RPF approach is based on the weight-of-evidence for carcinogenicity and the premise that many cPAHs are structurally and toxicologically similar to BaP. Products of each congener multiplied by its RPF are summed to equal the Benzo(a)pyrene relative potency equivalent (BaP-EQ).

Calcium, Magnesium

Calcium and magnesium are essential nutrients and are typically not harmful under most environmental exposure scenarios [15]. Therefore, no public health standards have been established for calcium and magnesium in drinking water. However, the Institute of Medicine has established Dietary Reference Intakes for elements [16]. DOH calculated an average daily intake for calcium and magnesium by multiplying the maximum level of the element in water by the amount of water ingested per day 1.4 liters (conservative drinking water default value). This was then compared to the Dietary Reference Intakes for that element.

Calcium

The maximum level of calcium detected in the surface water was 15,000 parts per billion (ppb). In a worst-case scenario, a person drinking 1.4 liters of water a day with the maximum level of calcium would obtain 21 mg/day of calcium. The Adequate Intakes for calcium from the Dietary Reference Intakes table range from 210 - 1,300 mg/day, depending on age and gender [15].

Magnesium

The maximum level of magnesium detected in the surface water was 5,060 ppb. In a worst-case scenario, a person drinking 1.4 liters of water a day with the maximum level of magnesium would obtain 7.08 mg/day of magnesium. The Recommended Dietary Allowances for magnesium from the Dietary Reference Intakes table range from 80 - 420 mg/day, depending on age and gender [15].

Calcium and magnesium are essential nutrients. Concentrations of these chemicals are well below levels expected to cause health effects and will not be evaluated further.

Evaluating Non-cancer Hazards

Assumptions for estimating exposure to contaminant doses from sediment are found in Appendix B, Table B1. In order to evaluate the potential for *non-cancer* adverse health effects a dose is estimated for each contaminant of concern (COC). Dioxin was the only non-cancer COC exceeding the screening value. A dioxin estimated dose was then compared to the minimum risk level (MRL). MRLs are an estimate of the daily human exposure to a substance that has no appreciable risk of adverse health effects during a specified duration of exposure. MRLs are derived from observed effect levels obtained from human population and laboratory animal studies. These observed 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.

Because of uncertainty in these data, the toxic effect level is divided by "uncertainty factors" to produce the lower and more protective MRL. If a dose exceeds the MRL, it does not mean that adverse health effects will occur, it just means further toxicological and exposure evaluation is needed. Further evaluation includes comparing the site-specific estimated dose to doses from animal and human studies that showed either an effect level or a no effect level. This comparison, combined with other toxicological information, such as sensitive groups and chemical metabolism, is used to determine the risk of specific harmful effects. A MRL is exceeded whenever the Hazard Quotient (HQ) is greater than one (See Appendix C for the hazard quotient equation).

Estimated exposure doses, exposure assumptions, and hazard quotients are presented in Appendix C for COCs found in sediment. Based on exposure estimates quantified in Appendix C Table C1, people accidently eating or touching sediment from the study area are not likely to experience adverse non-cancer health effects. An exposure dose based on the maximum level of dioxin in sediment at this site (the maximum level was found under more than 4 feet of water) for 15 days per year (1.12×10^{-11}) did not exceed the chronic MRL of 1.0×10^{-9} mg/kg/day. Since exposure estimates using the maximum concentrations were lower than the chronic MRL, DOH does not expect that exposure to dioxin in sediments could cause harmful non-cancer health effects. Also, direct contact exposures to in-water/submerged sediment dioxins are unlikely or negligible.

Evaluating Cancer Risk

Some chemicals have the ability to cause cancer. 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 real-world 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. 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 [17].

Estimated Cancer Risk

Estimated cancer risk does 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

This document describes estimated cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight, and insignificant in estimated cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of 1 cancer case per 10,000 persons similarly exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands similarly exposed persons over a lifetime and a slight estimate would require an similarly exposed population of several hundreds of thousands to result in a single case. DOH considers estimated cancer risk insignificant when the estimate results in less than 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.

Cancer is a common illness and its occurrence in a population increases with the age of the population. There are many different forms of cancer resulting from a variety of causes; not all are fatal. Approximately 1 in 3 to 1 in 2 people living in the United States will develop cancer at some point in their lives [18].

The assumptions used in calculating the cancer risk estimates in this health consultation are "conservative" (protective of health) to "extremely conservative" (highly protective of health). Therefore, cancer risks should not be taken to represent actual or likely risks for users to the site. Also, direct contact exposures to in-water or submerged sediment are unlikely or negligible. However, in-water or submerged sediments were evaluated as if they were exposed beach sediments.

Submerged or in-water sediments increased lifetime estimated cancer risk associated with 15 day exposure to the maximum concentration of cPAHs and dioxins in sediments is at Harbour Village Marina slight (2×10^{-6} or 2 in 1,000,000). As stated before, the major direct contact sediment exposures in this health consultation are expected to occur mainly along Log Boom Park. Increased lifetime estimated cancer risk associated with 30 day exposure at Log Boom Park to the maximum concentration of cPAHs in sediments is low to very low (5×10^{-6} or 5 in 1,000,000). The estimated cancer risk for a 120 day exposure at Log Boom Park to the maximum concentration of cPAHs in sediments is also low (2×10^{-5} or 2 in 100,000).

These estimates are within the range DOH considers acceptable risk. That range is 1 excess cancer case per 10,000 people exposed to 1 excess cancer case per 1,000,000 people exposed ($1x10^{-4}$ to $1x10^{-6}$) in these scenarios. EPA uses this target range of risk as part of their decision making process to determine if action is warranted. *Therefore, DOH does not expect that exposure to cPAHs and dioxin in sediment will cause harmful cancer health effects to people.*

Child Health Considerations

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

- Children are 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.
- 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 contaminated 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. The doses calculated for the COCs are not expected to result in adverse health effects for children.

Conclusions

1. Touching, breathing, or accidentally eating sediment from public access areas, as well as areas with limited public access, is not expected to harm people's health. Public access areas included Log Boom Park and the motor boat launch areas and limited public access areas included Kenmore Harbor, Kenmore Navigation Channel, Sammamish Navigation Channel, Harbour Village Marina, and KIP. The levels of contaminants found in sediments are below levels of health concern. Exposure to sediments in these areas is not expected to cause non-cancer health effects. The estimated cancer risk associated with exposure to the sediments is considered low to insignificant and is based on lifetime exposures (72 to 78 years). Cancer risks are estimated and should not be taken to represent actual or likely risks for the public. The risks could be as low as zero.

2. Swimming or accidentally ingesting groundwater discharging from the KIP site or surface water tested by the City of Kenmore near Log Boom Park is not expected to harm people's health. The maximum level of contaminants found in groundwater at the edge of the KIP site and surface water near Log Boom Park pose an insignificant cancer risk and are not expected to cause non-cancer health effects.

Public Health Action Plan

Actions Planned

DOH will provide copies of this health consultation to the following:

- City of Kenmore
- Washington State Department of Ecology
- City of Lake Forest Park
- Washington State Department of Transportation
- Washington State Department of Fish and Wildlife
- Washington State Department of Natural Resources
- United States Army Corps of Engineers
- Public Health Seattle and King County
- Kenmore Industrial Park
- Harbour Village Marina
- North Lake Marina
- 41st Legislative District Delegation: Senator David Frockt; Representative Jessyn Farrell; Representative Gerry Pollet
- Community repositories for the public health consultation and related fact sheets will be established at the following:
    - Kenmore Public Library; 6531 NE 181 Street; Kenmore, Washington 425-486-8747
    - DOH web site – www.doh.wa.gov/consults

Report Preparation

This Health Consultation for the City of Kenmore Sediment Project on Lake Washington was prepared by the Washington State Department of Health (DOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. This report was supported by funds from a cooperative agreement with the Agency for Toxics Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

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Appendix A 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 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 (CSF)	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.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
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.
Epidemiology	The study of the occurrence and causes of health effects in human populations. An epidemiological study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor (i.e., age, sex, occupation, economic status) is associated with the health effect.
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].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].
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 (IR)	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.

Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
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 into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
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 EMEG 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].

Surface Water	Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Appendix B Screening Value Calculations

Table B1. Range of chemical concentrations detected in surface water from Lake Washington in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppb)	Comparison Value (ppb)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	0.2 U – 1 U	4		RMEG	No
Arsenic	0.9 – 2	3	A	EMEG	No
Barium	6.2 – 11	2,000	CN		No
Beryllium	0.2 U – 0.5 U	20	KL		No
Cadmium	0.2 U – 0.5	1	B1	EMEG	No
Calcium	10,200 – 15,000				No†
Chromium	0.5 U – 2 U	10†	A	EMEG	No
Copper	1.6 – 2.8	100	D	IM EMEG	No
Iron	160 – 480	11,000		RSL	No
Lead	0.1 U – 0.5	15	B2	MCL	No
Magnesium	4,210 – 5,060				No†
Manganese	12.4 – 111	500	D	IM EMEG	No
Mercury	0.1 U – 0.1 U	3	D	RMEG	No
Nickel	0.7 – 2	200		RMEG	No
Selenium	0.5 U – 2 U	50	D	EMEG	No
Silver	0.2 U – 1 U	50	D	RMEG	No
Thallium	0.2 U – 1 U	2		MCL	No
Zinc	4 U – 6	3,000	D	EMEG	No
1,2,4-Trichlorobenzene	1 U – 1 U	1,000	D	EMEG	No
1,2-Dichlorobenzene	1 U – 1 U	3,000	D	EMEG	No
1,3-Dichlorobenzene	1 U – 1 U	200	D	IM EMEG	No
1,4-Dichlorobenzene	1 U – 1 U	700		EMEG	No
2,4-Dimethylphenol	3 U – 3 U	200		RMEG	No
2-Methylphenol	1 U – 1 U	200*	C	RMEG	No
4-Methylphenol	2 U – 2 U	200*	C	RMEG	No
Benzoic acid	20 U – 20 U	40,000	D	RMEG	No
Benzyl alcohol	2 U – 2 U	1,500		RSL	No
Bis(2-ethylhexyl)phthalate	3 U – 3 U	600	B2	EMEG	No
Butyl benzyl phthalate	1 U – 1 U	2,000	C	RMEG	No
Diethyl phthalate	1 U – 1 U	8,000	D	RMEG	No

Dimethyl phthalate	1 U – 1 U	1,000**		RMEG	No
Di-n-butyl phthalate	1 U – 1 U	1,000	D	RMEG	No
Di-n-octyl phthalate	1 U – 1 U	4,000		IM EMEG	No
Hexachlorobenzene	1 U – 1 U	1	B2	IM EMEG	No
Hexachlorobutadiene	0.05 U – 0.05 U	0.45	C	CREG	No
Hexachloroethane	2 U – 2 U	7	LC	RMEG	No
N-Nitrosodiphenylamine	1 U – 1 U	7.1	B2	CREG	No
Pentachlorophenol	0.025 U – 0.024 J	0.088	B2	CREG	No
Phenol	1 U – 1 U	3,000	D	RMEG	No
1-Methylnaphthalene	0.1 U – 0.1 U	700		EMEG	No
2-Methylnaphthalene	0.1 U – 0.1 U	400		EMEG	No
Acenaphthene	0.1 U – 0.1 U	400		RSL	No
Acenaphthylene	0.1 U – 0.1 U	3,000***	D	RMEG	No
Anthracene	0.1 U – 0.1 U	3,000	D	RMEG	No
Benzo(a)anthracene	0.1 U – 0.1 U	0.2	B2	MCL	No
Benzo(a)pyrene	0.1 U – 0.1 U	0.2	B2	MCL	No
Benzo (b)fluoranthene	0.1 U – 0.1 U	0.2	B2	MCL	No
Benzo (b,j,k)fluoranthene	0.2 U – 0.2 U	0.2	B2	MCL	No
Benzo(ghi)perylene	0.1 U – 0.1 U	3,000***	D	RMEG	No
Benzo (k)fluoranthene	0.1 U – 0.1 U	0.2	B2	MCL	No
Chrysene	0.1 U – 0.1 U	2.9	B2	RSL	No
Dibenzo(a,h)anthracene	0.1 U – 0.1 U	0.2	B2	MCL	No
Dibenzofuran	0.1 U – 0.1 U	5.8	D	RSL	No
Fluoranthene	0.1 U – 0.1 U	4,000	D	IM EMEG	No
Fluorene	0.1 U – 0.1 U	4,000	D	IM EMEG	No
Indeno(1,2,3-cd)pyrene	0.1 U – 0.1 U	0.2	B2	MCL	No
Naphthalene	0.1 U – 0.1 U	6,000	C	IM EMEG	No
Phenanthrene	0.1 U – 0.1 U	3,000***	D	RMEG	No
Pyrene	0.1 U – 0.1 U	300	D	RMEG	No

ATSDR - Agency for Toxic Substances and Disease Registry
CREG - ATSDR's Cancer Risk Evaluation Guide (child)
RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
D - EPA: Not classifiable as to health carcinogenicity
LC - EPA: Likely to be carcinogenic to humans
KL - EPA: Known/Likely human carcinogen
RSL – EPA: Regional Screening Level
MCL - Maximum contaminant level - Federal and state drinking water standard

ppb - parts per billion
EPA - Environmental Protection Agency
[†] Assume hexavalent chromium
* 2,4-Dimethylphenol RMEG value was used as a surrogate
** 1,4- Dimethyl phthalate RMEG value was used as a surrogate
*** Anthracene RMEG value was used as a surrogate
† - See Public Health Implications section

Table B2. Range of chemical concentrations detected in groundwater at the Kenmore Industrial Park in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppb)	Comparison Value (ppb)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	0.2 U – 0.49 U	4		RMEG	No
Arsenic	1 U – 1.96	3	A	EMEG	No
Barium	9.98 – 931	2,000	CN		No
Cadmium	0.02 U – 0.046	1	B1	EMEG	No
Chromium	5 U – 1.73	10†	A	EMEG	No
Copper	0.23 – 1.73	100	D	IM EMEG	No
Lead	0.02 U – 1.97	15	B2	MCL	No
Mercury	0.05 U – 0.05 U	3	D	RMEG	No
Nickel	0.46 – 3.1	200		RMEG	No
Selenium	0.05 U – 0.5 U	50	D	EMEG	No
Silver	0.02 U – 0.024 J	50	D	RMEG	No
Zinc	10 U – 27.6	3,000	D	EMEG	No
1-Methylnaphthalene	0.1 U – 0.2	700		EMEG	No
2-Methylnaphthalene	0.1 U – 0.11	400		EMEG	No
Acenaphthene	0.64 – 2.2	400		RSL	No
Acenaphthylene	0.099 U – 0.1 U	3,000*	D	RMEG	No
Anthracene	0.099 U – 0.1 U	3,000	D	RMEG	No
Benzo(a)anthracene	0.01 U – 0.053	0.2	B2	MCL	No
Benzo(a)pyrene	0.01 U – 0.057	0.2	B2	MCL	No
Benzo (b)fluoranthene	0.01 U – 0.077	0.2	B2	MCL	No
Benzo (j,k)fluoranthene	0.01 U – 0.057	0.2	B2	MCL	No
Benzo(ghi)perylene	0.01 U – 0.071	3,000*	D	RMEG	No
Chrysene	0.01 U – 0.059	2.9	B2	RSL	No
Dibenzo(a,h)anthracene	0.01 U – 0.05 U	0.2	B2	MCL	No
Dibenzofuran	0.1 U – 0.1 U	5.8	D	RSL	No
Fluoranthene	0.099 U – 0.2	4,000	D	IM EMEG	No
Fluorene	0.29 U – 1	4,000	D	IM EMEG	No
Indeno(1,2,3-cd)pyrene	0.01 U – 0.055	0.2	B2	MCL	No
Naphthalene	0.1 U – 0.23	6,000	C	IM EMEG	No
Phenanthrene	0.099 U – 0.1 U	3,000*	D	RMEG	No
Pyrene	0.099 U – 0.15	300	D	RMEG	No
Diesel Range (TPH)	250 U – 280 U	500		MTCA	No
Oil Range (TPH)	400 U – 750 U	500		MTCA	No

