Health Consultation

Newcastle Beach Park
Evaluation of Soil, Sediment, and Surface Water
Bellevue, King County, Washington

June 18, 2013

Prepared by

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

DOH 334-335 June 2013

Foreword

The Washington State Department of Health (DOH) prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services. ATSDR is 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.

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

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 at www.atsdr.cdc.gov.

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Summary

Introduction

Washington State Department of Health (DOH) prepared this health consultation to inform the public about exposure and potential health risks at Newcastle Beach Park in Bellevue, King County, Washington. Local residents and community members use the park for recreational activities such as wading, swimming, walking, playing, and picnicking. DOH evaluated available chemical data for soil, sediment, and water on the upland portion of the park as well as along the shoreline. DOH prepares health consultations under a cooperative agreement with the Agency of Toxic Substances and Disease Registry (ATSDR).

DOH reached the following conclusion in this health consultation.

Conclusion

DOH concludes that touching or accidentally ingesting soil, sediment, or water are not expected to harm people's health.

Basis for Decision

The amounts of chemicals in soil, sediment, or water are below levels of health concern. These exposures are similar to those at other parks located on Lake Washington.

Arsenic and other metals occur naturally in Puget Sound soil and water. Arsenic is also found in background samples from regional sources such as the Asarco smelter plume or possibly the Coal Creek mining area. In addition polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons have been found in the soil, sediment, and water of Newcastle Beach Park. These are mostly from vehicle and boating fuel spills or exhaust. They find their way into the park by storm water runoff from the highway (i.e., Interstate-405 (I-405)), park access road, and parking lot.

Next Steps

No public health actions are needed related to the Newcastle Beach Park.

In general, people can reduce their exposure by preventing the ingestion of soil by:

- Washing hands after playing, especially before eating.
- Washing children's toys and pacifiers frequently.

For More Information

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

Purpose and Statement of Issues

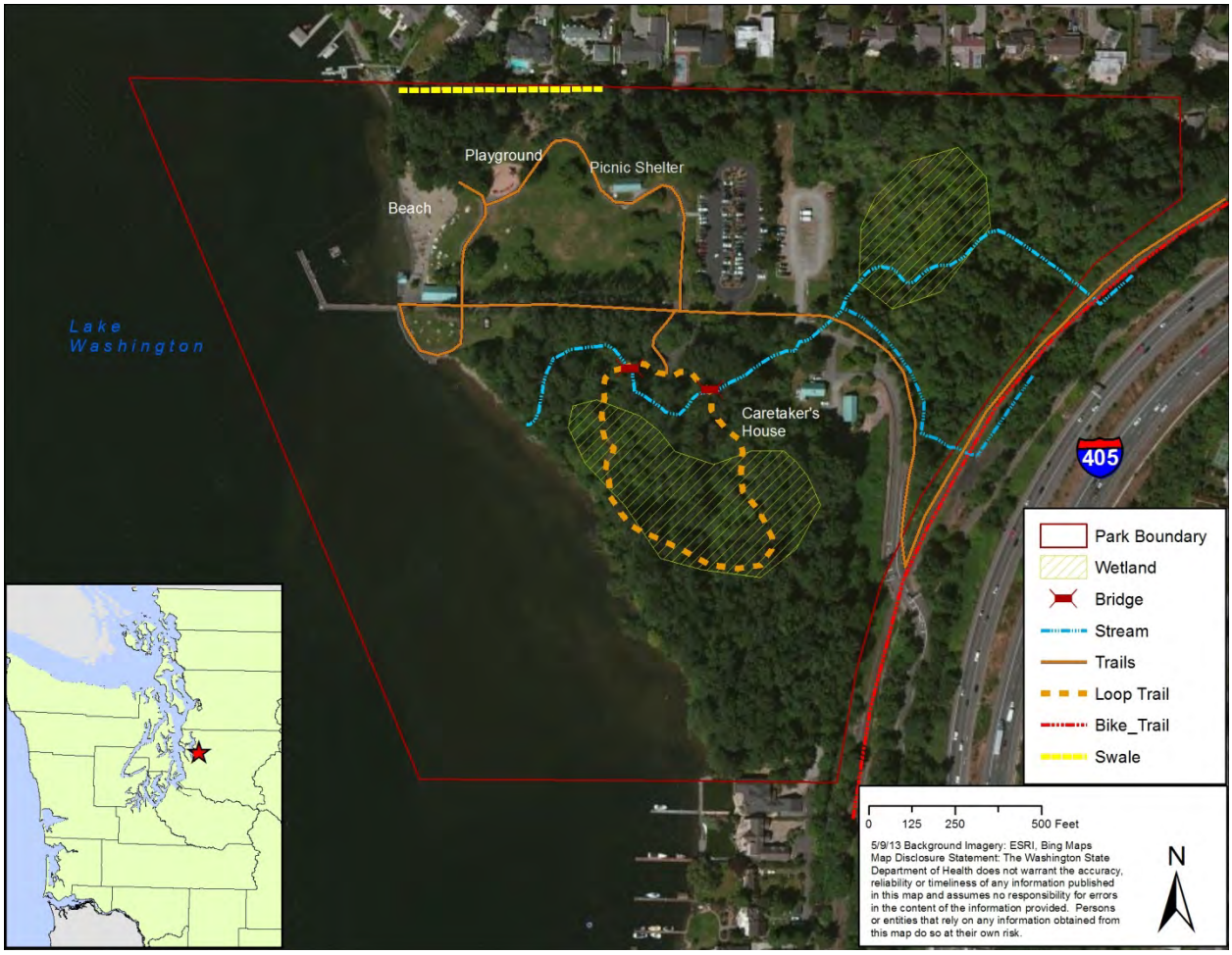
The Washington State Department of Health (DOH) conducted this health consultation to evaluate whether contaminants found at Newcastle Beach Park pose a health hazard to people. People use the park for recreational activities such as wading, swimming, walking, playing, and picnicking. This health consultation is for the community or local residents concerned about using the park. DOH prepares health consultations under a cooperative agreement with the Agency of Toxic Substances and Disease Registry (ATSDR).

Background

Location and Site Description

Newcastle Beach Park, owned by the City of Bellevue, is located adjacent to Lake Washington at 4400 Lake Washington Boulevard SE (Figure 1). The park borders residential neighborhoods to the north and south. To the east, the park borders the former Burlington Northern railway, now a paved biking trail. The biking trail runs adjacent to Interstate 405 (I-405), a major interstate running north and south along the eastside of Lake Washington.

Figure 1. Location and features of Newcastle Beach Park, Bellevue, Washington.



The 29-acre park provides a swimming beach at the lake, a 300-foot dock and swim raft, children's play area, large open grass area, ¾ mile nature loop trail in the lower wetland, picnic areas, and two wetland complexes (upper and lower). Lifeguards are on duty in the beach area late June through Labor Day. Sand from eastern Washington is brought annually to replenish the beach sands in late spring. Newcastle beach is the most popular park in the Bellevue Park system.