ATSDR - Agency for Toxic Substances and Disease Registry
CREG - ATSDR's Cancer Risk Evaluation Guide (child)
RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit or analyte was not detected at or above laboratory reporting limit
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
D - EPA: Not classifiable as to health carcinogenicity
RSL – EPA: Regional Screening Level
MCL - Maximum contaminant level - Federal and state drinking water standard
ppb - parts per billion
EPA - Environmental Protection Agency
† Assume hexavalent chromium
* Anthracene RMEG value was used as a surrogate
MTCA - Washington State Department of Ecology Model Toxics Control Act

Table B3. Range of chemical concentrations detected in sediment within Log Boom Park in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	6 UJ – 10 UJ	20	D	RMEG	No
Arsenic	6 U – 10 U	15	A	EMEG	No
Cadmium	0.2 U – 0.5	5	B1	EMEG	No
Chromium	17.8 J – 27 J	150[†]	A	RMEG	No
Copper	4.3 - 220	500	D	IM EMEG	No
Lead	4 - 16	250	B2	MTCA	No
Mercury	0.02 U – 0.23	1	D	MTCA	No
Nickel	20 – 36	1,000		RMEG	No
Selenium	0.6 U – 1 U	250	D	EMEG	No
Silver	0.4 U – 0.6U	250	D	RMEG	No
Zinc	34 - 69	15,000	D	EMEG	No
Tributyltin		15[††]	CN	EMEG	No
1,2,4-Trichlorobenzene	0.018 U – 0.02 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.018 U – 0.02 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.018 U – 0.02 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.018 U – 0.02 U	3,500		EMEG	No
2,4-Dimethylphenol	0.018UJ – 0.02UJ	1,000		RMEG	No
2-Methylphenol	0.016 J – 0.02 U	1,000*	C	RMEG	No
4-Methylphenol	0.016 J – 0.15	1,000*	C	RMEG	No
Benzoic acid	0.37 U – 0.39J	200,000	D	RMEG	No
Benzyl alcohol	0.018 U – 0.21	6,100		RSL	No
Bis(2-ethylhexyl)phthalate	0.016 J – 0.46	50	B2	CREG	No
Butyl benzyl phthalate	0.016 J – 0.065	10,000	C	RMEG	No
Diethyl phthalate	0.0046 U – 0.067	40,000	D	RMEG	No
Dimethyl phthalate	0.018 U – 0.02 U	5,000		RMEG	No
Di-n-butyl phthalate	0.018 U – 0.02 U	5,000	D	RMEG	No
Di-n-octyl phthalate	0.018 U – 0.02 U	20,000		IM EMEG	No
Hexachlorobenzene	0.018 U – 0.023	0.44	B2	CREG	No
Hexachlorobutadiene	0.01 UJ – 0.01 UJ	9	C	CREG	No
Hexachloroethane	0.018 U – 0.02 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.018 U – 0.02 U	140	B2	CREG	No
Pentachlorophenol	0.18 U – 0.2 U	1.8	B2	CREG	No
Phenol	0.01 J – 0.18	15,000	D	RMEG	No

1-Methylnaphthalene	0.0025 J – 0.083	3,500		EMEG	No
2-Methylnaphthalene	0.004 J – 0.19	2,000		EMEG	No
Acenaphthene	0.0031 J – 0.12	3,000		RMEG	No
Acenaphthylene	0.0034 J – 0.02	3,000**		RMEG	No
Anthracene	0.0038 J – 0.19	15,000	D	RMEG	No
Benzo(a)anthracene	0.0046 U – 0.33	1,500*** 0.15	 B2	RMEG RSL	No Yes (cPAH)
Benzo(a)pyrene	0.0046 U – 0.21	1,500*** 0.096	 B2	RMEG CREG	No Yes (cPAH)
Benzo (b,j,k)fluoranthene	0.038 U – 0.55 (0.12)	1,500*** 0.15†††	 B2	RMEG RSL	No Yes (cPAH)
Benzo(ghi)perylene	0.0032 J – 0.074	1,500***	D		No
Chrysene	0.0046 U – 0.48	1,500*** 15	 B2	RMEG RSL	No Yes (cPAH)
Dibenzo(a,h)anthracene	0.0046 U – 0.023	1,500*** 0.096††††		RMEG CREG	No Yes (cPAH)
Dibenzofuran	0.0046 U – 0.28	78	D	RSL	No
Fluoranthene	0.0043 J – 1.1	2,000	D	RMEG	No
Fluorene	0.0024 J – 0.23	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.0046 U – 0.069	1,500*** 0.15	 B2	RMEG RSL	No Yes (cPAH)
Naphthalene	0.0046 U – 0.38	30,000	C	IM EMEG	No
Phenanthrene	0.0031 J – 0.86	1,500***	D		No
Pyrene	0.003 J – 0.74	1,500	D	RMEG	No
Total Aroclors	0.018 U – 0.028 J	1****		EMEG	No
Total cPAH (BaP-EQ)	1.09	0.1	B2	CREG	**Yes**
Total Dioxin TEQ	3.0E-7 J – 7.9E-6	5.0E-5	B2	EMEG	No

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CREG - ATSDR's Cancer Risk Evaluation Guide (child)
RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
UJ - Compound analyzed, but not detected above estimated detection limit
EPA - Environmental Protection Agency
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - EPA: Carcinogenic potential cannot be determine
D - EPA: Not classifiable as to health carcinogenicity
LC - EPA: Likely to be carcinogenic to humans
RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Tributyltin oxide EMEG value was used as a surrogate

††† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate

†††† Benzo(a)pyrene CREG value was used as a surrogate

* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate
*** Pyrene RMEG value was used as a surrogate
**** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million
BOLD values exceed comparison values

Table B4. Range of chemical concentrations detected in sediment within the motor boat launch in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	6 UJ – 7 UJ	20	D	RMEG	No
Arsenic	6 U – 7 U	15	A	EMEG	No
Cadmium	0.3 – 0.4	5	B1	EMEG	No
Chromium	28.8 J – 29.6 J	150†	A	RMEG	No
Copper	21.9 – 38.2	500	D	IM EMEG	No
Lead	7 - 11	250	B2	MTCA	No
Mercury	0.02 U – 0.03U	1	D	MTCA	No
Nickel	26 – 28	1,000		RMEG	No
Selenium	0.6 U – 0.7 U	250	D	EMEG	No
Silver	0.4 U – 0.4U	250	D	RMEG	No
Zinc	54 - 64	15,000	D	EMEG	No
1,2,4-Trichlorobenzene	0.018 U – 0.019 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.018 U – 0.019 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.018 U – 0.019 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.018 U – 0.019 U	3,500		EMEG	No
2,4-Dimethylphenol	0.018 UJ – 0.019 UJ	1,000		RMEG	No
2-Methylphenol	0.018 U – 0.019U	1,000*	C	RMEG	No
4-Methylphenol	0.037 U – 0.038U	1,000*	C	RMEG	No
Benzoic acid	0.14 J – 0.37 U	200,000	D	RMEG	No
Benzyl alcohol	0.018 U – 0.023	6100		RSL	No
Bis(2-ethylhexyl)phthalate	0.072 – 0.13	50	B2	CREG	No
Butyl benzyl phthalate	0.019 U – 0.019	10,000	C	RMEG	No
Diethyl phthalate	0.0046 U – 0.048 U	40,000	D	RMEG	No
Dimethyl phthalate	0.097 – 0.97	5,000		RMEG	No
Di-n-butyl phthalate	0.017 J – 0.028	5,000	D	RMEG	No
Di-n-octyl phthalate	0.015 J – 0.018 U	20,000		IM EMEG	No
Hexachlorobenzene	0.018 U – 0.019U	0.44	B2	CREG	No
Hexachlorobutadiene	0.01 UJ – 0.01 UJ	9	C	CREG	No
Hexachloroethane	0.018 U – 0.019 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.018 U – 0.019 U	140	B2	CREG	No
Pentachlorophenol	0.18 U – 0.19 U	1.8	B2	CREG	No
Phenol	0.011 J – 0.018 U	15,000	D	RMEG	No
1-Methylnaphthalene	0.003 J – 0.0046 U	3,500		EMEG	No