A stream runs through the park and discharges into Lake Washington. Two upper forks (north and south) of the stream receive storm water runoff from I-405. The northern fork empties into the upper wetland complex on the east side. The forks converge near the upper parking lot located at the park's entrance. From there the stream splits and flows in front of and behind the caretaker's house. They empty into the lower wetland and Lake Washington. It is not a fish-bearing stream. Storm water runoff from the parking area is collected in catch basins then conveyed to an open ditch, called a swale. This swale runs along the northern boundary of the park then discharges into Lake Washington. Lake Washington water levels fluctuate about two feet during the year. The U.S. Army Corps of Engineers regulates the water levels which are lower in the winter and higher in the summer. Lake Washington is a popular recreational area and allows gas-powered boat traffic. During the summer months boats can be found moored off the shoreline of the park.

Site History and Natural Resources

The park has been influenced by several sources of contamination that contribute to regional background concentrations. Historically, the park was part of the Coal Creek delta entering into Lake Washington (1). Much of the area was likely underwater before the completion of Hiram Chittenden Locks in 1917. This lowered the level of the lake nine feet. Coal Creek has had three different mouths since 1936 (aerial photos). In 1956 the mouth of Coal Creek was at the northern park boundary. By 1968 the mouth of the creek was moved north to its present location during the construction of Newport Shores. In the lake, sediment migrates to the north. The sediment south of the present day pier appears to have been dredged between 1956 and 1968.

Extensive coal mining activities took place in the basin from 1863 and declined until 1963. Miners removed nearly one million tons of coal and four million tons of waste rock (2). The Burlington Northern (formerly Northern Pacific) Railway was put in along the shores of Lake Washington in 1904 to transport coal, forest products, and local produce (3). The railway continued to operate with decreasing frequency into the late 1950s, finally closing in 2008. After logging the area, the park area was farmland and eventually donated to the City of Bellevue.

The park lies within the northern edge of the Tacoma Smelter plume (4). Lead and arsenic and other byproducts of copper smelting were released through the smokestack of the smelter. These contaminants, carried by the wind, settled on the ground throughout King, Pierce, Thurston, and Kitsap counties.

Starting in late 2007, Washington State Department of Transportation (DOT) widened I-405 between Interstate-90 and 112th Avenue. This widening increased the surface area of the freeway, and resulted in increased runoff volume either into Coal Creek and/or the park. It is beyond the scope of DOH to evaluate the ecological impact of runoff flow into the park. For more information, contact the Department of Ecology and Department of Transportation.

Fresh water mussels and other bivalves can be found along the shore of Newcastle Beach Park. DOH does not recommend eating these shellfish. The harvest of freshwater clams and mussels is not regulated like marine shellfish. Hence, there is no information about the safety of consuming these shellfish which could contain biotoxin or fecal coliform contamination. King County has documented periods of time when the beach water is affected by high fecal coliform levels (http://www.kingcounty.gov/environment/waterandland/lakes/facts/bacteria.aspx).

Community Health Concerns

A citizen from the community requested that DOH review the available sampling data to assess the safety of people, including children, recreating at the park. Briefly, the citizen inquired into the safety and potential health risks of the following areas:

- Discharge of chemicals into the lake from the swale.
- Children playing in the sand on the beach.
- Chemical availability in the water when sediments are suspended.
- Chemicals in the stream and their discharge to the lake.
- Health risk from exposure to arsenic, petroleum hydrocarbons, and PAHs in the park.
- Increase in the level of contaminants from increased storm water runoff from highway expansion.

Discussion

The purpose of this section is to:

- Discuss who may be exposed and how (i.e., exposure pathway),
- Summarize the environmental data at points of contact,
- Screen data with health-based comparison values (CVs) to identify potential contaminants of concern, and
- Compare estimated levels of exposure to levels known to cause health effects.

Exposure Pathway

People must first come into contact with a chemical in order for it to harm their health. The method in which a chemical moves from a source and comes into contact with people is called an exposure pathway. A completed exposure pathway consists of 5 elements:

- A source,
- A release,
- An exposure point,
- An exposure route, and
- A potentially exposed population.

There is no one source of contamination at this site but there is regional background contamination. Because of this, Newcastle Park is not different from other urban areas around Lake Washington.

As a public park, recreational visitors are expected to be the potentially exposed population. Children visiting the park would be the most sensitive population. During the summer, adults and school age children (ages 6 to 18) visit the park from late June to early September. During the school year, children may occasionally play at the park during weekends or daylight hours after school. Pre-school children (< 6 years old) may frequent the park during summer with fewer visits during the school year.

Adults and children could be exposed by touching or accidentally ingesting water or sediment while swimming in Lake Washington. Children could be exposed by touching or accidentally ingesting soil, water, or sediments in upland areas, streams, or stagnant water during activities. In these upland areas, minimal contact may occur by feet, legs, and hands.

Exposure points or locations of potential contact for children include:

- The swim beach and shoreline.
- The playground.
- The grass field and picnic areas.
- The nature trail in the lower wetland. For wetland and stream preservation, it is expected that people remain on the trail.
- The swale on the northern boundary of the park in the woods. Considering its location in the trees on the side of the park, the swale is not considered a main destination for play.

Streams and ditches, including the swale, are not safe places to play, especially for young children. Water levels may be a drowning hazard for young children, especially less than two years old. There is always the possible presence of fecal coliform from animals and birds, and runoff from roads and parking lots. A child may accidentally fall into or enter the stream or swale in the upland. The child's main point of contact would be limited to lower legs, feet, and hands while wading or walking through the water.

Wetlands are not safe areas to play. Wetlands are not a destination for play but are created for natural preservation and water collection. By design, the upper wetland has and is currently receiving storm water runoff that may contain contaminants. These contaminants may become trapped in the wetland. In addition, animals (including birds) in the wetlands contribute fecal contamination that may lead to sickness.

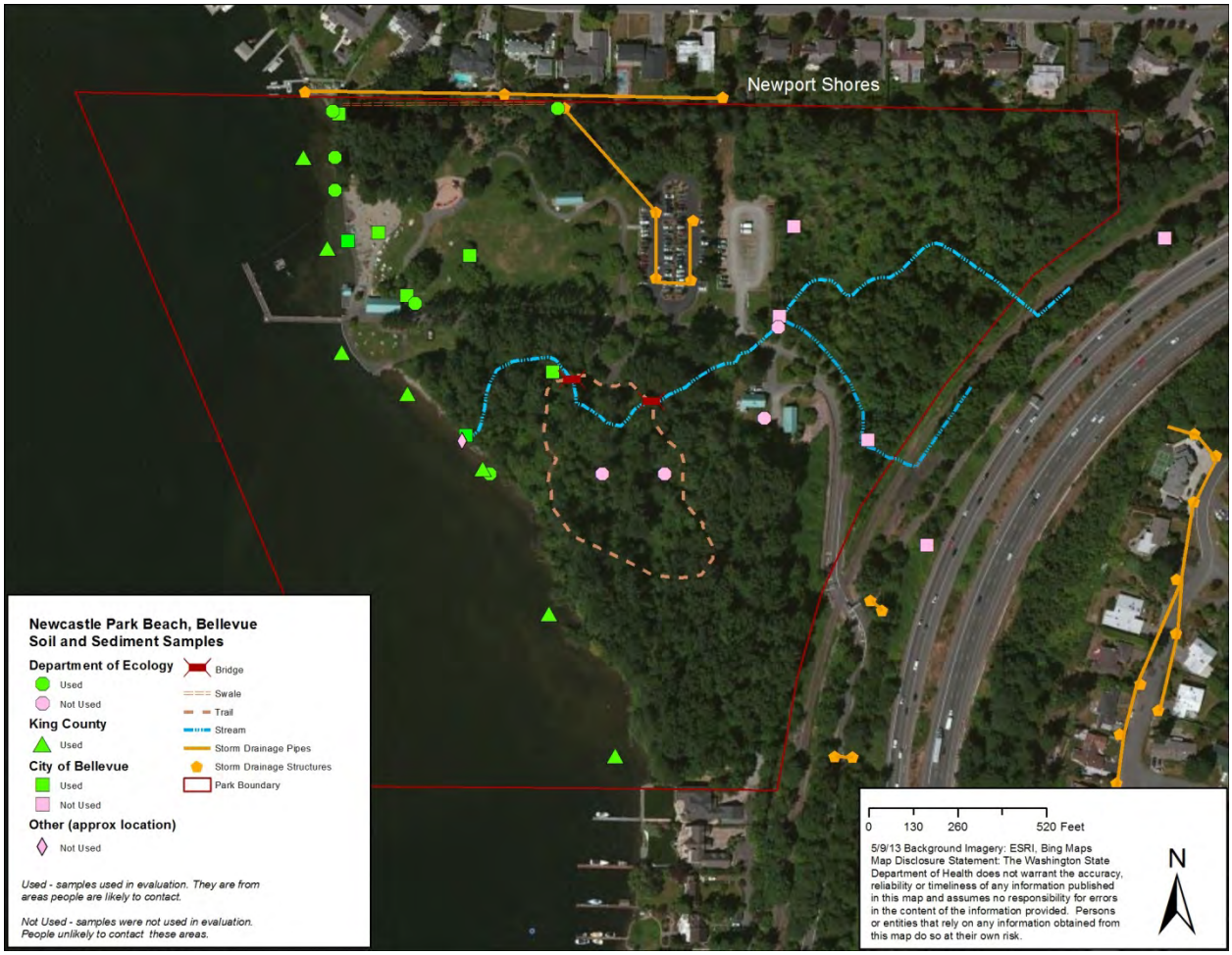
Environmental Data

The data available to estimate exposure at locations of contact are shown in Figures 1 and 2. DOH reviewed the sampling methodology and chemical analytical data of surface water, interflow water, groundwater, soil, and sediment samples. These samples were taken by or on behalf of Ecology, City of Bellevue, or King County. Sampling strategy and protocols were not provided for the samples collected by a private party. DOH considered these data qualitatively since Ecology made an effort to sample in the same locations (5). Data reviewed for this consultation is summarized in Appendices B (Table B1) and C (Table C1).

Sediment and Soil Samples

Sediment and soil sample locations are shown on Figure 1. DOH reviewed 15 sediment samples from the shoreline and 15 sediment/soil samples from upland areas of the park. The City of Bellevue contracted to have soil and sediment samples taken in 2007 and 2011 and analyzed them for metals, PAHs, and petroleum compounds (1;3;6-8). Ecology sampled soil and sediment in July and August 2011 and analyzed them for metals and/or petroleum compounds (5). King County sampled beach sediment in 2009 and measured total metals, petroleum hydrocarbons, PAHs as well as polybrominated diphenyl ethers (PBDEs), other semi-volatile organics, chlorinated pesticides, and polychlorinated biphenyls (PCBs) (9;10). Very few of these additional analyses performed by King County yielded detected data. One sediment sample was taken by a private party in August 2011 and submitted for diesel and heavy oil petroleum analysis (5;11).

Figure 1. Soil and sediment sampling locations at Newcastle Beach Park from 2007-2011, Bellevue, King County, Washington.



With the exception of one sample, the profile of metals in the soil and sediment samples fall within the range of background concentrations (12). Arsenic concentrations in the sediment along the shoreline are statistically lower ($p<0.001$, ANOVA) than in upland soils or stream

sediments. Arsenic in shoreline sediments ranged from 1.15–3.58 parts per million (ppm, same as milligrams per kilogram). Upland arsenic concentrations ranged from 2.27–32.4 ppm. The highest concentration was located upland at the beginning of the swale on the northern border of the park. Background soil concentrations of arsenic in the Puget Sound area are approximately 7.2 ppm (90^{th} percentile) (12).

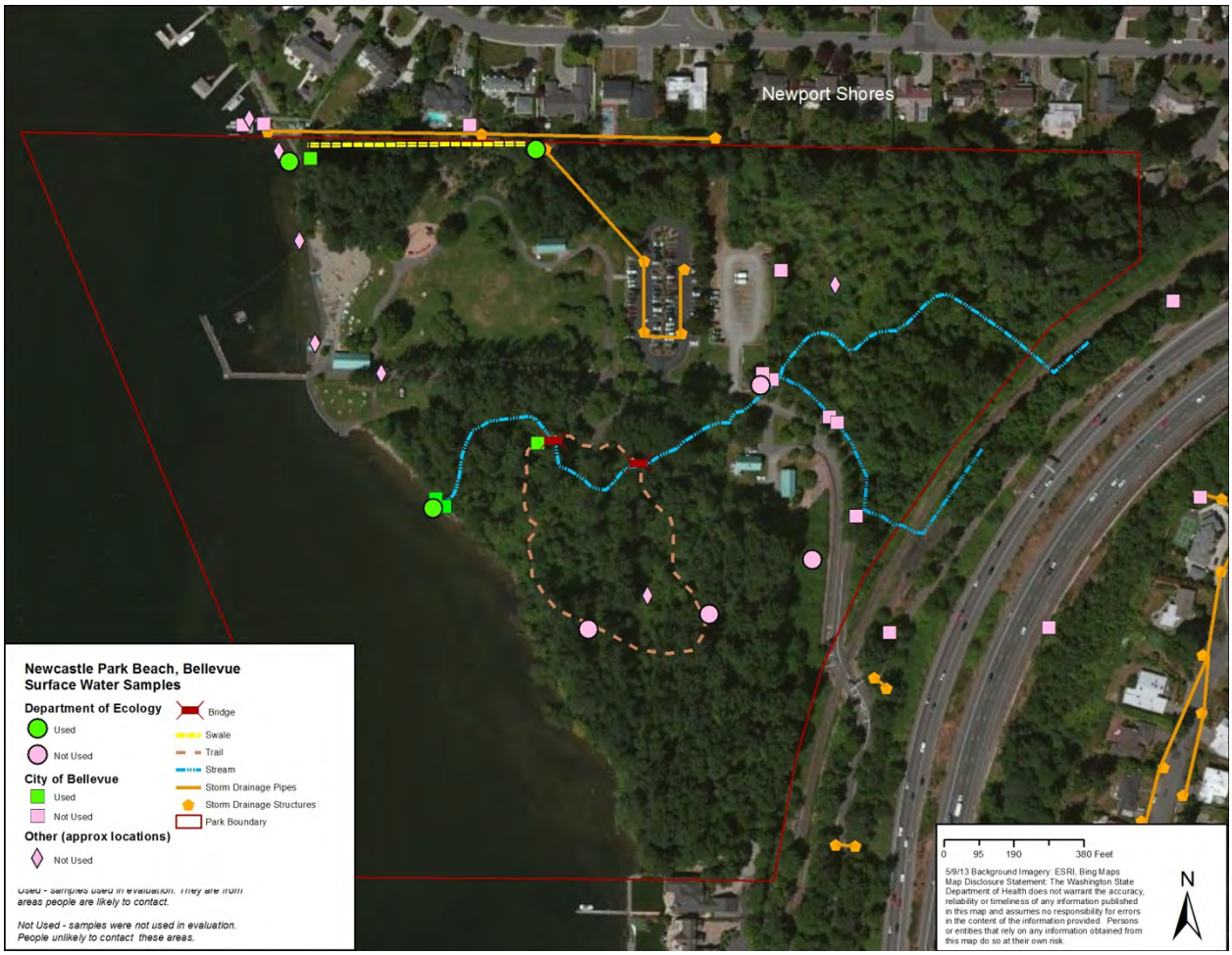
Some PAHs associated with non-carcinogenic effects are present but at low concentrations. Therefore, these are not potential contaminants of concern. PAHs associated with carcinogenic effects (cPAHs) are combined together based on each substance's ability to cause cancer compared to benzo(a)pyrene. The carcinogenic effects of benzo(a)pyrene have been well studied and serves as the reference chemical. Each PAH as a potency factor relative (RPF) to BaP . The weighted totals, or the BaP-Equivalent concentrations (BaP-EQ), are lower along the shoreline than in the upland. Shoreline sediments range from 2.7 –14.2 parts per billion (ppb or micrograms per kilogram). Upland cPAH BaP-EQ concentrations range from < 9.8–205.5 ppb.