2-Methylnaphthalene	0.0035 J – 0.0058	2,000		EMEG	No
Acenaphthene	0.0046 U – 0.0048 U	3,000		RMEG	No
Acenaphthylene	0.0046 U – 0.0048 U	3,000**		RMEG	No
Anthracene	0.0037 J – 0.0046 U	15,000	D	RMEG	No
Benzo(a)anthracene	0.0096 – 0. 024	1,500*** 0.15	 B2	RMEG RSL	No No
Benzo(a)pyrene	0.01 – 0.025	1,500*** 0.096	 B2	RMEG CREG	No No
Benzo (b,j,k)fluoranthene	0.025 – 0.064	1,500*** 0.15†††	 B2	RMEG RSL	No No
Benzo(ghi)perylene	0.0069 – 0.024	1,500***	D		No
Chrysene	0.015 – 0.035	1,500*** 15	 B2	RMEG RSL	No No
Dibenzo(a,h)anthracene	0.0038 J – 0.0046 U	1,500*** 0.096††††		RMEG CREG	No No
Dibenzofuran	0.0046 U – 0.0048 U	78	D	RSL	No
Fluoranthene	0.028 – 0.063	2,000	D	RMEG	No
Fluorene	0.0032 J – 0.0042 J	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.0057 – 0.019	1,500*** 0.15	 B2	RMEG RSL	No No
Naphthalene	0.0033 J – 0.0042 J	30,000	C	IM EMEG	No
Phenanthrene	0.011 – 0.048	1,500***	D		No
Pyrene	0.026 – 0.068	1,500	D	RMEG	No
Total Aroclors	0.017 U – 0.019 U	1****		EMEG	No
Total Dioxin TEQ	5.6E-7 J – 1.4E-6 J	5.0E-5	B2	EMEG	No

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IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
UJ - Compound analyzed, but not detected above estimated detection limit
EPA - Environmental Protection Agency
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - EPA: Carcinogenic potential cannot be determine
D - EPA: Not classifiable as to health carcinogenicity
LC - EPA: Likely to be carcinogenic to humans
RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Tributyltin oxide EMEG value was used as a surrogate

††† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate

†††† Benzo(a)pyrene CREG value was used as a surrogate

* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate
*** Pyrene RMEG value was used as a surrogate
**** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million

Table B5. Range of chemical concentrations detected in sediment within Kenmore Industrial Park shoreline in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	6 UJ – 10 UJ	20	D	RMEG	No
Arsenic	6 UJ – 10 UJ	15	A	EMEG	No
Cadmium	0.2 U – 0.4 U	5	B1	EMEG	No
Chromium	20.9 – 54	150[†]	A	RMEG	No
Copper	5.4 J – 13.5 J	500	D	IM EMEG	No
Lead	4 J – 7 J	250	B2	MTCA	No
Mercury	0.03 U – 0.04	1	D	MTCA	No
Nickel	20 – 34	1,000		RMEG	No
Selenium	0.6 U – 1 U	250	D	EMEG	No
Silver	0.4 U – 0.6U	250	D	RMEG	No
Zinc	43 J – 64 J	15,000	D	EMEG	No
Tributytin	0.0036 U	15[††]	CN	EMEG	No
1,2,4-Trichlorobenzene	0.019 U – 0.019 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.019 U – 0.019 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.019 U – 0.019 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.019 U – 0.019 U	3,500		EMEG	No
2,4-Dimethylphenol	0.019 UJ – 0.019 UJ	1,000		RMEG	No
2-Methylphenol	0.019 U – 0.019U	1,000*	C	RMEG	No
4-Methylphenol	0.01 J – 0.27	1,000*	C	RMEG	No
Benzoic acid	0.37 U – 0.43	200,000	D	RMEG	No
Benzyl alcohol	0.019 U – 0.062	6,100		RSL	No
Bis(2-ethylhexyl)phthalate	0.019 J – 0.15	50	B2	CREG	No
Butyl benzyl phthalate	0.019 U – 0.019 U	10,000	C	RMEG	No
Diethyl phthalate	0.0047 U – 0.048 U	40,000	D	RMEG	No
Dimethyl phthalate	0.019 U – 0.038	5,000		RMEG	No
Di-n-butyl phthalate	0.019 U – 0.019 U	5,000	D	RMEG	No
Di-n-octyl phthalate	0.011 J – 0.019 U	20,000		IM EMEG	No
Hexachlorobenzene	0.00097 U – 0.019U	0.44	B2	CREG	No
Hexachlorobutadiene	0.01 UJ – 0.01 UJ	9	C	CREG	No
Hexachloroethane	0.019 U – 0.019 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.019 U – 0.019 U	140	B2	CREG	No
Pentachlorophenol	0.19 U – 0.19 U	1.8	B2	CREG	No

Phenol	0.019 U – 0.082	15,000	D	RMEG	No
1-Methylnaphthalene	0.0047 U – 0.0049 U	3,500		EMEG	No
2-Methylnaphthalene	0.0047 U – 0.0074	2,000		EMEG	No
Acenaphthene	0.0038 J – 0.0049 U	3,000		RMEG	No
Acenaphthylene	0.0047 U – 0.0049 U	3,000**		RMEG	No
Anthracene	0.0047 U – 0.011 J	15,000	D	RMEG	No
Benzo(a)anthracene	0.0046 J – 0. 042	1,500*** 0.15	 B2	RMEG RSL	No No
Benzo(a)pyrene	0.0029 J – 0.041	1,500*** 0.096	 B2	RMEG CREG	No No
Benzo (b,j,k)fluoranthene	0.0082 – 0.091	1,500*** 0.15†††	 B2	RMEG RSL	No No
Benzo(ghi)perylene	0.0047 U – 0.027	1,500***	D		No
Chrysene	0.003 J – 0.064	1,500*** 15	 B2	RMEG RSL	No No
Dibenzo(a,h)anthracene	0.0047 U – 0.0049 U	1,500*** 0.096††††		RMEG CREG	No No
Dibenzofuran	0.0048 U – 0.0047	78	D	RSL	No
Fluoranthene	0.0011 J – 0.13	2,000	D	RMEG	No
Fluorene	0.0025 J – 0.0055	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.0047 U – 0.024	1,500*** 0.15	 B2	RMEG RSL	No No
Naphthalene	0.004 J – 0.0047 U	30,000	C	IM EMEG	No
Phenanthrene	0.0026 J – 0.093	1,500***	D		No
Pyrene	0.0097 J – 0.12	1,500	D	RMEG	No
Total Aroclors	0.018 U – 0.019 U	1****		EMEG	No
Total Dioxin TEQ	3.6E-7 J – 2.3E-6 J	5.0E-5	B2	EMEG	No

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IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
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EPA - Environmental Protection Agency
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - EPA: Carcinogenic potential cannot be determine
D - EPA: Not classifiable as to health carcinogenicity
LC - EPA: Likely to be carcinogenic to humans
RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Tributyltin oxide EMEG value was used as a surrogate

††† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate

†††† Benzo(a)pyrene CREG value was used as a surrogate

* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate
*** Pyrene RMEG value was used as a surrogate
**** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million