Surface, Ground, and Interflow Water Samples
DOH reviewed a total of 31 water samples. Samples included surface, ground, and interflow water samples. Of the 31 samples, only seven water samples were utilized for this evaluation. The samples shown in Figure 2 were selected because they characterize exposure to surface waters while swimming or playing. Of the seven water samples, three were taken during storm events. Although these samples were used, they may not adequately represent accurate, seasonal in-water exposure scenarios.

The DOH utilized samples from two sources: the City of Bellevue and Ecology. The City of Bellevue contracted to have surface water samples taken in 2007 and 2011 (1;6-8). These were analyzed for metals, PAHs, and petroleum compounds. Ecology sampled surface water in July 2011 and had them analyzed for metals and petroleum hydrocarbons (5). In August 2011 Ecology submitted four samples for petroleum hydrocarbon analysis (5). The sampling collection and analytical methodologies from these studies were validated and found acceptable. However, some of the samples measured for total petroleum hydrocarbon analyses (diesel and heavy oils) had high detection limits. The analytical laboratory who measured the samples stated that they "could not identify the compounds as petroleum compounds" and that "some of the compounds measured may be biologic in nature" (13). However, even though petroleum hydrocarbons were not specifically identified in these samples, DOH took a conservative approach and assumed that they were present at the reported levels for assessment purposes.

Seven water samples were also collected and analyzed by a private party in October 2010 and March and April 2011. These samples were analyzed for metals or petroleum hydrocarbons. Documentation of the purpose, strategy, and sampling techniques for collecting and processing these samples was not available and cannot be verified. However, DOH considered these data qualitatively since Ecology made efforts to sample in the same locations (5;11).

Figure 2. Water sampling locations at Newcastle Beach Park from 2007-2011, Bellevue, King County, Washington.



Screening Analysis

In order for any contaminant to be a health concern, the contaminant must be present at a high enough concentration to cause potential harm. DOH compiled analytical results from sediment, soil, and surface water samples taken from various Newcastle Beach Park investigations. DOH used a two step screening approach. In the first step, DOH screened the maximum concentration data against ATSDR comparison values (CVs), Environmental Protection Agency's (EPA) regional screening levels (RSL) and maximum contaminant level (MCL) or Ecology's Model Toxic Control Act (MTCA) for residential soil and drinking water (14). Chemicals that did not pass this screening were further scrutinized in step two using EPA regional screening calculator for recreational soil and surface water exposures. Appendices B and C describe soil/sediment screening and surface water screening in detail.

The first screening level evaluation compared sediment and soil chemical levels with approved chemical levels in soils found in residential settings. Two chemicals exceeded this screening and were identified for further screening. The two chemicals were arsenic and PAHs associated with carcinogenic effects. However, only two locations exceeded these standards. The two locations

are: the east end of the swale with an arsenic concentration of 32 ppm and the corner of the sidewalk near the lifeguard station, with a concentration of 0.1016 ppm of carcinogenic PAHs. A discussion of the site specific, potential health effects from touching sediment or soil at the park can be found in the Health Effects Evaluation Section.

For screening the surface and interflow waters, results were compared to drinking water standards (CVs, MCLs or MTCA levels). This comparison identified three chemical categories for site-specific evaluation: arsenic, petroleum hydrocarbons, and PAHs associated with carcinogenic effects. Note that drinking water CVs are not an accurate comparison for evaluating recreational exposures to surface water. Surface water in the park is not potable and should not be used for drinking. These chemicals were then compared to a surface water recreational screening level. This comparison resulted in these chemicals being screened out and not requiring any further evaluation. No harmful health effects are expected from contact with water in the park.

Health Effects Evaluation

For those chemical concentrations that exceed screening levels, a more in-depth analysis of exposure and levels causing adverse effects is warranted. Potential health risks were evaluated for children and adult recreational exposures at the park. The mathematical equations used to estimate how much of a substance a person is exposed to when coming into contact with soil or sediment during different activities in the park is described in Appendix B.

Non-carcinogenic Effects

In order to evaluate the potential for non-carcinogenic adverse health effects, an exposure dose is estimated for each chemical of potential concern. This dose is compared to ATSDR's minimal risk level (MRL). If an MRL is not available or not updated with recent toxicity information, an EPA oral reference dose (RfD) is used. The doses used to derive the MRL or RfD can be based on either the Lowest-Adverse-Effect-Level (LOAEL), or a No-Observed-Adverse-Effect-Level (NOAEL) from human populations and/or laboratory studies. Because of data uncertainty, the toxic effect level is divided by uncertainty factors to produce the lower and more protective MRL or RfD, whichever is applicable. When the estimated dose exceeds an MRL or RfD, further toxicological evaluation is needed. Further evaluation then compares 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 is combined with other toxicological information, such as responses by sensitive groups or chemical metabolism, to determine the risk of specific harmful effects.

Arsenic

Arsenic is a naturally-occurring element in the earth's soil and is present naturally in Puget Sound. Normal Puget Sound background concentrations for soil rarely exceed 7.2 mg/kg (90^{th} percentile) and average 2.86 mg/kg (12). Arsenic consists of two forms, organic arsenic and inorganic arsenic. Inorganic arsenic is much more harmful than organic arsenic. Based on known geology for the region, inorganic arsenic is most likely the dominant form in both the soil and sediment at Newcastle Beach Park.

The ATSDR MRL and EPA-RfD for arsenic is 0.0003 mg/kg-day. This level is based on drinking the water and reflects possible skin color changes and excessive growth of tissue (15). From this exposure, the dose to a child playing in the swale 12 times a year is 56 times lower than the NOAEL (0.0008 mg/kg-day) and 990 times below the LOAEL (0.014 mg/kg-day), based on the most sensitive human study.

Estimated exposures to arsenic from sediments and water for children or adults visiting the park are below levels where observable non-cancerous effects have been reported in human studies. Sediment and water contact could result in an estimated arsenic exposure dose of 0.000014 mg/kg-day and 0.00000074 mg/kg-day for a child and adult respectively (Appendix B, Table B6).

Petroleum Hydrocarbons

Petroleum products are complex mixtures that include hundreds of compounds. Petroleum hydrocarbons were measured by fractions and include gasoline range organics (C7 to C12), diesel range organics (C12 to C24), and heavy or lube oil range organics (> C24). The screening levels determined by EPA's regional screening level calculator for recreational exposures did not identify petroleum hydrocarbons to be a problem. No health effects are expected from contact with these chemicals. Since none of the gasoline range samples simultaneously detected benzene, toluene, ethylbenzene, or xylenes (BTEX) these compounds do not need to be assessed for carcinogenic effects.

Carcinogenic Effects

Some chemicals have the ability to cause cancer. According to the National Cancer Institute (NCI), 40.76% of men and women born today (approximately 1 in 2 adults) will be diagnosed with cancer at some time during their lifetime (based on 2008–2010 incidence rates) (16). Cancer risk is estimated by calculating a dose for a chemical and multiplying it by a cancer potency factor, also known as a cancer slope factor. Some cancer potency factors are derived from human population data and others are derived from laboratory animal studies involving doses much higher than encountered in the environment. Use of animal data requires extrapolation of the cancer potency from high- to low-level exposures. This extrapolation includes notable uncertainty.

Estimated Cancer Risk

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		Number of Excess Cancers
Moderate	approximately equal to	1 in 1,000
Low	approximately equal to	1 in 10,000
Very Low	approximately equal to	1 in 100,000
Slight	approximately equal to	1 in 1,000,000
Insignificant	is less than	1 in 1,000,000

Current regulatory practice assumes there is no "safe dose" of a carcinogen. In other words, any dose of a carcinogen will result in some additional cancer risk. Cancer risk estimates are not yes/no answers but measures of chance (probability). The validity of "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. Unless a chemical has been shown to have a threshold, DOH assumes that no threshold exists.

This document estimates cancer risk that is attributable to site-related contaminants in qualitative terms like moderate, low, very low, slight, and no significant increase in estimated cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. It should be noted that EPA generally considers an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} as an acceptable range. That means 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. Carcinogenic risk estimates were calculated for arsenic and PAHs.

Arsenic

EPA classifies inorganic arsenic as a 'Class A' human carcinogen. Long-term oral exposure to arsenic in drinking water results in increased risk of skin, bladder, and lung cancer; however, much uncertainty exists about what levels of intake might lead to increased cancer risk. Several recent reviews of the literature have evaluated bladder and lung cancer endpoints instead of skin cancer (which is the endpoint used for the current EPA IRIS value) (15;17). Information provided in these reviews allows the calculation of slope factors for arsenic which range from 0.4 to 27 per mg/kg-day (but mostly greater than 3.7 mg/kg-day).

Although there is some uncertainty surrounding the magnitude of the carcinogenic potential of arsenic, there is a strong scientific basis for choosing a slope factor that is different from the 1.5 per mg/kg-day currently listed in the EPA Integrated Risk Information System (IRIS) database (18). The EPA IRIS review draft for the Science Advisory Board presented a slope factor for combined lung and bladder cancer of 5.7 per mg/kg-day (19). The slope factor calculated from the work by the National Research Council is about 21 per mg/kg-day (20). The revised external review draft of the EPA IRIS toxicological review presented revised cancer slope factors for these cancers as 16.9 and 25.7 per mg/kg-day for men and women respectively (21). Until EPA officially implements these values in IRIS and ATSDR recommends using these values, DOH will apply the interim slope factor of 5.7 per mg/kg-day. Assuming that the highest concentration of arsenic found in Newcastle Beach Park, exposure to arsenic from contacting sediment/soil and water at Newcastle Beach Park could result in a lifetime excess risk of developing 5.7 or 1.1 additional cancers in every 1,000,000 people exposed, for child or adult respectively (see Appendix B, Table B7).

Polycyclic Aromatic Hydrocarbons Associated with Carcinogenic Effects (cPAHs)

PAHs are generated by the incomplete combustion of organic matter, including oil, wood, and coal. They are found in materials such as creosote, coal, coal tar, and used motor oil. Dietary sources make up a large percentage of PAH exposure in the U.S. population (22). Smoked or barbequed meat and fish contain relatively high levels of PAHs. The majority of dietary exposure to PAHs for the average person comes from ingestion of vegetables and grains (cereals). Based on structural similarities, metabolism and toxicity, PAHs are often grouped together when evaluating the potential for adverse health effects. Exposures to PAHs in the park occur at levels much lower than levels where observable non-carcinogenic effects have been reported. Many of these compounds were several orders of magnitude below comparison values.

EPA classified some PAHs as probable human carcinogens (Class B2) as a result of *sufficient* evidence of carcinogenicity in animals but *inadequate* evidence in humans. These compounds include benz(a)anthracene, benzo(a)pyrene (BaP), benzo(b)fluoranthene, benzo(k)fluoranthene,

chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene. EPA has established a cancer slope factor only for BaP, at 2.0 per mg/kg-day. BaP is considered the most carcinogenic, and is known to cause stomach cancers in animals drinking water. Each cPAH is multiplied by a Relative Potency Factor (RPF). In 1993 EPA established RPFs using the weight-of-evidence for carcinogenicity of the cPAHs (23). Products of each congener multiplied by its RPF are summed to equal the BaP-relative potency equivalent (BaP-EQ).

Exposures for children playing at the park where cPAHs are accessible (corner of the walk near the lifeguard stand) could result in a lifetime excess risk of developing 2.6 additional cancer cases in every 1,000,000 people exposed. Estimated adult exposures could result in an excess risk of developing 7.5 additional cancer cases in every 100,000,000 adults exposed. This excess cancer risk is considered to be insignificant.

Multiple Chemicals

A person can be exposed to more than one chemical through more than one pathway. Exposure to a chemical through multiple pathways occurs if a contaminant is present in more than one medium (i.e., air, soil, surface water, groundwater, and sediment). For example, the dose of a contaminant received from drinking water might be combined with the dose received from contact with the same contaminant in soil.

Information is available on how an individual chemical produces effects however, it is much more difficult to assess exposure and effects for multiple chemicals. Because of the large number of chemicals in the environment, it is impossible to measure all of the possible interactions between these chemicals. The potential exists for these chemicals to interact in the body and increase or decrease the potential for adverse health effects. Individual cancer risk estimates can be added since they are measures of probability. However, when estimating noncancer risk, similarities must exist between the chemicals if the doses are to be added. Groups of chemicals that have similar toxic effects can be added, such as volatile organic compounds (VOCs) which cause liver toxicity. PAHs are another group of compounds that can be assessed as one combined dose based on similarities in chemical structure and metabolites.

The lifetime cancer risk can be combined for exposures to arsenic and PAHs as described above. This lifetime cancer risk is 1.2 excess cancers in 100,000 people exposed.

Children's Health Considerations

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

- Children are more likely to not see signs and wander into restricted locations.
- Children often bring food into contaminated areas resulting in hand-to-mouth activities leading to increased exposure.
- Children are smaller and receive higher doses of chemical exposure per body weight.

- Fetal and child exposure to some contaminants can cause permanent damage during critical growth stages.