Table B6. Range of chemical concentrations detected in sediment within Kenmore Navigation Channel in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	6 U – 20 U	20	D	RMEG	No
Arsenic	6 U – 20 U	15	A	EMEG	No
Cadmium	0.3 – 0.8	5	B1	EMEG	No
Chromium	35 – 57	150†	A	RMEG	No
Copper	14.6 – 43.6	500	D	IM EMEG	No
Lead	5 – 31	250	B2	MTCA	No
Mercury	0.02 U – 0.11	1	D	MTCA	No
Nickel	30 – 46	1,000		RMEG	No
Selenium	0.6 U – 2 U	250	D	EMEG	No
Silver	0.4 U – 1U	250	D	RMEG	No
Zinc	49 – 164	15,000	D	EMEG	No
1,2,4-Trichlorobenzene	0.019 U – 0.02 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.019 U – 0.02 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.019 U – 0.02 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.019 U – 0.02 U	3,500		EMEG	No
2,4-Dimethylphenol	0.019 UJ – 0.02 UJ	1,000		RMEG	No
2-Methylphenol	0.019 U – 0.02 UJ	1,000*	C	RMEG	No
4-Methylphenol	0.022 J – 0.091	1,000*	C	RMEG	No
Benzoic acid	0.3 J – 1.3	200,000	D	RMEG	No
Benzyl alcohol	0.02 U – 0.19	6,100		RSL	No
Bis(2-ethylhexyl)phthalate	0.062 – 0.54	50	B2	CREG	No
Butyl benzyl phthalate	0.019 U – 0.057	10,000	C	RMEG	No
Diethyl phthalate	0.048 U – 0.058	40,000	D	RMEG	No
Dimethyl phthalate	0.019 U – 0.02 U	5,000		RMEG	No
Di-n-butyl phthalate	0.012 J – 0.02 U	5,000	D	RMEG	No
Di-n-octyl phthalate	0.019 U – 0.041	20,000		IM EMEG	No
Hexachlorobenzene	0.0048 U – 0.005U	0.44	B2	CREG	No
Hexachlorobutadiene	0.0048 U – 0.005U	9	C	CREG	No
Hexachloroethane	0.019 U – 0.02 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.019 U – 0.02 U	140	B2	CREG	No
Pentachlorophenol	0.19 U – 0.2 U	1.8	B2	CREG	No
Phenol	0.02 U – 0.18	15,000	D	RMEG	No
1-Methylnaphthalene	0.0096 J – 0.02 U	3,500		EMEG	No

2-Methylnaphthalene	0.019 U – 0.026	2,000		EMEG	No
Acenaphthene	0.019 U – 0.026	3,000		RMEG	No
Acenaphthylene	0.019 U – 0.02 U	3,000**		RMEG	No
Anthracene	0.019 U – 0.039	15,000	D	RMEG	No
Benzo(a)anthracene	0.04 – 0. 11	1,500*** 0.15	B2	RMEG RSL	No Yes (cPAH)
Benzo(a)pyrene	0.045 – 0.12	1,500*** 0.096	B2	RMEG CREG	No Yes (cPAH)
Benzo (b,j,k)fluoranthene	0.12 – 0.3	1,500*** 0.15††	B2	RMEG RSL	No Yes (cPAH)
Benzo(ghi)perylene	0.036 – 0.093	1,500***	D		No
Chrysene	0.072 – 0.19	1,500*** 15	B2	RMEG RSL	No Yes (cPAH)
Dibenzo(a,h)anthracene	0.011 J – 0.037	1,500*** 0.096†††		RMEG CREG	No Yes (cPAH)
Dibenzofuran	0.019 U – 0.028	78	D	RSL	No
Fluoranthene	0.12 – 0.31	2,000	D	RMEG	No
Fluorene	0.019 U – 0.037	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.033 – 0.081	1,500*** 0.15	B2	RMEG RSL	No Yes (cPAH)
Naphthalene	0.02 U – 0.050	30,000	C	IM EMEG	No
Phenanthrene	0.059 – 0.18	1,500***	D		No
Pyrene	0.12 – 0.3	1,500	D	RMEG	No
4,4-DDD	0.0016 U – 0.0017 U	2.9	B2	CREG	No
4,4-DDE	0.0016 U – 0.0017 U	2.1	B2	CREG	No
4,4-DDT	0.0016 U – 0.0017 U	2.1	B2	CREG	No
Aldrin	0.00063U – 0.00065U	0.041	B2	CREG	No
Chlordane, alpha	0.00081U – 0.00084U	2****	KL	CREG	No
Chlordane, beta	0.00076U – 0.00079U	2****	KL	CREG	No
Dieldrin	0.0016 U – 0.0017 U	0.044	B2	CREG	No
Heptachlor	0.00063U – 0.00065U	0.16	B2	CREG	No
Nonachlor, cis-	0.0016U – 0.0016 U	2****	KL	CREG	No
Nonachlor, tras-	0.0046 U – 0.0048 U	2****	KL	CREG	No
Oxychlordane	0.0022 U – 0.0023 U	2****	KL	CREG	No
Total Aroclors	0.018 U – 0.022	1*****		EMEG	No
Total cPAH (BaP-EQ)	0.80	0.1	B2	CREG	**Yes**
Total Dioxin TEQ	1.5E-6 J – 8.4E-6 J	5.0E-5	B2	EMEG	No

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EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
UJ - Compound analyzed, but not detected above estimated detection limit
EPA - Environmental Protection Agency
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - EPA: Carcinogenic potential cannot be determine
D - EPA: Not classifiable as to health carcinogenicity
LC - EPA: Likely to be carcinogenic to humans
KL - EPA: Known/Likely human carcinogen
RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate
††† Benzo(a)pyrene CREG value was used as a surrogate
* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate
*** Pyrene RMEG value was used as a surrogate
**** Chlordane CREG value was used as a surrogate
***** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million
BOLD values exceed comparison values

Table B7. Range of chemical concentrations detected in sediment within Harbour Village Marina in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	9 UJ – 30 UJ	20	D	RMEG	No
Arsenic	9 UJ – 30 UJ	15	A	EMEG	No
Cadmium	0.9 U – 0.4	5	B1	EMEG	No
Chromium	29.8 – 55	150†	A	RMEG	No
Copper	18.8 J – 97 J	500	D	IM EMEG	No
Lead	19 J – 50 J	250	B2	MTCA	No
Mercury	0.04 – 0.1	1	D	MTCA	No
Nickel	33 – 47	1,000		RMEG	No
Selenium	0.9 U – 3 U	250	D	EMEG	No
Silver	0.5 U – 2 U	250	D	RMEG	No
Zinc	97 J – 377 J	15,000	D	EMEG	No
Tributytin	0.0036 U – 0.012	15††	CN	EMEG	No
1,2,4-Trichlorobenzene	0.02 U – 0.02 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.02 U – 0.02 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.02 U – 0.02 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.02 U – 0.02 U	3,500		EMEG	No
2,4-Dimethylphenol	0.02 UJ – 0.02 UJ	1,000		RMEG	No
2-Methylphenol	0.02 U – 0.014 J	1,000*	C	RMEG	No
4-Methylphenol	0.074 – 0.16	1,000*	C	RMEG	No
Benzoic acid	0.52 – 1.7	200,000	D	RMEG	No
Benzyl alcohol	0.2 – 0.53	6,100		RSL	No
Bis(2-ethylhexyl)phthalate	0.36 – 0.74	50	B2	CREG	No
Butyl benzyl phthalate	0.02 U – 0.082	10,000	C	RMEG	No
Diethyl phthalate	0.05 U – 0.1	40,000	D	RMEG	No
Dimethyl phthalate	0.02 U – 0.02 U	5,000		RMEG	No
Di-n-butyl phthalate	0.02 U – 0.026	5,000	D	RMEG	No
Di-n-octyl phthalate	0.02 U – 0.087	20,000		IM EMEG	No
Hexachlorobenzene	0.0039 U – 0.0049 U	0.44	B2	CREG	No
Hexachlorobutadiene	0.0039 U – 0.0049 U	9	C	CREG	No
Hexachloroethane	0.02 U – 0.02 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.02 U – 0.02 U	140	B2	CREG	No
Pentachlorophenol	0.2 U – 0.055 J	1.8	B2	CREG	No