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

DOH concludes that touching or accidentally ingesting soil, sediment, or water are not expected to harm people's health. The amounts of chemicals in soil, sediment, or water are below levels of health concern. These exposures are similar to those at other parks located on Lake Washington. Arsenic and other metals occur naturally in Puget Sound soil and water. Arsenic is also found in background samples from regional sources such as the Asarco smelter plume or possibly the Coal Creek mining area. In addition polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons have been found in the soil, sediment, and water of Newcastle Beach Park. These are mostly from vehicle and boating fuel spills or exhaust. They find their way into the park by storm water runoff from the highway (i.e., Interstate-405 (I-405)), park access road, and parking lot.

Recommendations

No public health actions are needed related to the Newcastle Beach Park.

In general, people can reduce their exposure by preventing the ingestion of soil by:

- Washing hands after playing, especially before eating.
- Washing children's toys and pacifiers frequently.

Public Health Action Plan

No public health actions are needed related to the Newcastle Beach Park.

Report Preparation

This Public Health Assessment/Health Consultation for the Newcastle Beach Park 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, of intermediate duration, or long-term [see **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 per day (1/day) for water and milligrams per day (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 [see **inhalation**], eating or drinking [see **ingestion**], or contact with the skin [see **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 – Summary of Sediment/Soil Data and Screening Analysis

Appendix B contains a summary of sediment and soil concentration data, a description of the screening method, and a screening analysis. DOH screens data that meet adequate sampling and analytical standards to identify chemicals of potential concern. DOH screened data in two steps as described below.

Step 1 Screening
In the first screening, DOH compared chemical concentrations with ATSDR health-based comparison values (CV) for residential soil exposures. These guidelines are derived in a uniform way using health guidelines and standard default exposure assumptions. The default exposure assumptions generally represent high estimates of exposure (greater than the mean, approaching the 90th percentile) based on observed ranges of child activity patterns (e.g., ingestion rates, residence times, etc.). ATSDR CVs used in the screening analyses include:

- **Environmental Media Evaluation Guides (EMEGs):** EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR minimal risk levels (MRL) and conservative child assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.
- **Cancer Risk Guides (CREGs):** CREGs are estimated contaminant concentrations that would be expected to cause no more than 1 excess cancer in 1,000,000 (10^{-6}) persons exposed during their lifetime (70 years). ATSDR's CREGs are calculated from EPA's cancer slope factors (CSFs) for oral exposures or unit risk values for inhalation exposures. These values are based on EPA evaluations and assumptions about hypothetical cancer risks at low levels of exposure for residents.
- **Reference Dose Media Evaluation Guides (RMEGs):** ATSDR derives RMEGs from EPA's oral reference doses (RfD, see description below), which are developed based on EPA evaluations. RMEGs represent the concentration in water or soil at which daily human exposure is unlikely to result in adverse non-carcinogenic effects.

In this case, chronic residential exposures for children overestimate exposure that would occur by recreational users of the site. ATSDR CVs used to screen sediment and soil data are found in Table B1. In the absence of ATSDR CVs, residential EPA regional screening levels (RSLs) (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search) or cleanup standards developed under the Washington State Model Toxics Control Act (MTCA) were used to determine if levels pose potential health impacts. Maximum concentrations measured at the park were compared to CVs. If a maximum concentration was above the health-based CV, it does not mean that adverse health effects will occur. Exceeding a CV identifies a chemical for further site-specific exposure evaluation.

ATSDR and DOH have an exception to this methodology that applies to this site. Mean and range of arsenic in soil and sediment in the U.S. are 7.2 ppm and < 0.1–97 ppm (17). The CREG (0.47 ppm) is below background levels. ATSDR recommends using 15 ppm, the cEMEG (14). The

median (50th percentile) and range of background arsenic in the soil of Puget Sound are 2.86 ppm and 1.45–17.17 ppm (12). The 90th percentile for background arsenic in the Puget Sound is 7.2 ppm. This value will be used to screen arsenic concentrations in sediment or soil at the site.

Table B1. Concentration of chemicals found in sediment and soil at Newcastle Beach Park, King County, Washington with soil health-based comparison values (CVs).

Chemical	Range of Concentration (ppm or ppb)	Detected Above CV*	CV	Type of CV	Further Analysis
Total Metals (ppm, DW)					
Antimony	<0.087–0.385	0/13	20	RMEG	No
Arsenic	1.2–32.4	1/23 4/23 (1)[b]	15 7.2	cEMEG [a] background	Yes
Beryllium	0.110– <0.498	0/13	100	cEMEG	No
Cadmium	0.028–0.650	0/15	5	cEMEG	No
Chromium	8.1–29.5	0/15	45	cEMEG	No
Copper	2.7–55	0/25	500	iEMEG	No
Iron	10600–24000	0/12	-	-	No
Lead	1.38–82	0/15	250	MTCA	No
Magnesium	4900–5100	0/2	-	-	No
Manganese	77.1–320	0/9	2,500	RMEG	No
Mercury	<0.0065–0.037	0/13	5	RMEG (MeHg)	No
Nickel	6.32–31.3	0/15	1,000	RMEG	No
Phosphorus	120–504	0/7	-	-	No
Selenium	<0.140–0.396	0/13	250	cEMEG	No
Silver	<0.014–0.65	0/15	250	RMEG	No
Thallium	0.019–0.069	0/13	-	-	No
Zinc	20.3–284	0/25	15,000	cEMEG	No
Petroleum Hydrocarbons (ppm, DW)					
Diesel Range (>C12-C24)	<16–<250	0/30	2,000	MTCA	No
Lube Oil Range (>C24)	<40–1600	0/30	2,000	MTCA	No
Gasoline Range (C7-C12)	<0.31–30	0/19	2,000	MTCA	No
Benzene	<0.013–<0.054	0/12	13	CREG	No
Toluene	<0.013–<0.054	0/12	4,000	RMEG	No
Ethyl benzene	<0.013–<0.054	0/12	5,000	RMEG	No
m,p-Xylene	<0.013–<0.054	0/12	10,000	RMEG	No
o-Xylene	<0.013–<0.054	0/12	10,000	REMEG	No
Semi-Volatile Organic Compounds: Non-carcinogenic Polycyclic Aromatic Hydrocarbons (ppb, DW)					
Naphthalene	<2.3–<7.8	0/9	1,000,000	RMEG	No
2-Methylnaphthalene	<2.3–<91	0/19	200,000	RMEG	No
1-Methylnapthalene	<7.1–<91	0/5	3,500,000	cEMEG	No
Acenaphthylene	<2.3–<91	0/19	3,000,000	RMEG	No
Acenaphthene	<2.3–<91	0/19	3,000,000	RMEG (acenaphthylene)	No
Fluorene	<2.3–<91	0/19	2,000,000	RMEG	No
Phenanthrene	<2.3–91	0/19	1,500,000	RMEG (pyrene)	No
Anthracene	<2.3–<91	0/19	15,000,000	RMEG	No
Benzo(g,h,i)perylene	<2.3–46	0/19	1,500,000	RMEG (pyrene)	No