Phenol	0.055 – 0.35	15,000	D	RMEG	No
1-Methylnaphthalene	0.0052 – 0.018 J	3,500		EMEG	No
2-Methylnaphthalene	0.012 – 0.047	2,000		EMEG	No
Acenaphthene	0.014 – 0.032	3,000		RMEG	No
Acenaphthylene	0.0035 J – 0.026	3,000**		RMEG	No
Anthracene	0.041 – 0.066	15,000	D	RMEG	No
Benzo(a)anthracene	0.12 – 0.2	1,500*** 0.15	B2	RMEG RSL	No Yes (cPAH)
Benzo(a)pyrene	0.11 – 0.21	1,500*** 0.096	B2	RMEG CREG	No Yes (cPAH)
Benzo (b,j,k)fluoranthene	0.29 – 0.57	1,500*** 0.15†††	B2	RMEG RSL	No Yes (cPAH)
Benzo(ghi)perylene	0.085 – 0.14	1,500***	D		No
Chrysene	0.21 – 0.37	1,500*** 15	B2	RMEG RSL	No Yes (cPAH)
Dibenzo(a,h)anthracene	0.026 – 0.045	1,500*** 0.096††††		RMEG CREG	No Yes (cPAH)
Dibenzofuran	0.012 – 0.024	78	D	RSL	No
Fluoranthene	0.22 – 0.48	2,000	D	RMEG	No
Fluorene	0.028 – 0.059	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.077 – 0.11	1,500*** 0.15	B2	RMEG RSL	No Yes (cPAH)
Naphthalene	0.038 – 0.04	30,000	C	IM EMEG	No
Phenanthrene	0.16 – 0.26	1,500***	D		No
Pyrene	0.23 – 0.8	1,500	D	RMEG	No
4,4-DDD	0.0013 U – 0.0017 U	2.9	B2	CREG	No
4,4-DDE	0.0016 U – 0.0072 J	2.1	B2	CREG	No
4,4-DDT	0.0013 U – 0.0017 U	2.1	B2	CREG	No
Aldrin	0.00051U – 0.00064U	0.041	B2	CREG	No
Chlordane, alpha	0.00066U – 0.00083U	2****	KL	CREG	No
Chlordane, beta	0.00062U – 0.00078U	2****	KL	CREG	No
Dieldrin	0.0013 U – 0.0017 U	0.044	B2	CREG	No
Heptachlor	0.00051U – 0.00064U	0.16	B2	CREG	No
Nonachlor, cis-	0.0013U – 0.0016 U	2****	KL	CREG	No
Nonachlor, tras-	0.0038 U – 0.0047 U	2****	KL	CREG	No
Oxychlordane	0.0018 U – 0.0023 U	2****	KL	CREG	No
Total Aroclors	0.032 U – 0.029 J	1*****		EMEG	No
Total cPAH (BaP-EQ)	1.23	0.1	B2	CREG	**Yes**
Total Dioxin TEQ	6.6E-6 J – 7.1E-5 J	5.0E-5	B2	EMEG	**Yes**

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EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
UJ - Compound analyzed, but not detected above estimated detection limit
EPA - Environmental Protection Agency
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - EPA: Carcinogenic potential cannot be determine
D - EPA: Not classifiable as to health carcinogenicity
LC - EPA: Likely to be carcinogenic to humans
KL - EPA: Known/Likely human carcinogen
RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate
††† Benzo(a)pyrene CREG value was used as a surrogate
* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate
*** Pyrene RMEG value was used as a surrogate
**** Chlordane CREG value was used as a surrogate
***** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million
BOLD values exceed comparison values

Table B8. Range of chemical concentrations detected in sediment within Kenmore Harbor in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	10 UJ	20	D	RMEG	No
Arsenic	10 UJ	15	A	EMEG	No
Cadmium	0.7	5	B1	EMEG	No
Chromium	36	150†	A	RMEG	No
Copper	111 J	500	D	IM EMEG	No
Lead	26 J	250	B2	MTCA	No
Mercury	0.24	1	D	MTCA	No
Nickel	35	1,000		RMEG	No
Selenium	1 U	250	D	EMEG	No
Silver	0.7 U	250	D	RMEG	No
Zinc	182 J	15,000	D	EMEG	No
1,2,4-Trichlorobenzene	0.019 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.019 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.019 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.019 U	3,500		EMEG	No
2,4-Dimethylphenol	0.019 UJ	1,000		RMEG	No
2-Methylphenol	0.019 U	1,000*	C	RMEG	No
4-Methylphenol	0.059	1,000*	C	RMEG	No
Benzoic acid	0.61	200,000	D	RMEG	No
Benzyl alcohol	0.1	6,100		RSL	No
Bis(2-ethylhexyl)phthalate	0.28	50	B2	CREG	No
Butyl benzyl phthalate	0.043	10,000	C	RMEG	No
Diethyl phthalate	0.068	40,000	D	RMEG	No
Dimethyl phthalate	0.019 U	5,000		RMEG	No
Di-n-butyl phthalate	0.019 U	5,000	D	RMEG	No
Di-n-octyl phthalate	0.024	20,000		IM EMEG	No
Hexachlorobenzene	0.0049 U	0.44	B2	CREG	No
Hexachlorobutadiene	0.0049 U	9	C	CREG	No
Hexachloroethane	0.019 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.019 U	140	B2	CREG	No
Pentachlorophenol	0.19 U	1.8	B2	CREG	No
Phenol	0.08	15,000	D	RMEG	No
1-Methylnaphthalene	0.034	3,500		EMEG	No

2-Methylnaphthalene	0.059	2,000		EMEG	No
Acenaphthene	0.13	3,000		RMEG	No
Acenaphthylene	0.026	3,000**		RMEG	No
Anthracene	0.15	15,000	D	RMEG	No
Benzo(a)anthracene	0.36	1,500*** 0.15	 B2	RMEG RSL	No Yes (cPAH)
Benzo(a)pyrene	0.25	1,500*** 0.096	 B2	RMEG CREG	No Yes (cPAH)
Benzo (b,j,k)fluoranthene	0.72	1,500*** 0.15††	 B2	RMEG RSL	No Yes (cPAH)
Benzo(ghi)perylene	0.095	1,500***	D		No
Chrysene	0.55	1,500*** 15	 B2	RMEG RSL	No Yes (cPAH)
Dibenzo(a,h)anthracene	0.042	1,500*** 0.096†††		RMEG CREG	No Yes (cPAH)
Dibenzofuran	0.09	78	D	RSL	No
Fluoranthene	1.2	2,000	D	RMEG	No
Fluorene	0.15	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.097	1,500*** 0.15	 B2	RMEG RSL	No Yes (cPAH)
Naphthalene	0.17	30,000	C	IM EMEG	No
Phenanthrene	0.83	1,500***	D		No
Pyrene	0.92	1,500	D	RMEG	No
4,4-DDD	0.0017 U	2.9	B2	CREG	No
4,4-DDE	0.0017 U	2.1	B2	CREG	No
4,4-DDT	0.0017 U	2.1	B2	CREG	No
Aldrin	0.00064 U	0.041	B2	CREG	No
Chlordane, alpha	0.00082 U	2****	KL	CREG	No
Chlordane, beta	0.00077 U	2****	KL	CREG	No
Dieldrin	0.0016 U	0.044	B2	CREG	No
Heptachlor	0.00064 U	0.16	B2	CREG	No
Nonachlor, cis-	0.0016 U	2****	KL	CREG	No
Nonachlor, tras-	0.0047 U	2****	KL	CREG	No
Oxychlordane	0.0023 U	2****	KL	CREG	No
Total Aroclors	0.02	1*****		EMEG	No
Total cPAH (BaP-EQ)	1.42	0.1	B2	CREG	**Yes**
Total Dioxin TEQ	1.0E-5 J	5.0E-5	B2	EMEG	No

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RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
IM EMEG - ATSDR's Intermediate Environmental Media Evaluation Guide (child)
J - Estimated value
U - Compound analyzed, but not detected above detection limit
UJ - Compound analyzed, but not detected above estimated detection limit
EPA - Environmental Protection Agency
A - EPA: human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
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RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate
††† Benzo(a)pyrene CREG value was used as a surrogate
* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate
*** Pyrene RMEG value was used as a surrogate
**** Chlordane CREG value was used as a surrogate
***** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million
BOLD values exceed comparison values

Table B9. Range of chemical concentrations detected in sediment within the Sammamish Navigation Channel in Kenmore, King County, Washington.