Chemical	Range of Concentration (ppm or ppb)	Detected Above CV*	CV	Type of CV	Further Analysis
Fluoranthene	<2.8–150	0/19	2,000,000	RMEG	No
Pyrene	<2.3–180	0/19	1,500,000	RMEG	No
Semi-Volatile Organic Compounds: Carcinogenic Polycyclic Aromatic Hydrocarbons (ppb, DW)					
~Benzo(a)anthracene (0.1)	<0.23–9.1	0/19 (19)	**96**	CREG (BaP)	**Yes** [b]
~Chrysene (0.001)	<0.0023–0.083	0/19 (18)			
~Benzo(b)fluoranthene (0.1)	<0.23–9.1	0/19 (19)			
~Benzo(k)fluoranthene (0.01)	<0.023–1.0	0/19 (19)			
~Benzo(a)pyrene BaP (1)	<2.3–91.0	0/19 (19)			
~Indeno(1,2,3-c,d)pyrene (0.1)	<0.23–14.0	0/19 (19)			
~Dibenzo(a,h)anthracene (1)	<2.3–**100**	1/19 (18)			
Total BaP-EQ (ND=1/2DL)	<2.7–**205**	3/19 (16)			
Semi-Volatile Organic Compounds: Other (ppb, DW)					
1,2,4-Trichlorobenzene	<0.12–0.15	0/7	500,000	RMEG	No
1,2-Dichlorobenzene	<0.23–0.30	0/7	4,500,000	RMEG	No
1,3-Dichlorobenzene	<0.23–0.30	0/7	1,000,000	RMEG	No
1,4-Dichlorobenzene	<0.23–1.2	0/7	3,500,000	cEMEG	No
2,4-Dimethylphenol	<1.2–1.5	0/7	1,000,000	RMEG	No
2-Methylphenol	<2.3–3.0	0/7	2,500,000	RMEG	No
4-Methylphenol	<4.7–6.4	0/7	2,500,000	RMEG	No
Benzoic Acid	<159–<801	0/7	200,000	RMEG	No
Benzyl Alcohol	<2.3–<3.0	0/7	6,100,000	RSL	No
Butyl benzyl phthalate	<1.2–<1.5	0/7	100,000,000	RMEG	No
Di(2-ethylhexyl) phthalate	7.4–57	0/7	50,000	CREG	No
Bis(2-ethylhexyl) adipate	<12–<15	0/7	580,000	CREG	No
Bisphenol A	<12–<15	0/7	3,100,000	RSL	No
Caffeine	<4.76–<6.0	0/7	-	NA	No
Carbazole	<2.3–<3.0	0/7	-	NA	No
Coprostanol	<47–<60	0/7	-	NA	No
Di-n-Butyl Phthalate	<12.9–<16	0/7	5,000,000	RMEG	No
Di-n-Octyl Phthalate	<4.7–160	0/17	20,000,000	iEMEG	No
Dibenzofuran	<2.3–<3.0	0/7	-	NA	No
Diethyl Phthalate	<4.7–<6.0	0/7	40,000,000	RMEG	No
Dimethyl Phthalate	<4.7–<6.0	0/7	5,000,000	RMEG	No
Hexachlorobenzene	<0.12–<0.15	0/7	440	CREG	No
Hexachlorobutadiene	<0.59–<0.75	0/7	9,000	CREG	No
Hexachloroethane	<1.2–<1.5	0/7	12,000	RSL	No
N-Nitrosodiphenylamine	<4.7–<6.0	0/7	140,000	CREG	No
Pentachlorophenol	<12.0–<15	0/7	1,800	CREG	No
Phenol	4.7–10	0/7	15,000,000	RMEG	No
4-Nonylphenol	<23.0–<30	0/7	-	NA	No
Polychlorinated Biphenyls (Aroclors) (ppb, DW)					
Aroclor 1016	1.5–2.0	0/7	3,500	RMEG	No
Aroclor 1221	2.9–3.8	0/7	-	NA	No
Aroclor 1232	2.9–3.8	0/7	-	NA	No
Aroclor 1242	1.5–2.0	0/7	-	NA	No

Chemical	Range of Concentration (ppm or ppb)	Detected Above CV*	CV	Type of CV	Further Analysis
Aroclor 1248	1.5–2.0	0/7	-	NA	No
Aroclor 1254	1.5–2.0	0/7	1,000	cEMEG	No
Aroclor 1260	1.5–2.0	0/7	-	NA	No
Total Aroclors (ND = 1/2DL)	6.7–8.8	0/7	350	CREG	No
Chlorinated Pesticides (ppb, DW)					
4,4'-DDD	<0.8–<1.0	0/7	2,900	CREG	No
4,4'-DDE	<0.8–<1.0	0/7	2,100	CREG	No
4,4'-DDT	<0.8–<1.0	0/7	2,100	CREG	No
Aldrin	<0.8–1.0	0/7	41	CREG	No
Alpha-BHC (hexachlorocyclohexane)	<0.4–0.5	0/7	110	CREG	No
Alpha-Chlordane	<0.4–0.5	0/7	2,000	CREG	No
Beta-BHC	<0.4–0.5	0/7	390	CREG	No
Delta-BHC	<0.4–0.5	0/7	7,000	RMEG (γ-BHC)	No
Dieldrin	<0.8–1.0	0/7	44	CREG	No
Endosulfan I	<0.8–1.0	0/7	100,000	cEMEG	No
Endosulfan II	<0.8–1.0	0/7	100,000	cEMEG (I)	No
Endosulfan Sulfate	<0.8–1.0	0/7	100,000	cEMEG (I)	No
Endrin	<0.8–1.0	0/7	15,000	cEMEG	No
Endrin Aldehyde	<0.8–1.0	0/7	15,000	cEMEG (Endrin)	No
Gamma-BHC (Lindane)	<0.4–0.5	0/7	500	RMEG	No
Gamma-Chlordane	<0.4–0.5	0/7	2	CREG (α-chlordane)	No
Heptachlor	<0.4–0.5	0/7	160	CREG	No
Heptachlor Epoxide	0.4–0.5	0/7	77	CREG	No
Methoxychlor	3.9–5.0	0/7	3,000	RMEG	No
Toxaphene	7.9–10	0/7	640	CREG	No
Polybrominated Diphenyl Ethers (ppb, DW)					
DecaBDE-209	0.089–0.859	0/7			
HeptaBDE-183	<0.012–<0.015	0/7			
HeptaBDE-190	<0.013–0.016	0/7			
HexaBDE-138	<0.012–0.031	0/7			
HexaBDE-153	<0.012–0.160	0/7			
HexaBDE-154	<0.012–<0.024	0/7			
PentaBDE-100	<0.012–<0.033	0/7			
PentaBDE-85	<0.012–<0.015	0/7			
PentaBDE-99	0.020–0.173	0/7			
TetraBDE-47	0.039–0.133	0/7			
TetraBDE-66	<0.012–<0.015	0/7			
TetraBDE-71	<0.012–<0.015	0/7			
TriBDE-17	<0.012–0.015	0/7			
TriBDE-28	<0.012–0.015	0/7			
Total PBDEs (ND=1/2DL)	<0.23–1.2	0/7	100,000	RMEG	No

Source: King County 2009; Watershed Company 2007; Otak 2011a,b; Ecology 2012

Notes: Soil CVs use residential exposure parameters and is considered a conservative approach considering the recreational scenario has less soil contact. Exceeding a CV does not indicate that a health effect will occur and requires a more thorough exposure evaluation (see note a.)

a. The CREG for inorganic arsenic is lower than the background levels and detection limits for these samples. ATSDR recommends using the cEMEG to screen soil values (15 ppm). Background of arsenic in Puget Sound soil is considered to be 7.2 ppm (90th percentile, Ecology 1994). Backgound levels were exceeded at four locations and screened further for recreational use.
b. Carcinogenic effects only