Compounds	Range of Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	6 UJ	20	D	RMEG	No
Arsenic	6 UJ	15	A	EMEG	No
Cadmium	0.2 U	5	B1	EMEG	No
Chromium	29.3	150†	A	RMEG	No
Copper	5.9 J	500	D	IM EMEG	No
Lead	4 J	250	B2	MTCA	No
Mercury	0.03 U	1	D	MTCA	No
Nickel	23	1,000		RMEG	No
Selenium	0.6 U	250	D	EMEG	No
Silver	0.4 U	250	D	RMEG	No
Zinc	43 J	15,000	D	EMEG	No
1,2,4-Trichlorobenzene	0.019 U	5,000	D	EMEG	No
1,2-Dichlorobenzene	0.019 U	15,000		EMEG	No
1,3-Dichlorobenzene	0.019 U	1,000	D	IM EMEG	No
1,4-Dichlorobenzene	0.019 U	3,500		EMEG	No
2,4-Dimethylphenol	0.019 UJ	1,000		RMEG	No
2-Methylphenol	0.019 UJ	1,000*	C	RMEG	No
4-Methylphenol	0.038 U	1,000*	C	RMEG	No
Benzoic acid	0.38 U	200,000	D	RMEG	No
Benzyl alcohol	0.019 U	6,100		RSL	No
Bis(2-ethylhexyl)phthalate	0.028	50	B2	CREG	No
Butyl benzyl phthalate	0.019 U	10,000	C	RMEG	No
Diethyl phthalate	0.048 U	40,000	D	RMEG	No
Dimethyl phthalate	0.019 U	5,000		RMEG	No
Di-n-butyl phthalate	0.019 U	5,000	D	RMEG	No
Di-n-octyl phthalate	0.019 U	20,000		IM EMEG	No
Hexachlorobenzene	0.019 U	0.44	B2	CREG	No
Hexachlorobutadiene	0.01 UJ	9	C	CREG	No
Hexachloroethane	0.019 U	18	LC	CREG	No
N-Nitrosodiphenylamine	0.019 U	140	B2	CREG	No
Pentachlorophenol	0.19 U	1.8	B2	CREG	No
Phenol	0.019 U	15,000	D	RMEG	No
1-Methylnaphthalene	0.0048 U	3,500		EMEG	No

2-Methylnaphthalene	0.0048 U	2,000		EMEG	No
Acenaphthene	0.0048 U	3,000		RMEG	No
Acenaphthylene	0.0048 U	3,000**		RMEG	No
Anthracene	0.0048 U	15,000	D	RMEG	No
Benzo(a)anthracene	0. 015 J	1,500*** 0.15	 B2	RMEG RSL	No No (cPAH)
Benzo(a)pyrene	0. 015 J	1,500*** 0.096	 B2	RMEG CREG	No No (cPAH)
Benzo (b,j,k)fluoranthene	0.035 J	1,500*** 0.15††	 B2	RMEG RSL	No No (cPAH)
Benzo(ghi)perylene	0.0032 J	1,500***	D		No
Chrysene	0.02	1,500*** 15	 B2	RMEG RSL	No No (cPAH)
Dibenzo(a,h)anthracene	0.0048 U	1,500*** 0.096†††		RMEG CREG	No No (cPAH)
Dibenzofuran	0.0048 U	78	D	RSL	No
Fluoranthene	0.051	2,000	D	RMEG	No
Fluorene	0.0048 U	2,000	D	RMEG	No
Indeno(1,2,3-cd)pyrene	0.0036 J	1,500*** 0.15	 B2	RMEG RSL	No No (cPAH)
Naphthalene	0.0048 U	30,000	C	IM EMEG	No
Phenanthrene	0.026	1,500***	D		No
Pyrene	0.039	1,500	D	RMEG	No
Total Aroclors	0.017 U	1****		EMEG	No
Total Dioxin TEQ	4.6E-7 J	5.0E-5	B2	EMEG	No

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J - Estimated value
U - Compound analyzed, but not detected above detection limit
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EPA - Environmental Protection Agency
A - EPA: human carcinogen
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RSL – EPA: Regional Screening Level
† Assume hexavalent chromium
†† Benzo (b)fluoranthene carcinogenic EPA: Regional Screening Level value was used as a surrogate
††† Benzo(a)pyrene CREG value was used as a surrogate
* 2,4-Dimethylphenol RMEG value was used as a surrogate
** Acenaphthene RMEG value was used as a surrogate

*** Pyrene RMEG value was used as a surrogate
**** Arocolor 1254 EMEG value was used as a surrogate
Total Dioxin TEQ – sum of dioxin/furans toxic equivalent (TEQ)
cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
PPM – parts per million

Appendix C Exposure Assumptions

This section provides calculated exposure doses and assumptions used for exposure to chemicals in sediment along Lake Washington for 30 and 120 days. The different exposure scenarios were developed to model exposures that might occur. These scenarios were devised to represent exposures over a lifetime from a child to an adult. The following exposure parameters and dose equations were used to estimate exposure doses from direct contact with chemicals in sediment.

Exposure to chemicals in sediments via ingestion and dermal absorption.

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

Total Risk $_{(cancer)}$ = Ingested + dermally absorbed dose

Ingestion Route

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

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

Dermal Route

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

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

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

Table C1. Assumptions used in exposure evaluation of people in contact with sediments from the Kenmore area of Lake Washington, King County, Washington.

Parameter and Abbreviation		Value	Units	Source
Concentration in Sediment	Cs	Variable	mg/kg	Maximum chemical-specific concentration for sediment
Conversion Factor	CF	0.000001	kg/mg	Converts from kilograms sediment to milligrams sediment
Body Weight	BW	9.2	kg	Child 0.5 to < 1 year [19]
		11.4		Child 1 to < 2 years [19]
		17.4		Child 2 to < 6 years [19]
		31.8		Child 6 to < 11 years [19]
		56.8		Child 11 to < 16 years [19]
		71.6		Child 16 to < 21 years [19]
		80		Adult 21 to < 65 years [19]
		76		Adult 65+ years [19]
Exposure Frequency	EF	15	days/year	Limited access areas
		30		General population, number of days per year in sediments
		120		General population resident, based on number of days during summer (4 months year) per year in sediments
Age-specific Exposure Duration (used for age-specific calculations)	ED	0.5	year	Child 0.5 to < 1 year
		1		Child 1 to < 2 years
		4		Child 2 to < 6 years
		5		Child 6 to < 11 years
		5		Child 11 to <16 years
		5		Child 16 to <21 years
		44		Adult 21 to < 65 years
		13		Adult 65+
Averaging Time$_{non\text{-}cancer}$	AT	Variable	day	Equal to Exposure Duration
Averaging Time$_{cancer}$	AT	28,470		78 years
Minimal Risk Level	MRL	1.00E-9	mg/kg/day	Dioxins (ATSDR)
Cancer Slope Factor	CSF	7.3	mg/kg-day^{-1}	BaP used as a reference chemical for cPAHs [13]
		150,000		Dioxins [20]
Ingestion Parameters				
Incidental Ingestion Rate	IR	60	mg/day	Child 0.5 years to < 1 year [19]
		100		Child 1 to < 21 years [19]
		50		Adult > 21 years [19]
Dermal Parameters				
Oral Route Adjustment Factor	ORAF	1	unitless	Cancer (c) – default, [21]

Parameter and Abbreviation		Value	Units	Source
Absorption Duration	AD	1	day	Fraction of day sediment is in contact with the skin (worst-case) [21]
Skin-sediment Adherence Factor	AF	0.07	mg/cm^2	Amount of sediment that adheres to skin, adult [21]
		0.2		Amount of sediment that adheres to skin, child (< 1-21 years) [21]
Dermal Absorption Factor	ABS	Dioxin 0.03	unitless	Chemical-specific, fraction of chemical that absorbs through the skin in 24-hours [21]
		PAH 0.13		
Surface Area	SA	1,800	cm^2	Child 0-1 year
		1,700		Child 1-2 years
		2,500		Child 2-6 years
		3,600		Child 6-11 years
		5,900		Child 11-21 years
		5,700		Adult

Abbreviations not defined in the table:

ATSDR	Agency for Toxic Substances and Disease Registry
EPA	U.S. Environmental Protection Agency
mg	milligram
kg	kilogram
mg/kg	milligrams chemical per kilogram dry weight (same as parts per million, ppm)
mg/kg/day	Daily dose in milligrams chemical per kilograms bodyweight per day
kg/mg	kilogram per milligrams
mg/cm^2	milligrams per square centimeter
cm^2	square centimeter
mg/day	milligrams per day
cPAHs	Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP	Benzo(a)pyrene
MRL	Minimum Risk Level established by ATSDR

Table C2: Benzo(a)pyrene relative potency equivalent (BaP-EQ) for Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) [13, 14].

Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)	BaP-EQ
Benzo(a)anthracene	0.2
Chrysene	0.1
Benzo(a)pyrene	1
Dibenz(a,h)anthracene	10
Benzo(g,h,i)perylene	0.009
Indeno(1,2,3-cd)pyrene	0.07
Benzo(b,j,k)fluoranthene	0.8*
Fluoranthene	0.08

cPAHs – Carcinogenic Polycyclic Aromatic Hydrocarbons
BaP-EQ – Benzo(a)pyrene Equivalents: sum of individual cPAHs multiplied by the relative potency factor (RPF) describing the carcinogenic potential relative to BaP.
* Benzo(b)fluoranthene BaP-EQ was used as surrogate for Benzo(b,j,k)fluoranthene

Table C3. Location-specific non-cancer dose calculated from maximum exposure to dioxin concentration in sediment at limited access area, Kenmore, King County, Washington.

Location	Maximum Concentration TEQ (mg/kg)	Age	MRL	Estimated Dose (15 days per year) (mg/kg/day)		Total Dose	Hazard Quotient
				Ingestion	Dermal Contact		
Harbour Village Marina	7.1E-5	Child < 2 years	1.00E-9	NA	NA	NA	NA
		Child 2 to < 6 years		NA	NA	NA	NA
		Child 6 to < 11 years		9.18E-12	1.98E-12	1.12E-11	0.01
		Child 11 to < 21 years		9.21E-12	3.26E-12	1.25E-11	0.01
		Adult 21+ years		3.74E-12	8.96E-13	4.64E-12	0.005

Abbreviations

<	less than
ATSDR	Agency for Toxic Substances and Disease Registry
mg/kg	milligrams chemical per kilogram dry weight (same as parts per million, ppm)
mg/kg/day	Daily dose in milligrams chemical per kilograms bodyweight per day
MRL	Minimum Risk Level established by ATSDR
TEQ	Toxic Equivalency Quotient
yr	year
NA	Not Appreciable – 4.5 feet or more of water

Hazard Quotient (HQ) formula:

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

Table C4. Location-specific carcinogenic risk estimates from exposure to the maximum concentration of carcinogenic polycyclic aromatic hydrocarbons (cPAH) Benzo(a)pyrene relative potency equivalent (BaP-EQ) in sediment, Kenmore, Washington.

Location	Maximum Concentration (mg/kg)	Age	Cancer Slope Factor	Increased Cancer Risk (30 days per year exposure)			Increased Cancer Risk (120 days per year exposure)		
				Ingestion	Dermal Contact	Total	Ingestion	Dermal Contact	Total
Log Boom Park	1.09	Child < 2 years	7.3	1.01E-06	5.38E-07	1.55E-06	4.04E-06	2.15E-06	6.19E-06
		Child 2 to < 6 years		5.78E-07	8.76E-07	9.54E-06	2.31E-06	1.50E-06	3.82E-06
		Child 6 to < 11 years		3.96E-07	3.70E-07	7.66E-07	1.58E-06	1.48E-06	3.06E-06
		Child 11 to < 21 years		2.80E-07	4.29E-07	7.09E-07	1.12E-06	1.72E-06	2.84E-06
		Adult 21+ years		3.02E-07	3.14E-07	6.16E-07	1.21E-06	1.25E-06	2.84E-06
		Lifetime		2.56E-06	2.03E-06	4.59E-06	1.03E-05	8.11E-06	1.84E-05

Abbreviations

<	less than
ATSDR	Agency for Toxic Substances and Disease Registry
CSF	Cancer slope factor
EPA	U.S. Environmental Protection Agency
mg/kg	milligrams chemical per kilogram dry weight (same as parts per million, ppm)
mg/kg-day	Daily dose in milligrams chemical per kilograms bodyweight per day
yr	year

Table C5. Location-specific carcinogenic risk estimates for exposure to maximum concentrations of contaminants in in-water sediments at limited access areas, Kenmore, King County, Washington.

Location	Contaminant	Maximum Concentration TEQ (mg/kg)	Age	Cancer Slope Factor	Increased Cancer Risk (15 days per year exposure)		
					Ingestion	Dermal Contact	Total
Harbour Village Marina	Dioxin	7.1E-5	Child < 2 years	150000*	NA	NA	NA
			Child 2 to < 6 years		NA	NA	NA
			Child 6 to < 11 years		8.82E-08	1.91E-08	1.07E-07
			Child 11 to < 21 years		8.86E-08	3.65E-08	1.20E-07
			Adult 21+ years		2.02E-07	5.08E-08	2.51E-07
			Lifetime		3.79E-07	1.06E-07	4.78E-07
Harbour Village Marina	cPAH	1.23	Child < 2 years	7.3	NA	NA	NA
			Child 2 to < 6 years		NA	NA	NA
			Child 6 to < 11 years		2.23E-07	2.09E-07	4.32E-07
			Child 11 to < 21 years		1.58E-07	2.42E-07	4.00E-07
			Adult 21+ years		1.71E-07	1.77E-07	3.47E-07
			Lifetime		5.52E-07	6.28E-07	1.18E-06
Kenmore Navigation Channel		0.801	Child < 2 years		NA	NA	NA
			Child 2 to < 6 years		NA	NA	NA
			Child 6 to < 11 years		1.45E-07	1.36E-07	2.81E-07
			Child 11 to < 21 years		1.03E-07	1.58E-07	2.61E-07
			Adult 21+ years		1.11E-07	1.15E-07	2.26E-07
			Lifetime		3.59E-07	4.09E-07	7.68E-07
Kenmore Harbor		1.48	Child < 2 years		NA	NA	NA
			Child 2 to < 6 years		NA	NA	NA
			Child 6 to < 11 years		2.69E-07	2.51E-07	5.20E-07
			Child 11 to < 21 years		1.90E-07	2.92E-07	4.82E-07
			Adult 21+ years		2.05E-07	2.13E-07	4.18E-07
			Lifetime		6.64E-07	7.55E-07	1.42E-06

Abbreviations	
<	less than
CSF	Cancer slope factor
mg/kg	milligrams chemical per kilogram dry weight (same as parts per million, ppm)
mg/kg-day	Daily dose in milligrams chemical per kilograms bodyweight per day
TEQ	Toxic Equivalency Quotient
yr	year
*	HEAST = EPA's Health Effects Assessment Summary Tables [20]
EPA	U.S. Environmental Protection Agency
NA	Not Appreciable – 4.5 feet or more of water

Harbour Village Marina Lifetime Cancer Risk (cPAH and Dioxin-15 days per year) – 1.18E-6 + 4.78E-7 = 1.66E-6