Abbreviations:

ATSDR – Agency of Toxic Substances and Disease Registry
BaP-EQ – Benzo(a)pyrene equivalents
BDE – brominated diphenyl ethers
BHC - hexachlorocyclohexane
cEMEG – Environmental media evaluation guide based on child chronic exposures; comparison value developed by ATSDR
CREG – Cancer Risk Guides
CV – health based comparison values
DDD, DDE, DDT – dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, dichlorodiphenyltrichloroethane
DL – detection limit
DMP – dimethyl phthalate
DW – dry weight
EPA – U.S. Environmental Protection Agency
iEMEG - Environmental media evaluation guide based on child intermediate exposures; ATSDR comparison value
MTCA A – Washington State Model Toxics Control Act clean up standards for unrestricted land use (Method A)
NA – not available
ND – non-detect
PAH – Polycyclic aromatic hydrocarbons
ppb – parts per billion (same as µg/kg)
ppm – parts per million (same as mg/kg)
RfD – Reference dose (developed by U.S. EPA)
RMEG – RfD Media Evaluation Guide; comparison value developed by ATSDR
RPF – relative potency factor
RSL – U.S. EPA regional screening level

Step 2 Screening

For chemicals identified in the Step 1 screening process, DOH used either background or EPA's soil recreational screening level calculator (REF) to develop protective screening levels. The output from the regional screening calculator is presented in Tables B3 and B4. These include input parameters used in the calculator.

Table B2. Comparison of recreational screening levels with soil and sediment concentrations at specific locations in Newcastle Beach Park, King County, Washington.

Chemical	Concentration (ppm)	Upland Location	SL	Type of SL	Further Analysis
Arsenic	32	East end of swale	7.2	Background	Yes
	7.42	Stream confluence	11.0	Limited Access* (RSL Calculator)	No
	< 11	Upper wetland			
	10.1 (S) 11.0 (N)	Freeway cross drains			
cPAH BaP-EQ (ppm)	0.102	Corner of walk near lifeguard building	0.066	Shoreline access (RSL Calculator)	Yes
	0.126	Upper wetland	1.7	Limited Access * (RSL Calculator)	No
	0.206	Freeway cross drain (S)			

Note: *Limited access to areas rarely or not used by people, estimated to be once a month.

Abbreviations:

BaP-EQ Benzo(a)pyrene equivalents for all cPAH compounds
cPAH Polycyclic aromatic hydrocarbons associated with carcinogenic effects
EPA U.S. Environmental Protection Agency
ppm parts per million or milligrams chemical per kilograms sediment (mg/kg)
RSL Screening levels from EPA's regional screening calculator for recreational soil exposures (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search); see Tables B3 and B4 for input parameters and model output.
S Southern sample location outside of the park between Interstate 405 and the bike trail
N Northern sample location outside of the park between Interstate 405 and the bike trail

Table B3. Input parameters in the EPA Regional Screening Level Calculator for recreational exposures to soil or sediment at Newcastle Beach Park, King County, Washington.

Variable	Upland (limited access)	Upland (intermittent access)	Shoreline
TR (target cancer risk) unitless	0.000001	0.000001	0.000001
SA_{recsc} (skin surface area - child) cm^2/day	490	490	2250
SA_{recsa} (skin surface area - adult) cm^2/day	1320	1320	5304.2
SA_{0-2} (skin surface area - mutagenic) cm^2/day	0	0	1750
SA_{2-6} (skin surface area - mutagenic) cm^2/day	490	490	2500
SA_{6-16} (skin surface area - mutagenic) cm^2/day	1250	1250	4700
SA_{16-30} (skin surface area - mutagenic) cm^2/day	1370	1370	5700
SA_{recsa} (skin surface area - adult) cm^2/day	1320	1320	5283.3
THQ (target hazard quotient) unitless	1	1	1
LT (lifetime - recreator) year	70	70	70
$IFS_{rec-adj}$ (age-adjusted soil ingestion factor) mg/kg	626.785	2716.07	7690.855
$DFS_{rec-adj}$ (age-adjusted soil dermal factor) mg/kg	726.219	3146.951	40032.595
$IFSM_{rec-adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	1785.241	7736.043	32252.406
$DFSM_{rec-adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	1776.187	7696.809	162847.123
EF_{0-2} (exposure frequency) day/year	0	0	120
EF_{2-6} (exposure frequency) day/year	12	52	120
EF_{6-16} (exposure frequency) day/year	12	52	120
EF_{16-30} (exposure frequency) day/year	12	52	120
EF_{recsc} (exposure frequency - child) day/year	12	52	120
EF_{recsa} (exposure frequency - adult) day/year	12	52	120
EF_{recsa} (exposure frequency - adult) day/year	12	52	120
EF_{recs} (exposure frequency - recreator) day/year	12	52	120
IRS_{0-2} (soil intake rate) mg/day	0	0	60
IRS_{2-6} (soil intake rate) mg/day	100	100	100
IRS_{6-16} (soil intake rate) mg/day	100	100	100
IRS_{16-30} (soil intake rate) mg/day	50	50	50
IRS_{recsc} (soil intake rate - child) mg/day	100	100	86.7
IRS_{recsa} (soil intake rate - adult) mg/day	70.8	70.8	70.8
IRS_{recsa} (soil intake rate - adult) mg/day	70.8	70.8	70.8
ED_{0-2} (exposure duration) year	0	0	2
ED_{2-6} (exposure duration) year	4	4	4
ED_{6-16} (exposure duration) year	10	10	10
ED_{16-30} (exposure duration) year	14	14	14
ED_{recsc} (exposure duration - child) year	4	4	6
ED_{recsa} (exposure duration - adult) year	24	24	24

Variable	Upland (limited access)	Upland (intermittent access)	Shoreline
ED_{recsa} (exposure duration - adult) year	24	24	24
ED_{recs} (exposure duration - recreator) year	28	28	30
ET_{0-2} (exposure time) hr/day	0	0	1
ET_{2-6} (exposure time) hr/day	0.25	0.25	1
ET_{6-16} (exposure time) hr/day	0.25	0.25	1
ET_{16-30} (exposure time) hr/day	0.25	0.25	1
ET_{recsc} (exposure time - child) hr/day	0.3	0.3	1
ET_{recsa} (exposure time - adult) hr/day	0.3	0.3	1
ET_{recsa} (exposure time - adult) hr/day	0.3	0.3	1
ET_{recs} (exposure time - recreator) hr/day	0.3	0.3	1
BW_{0-2} (body weight) kg	0	0	10
BW_{2-6} (body weight) kg	17	17	17
BW_{6-16} (body weight) kg	44	44	44
BW_{16-30} (body weight) kg	70	70	70
BW_{recsc} (body weight - child) kg	17	17	14.7
BW_{recsa} (body weight - adult) kg	59.2	59.2	59.2
BW_{recsa} (body weight - adult) kg	59.2	59.2	59.2
AF_{0-2} (skin adherence factor) mg/cm^2	0	0	0.2
AF_{2-6} (skin adherence factor) mg/cm^2	0.2	0.2	0.2
AF_{6-16} (skin adherence factor) mg/cm^2	0.07	0.07	0.07
AF_{16-30} (skin adherence factor) mg/cm^2	0.07	0.07	0.07
AF_{recsc} (skin adherence factor - child) mg/cm^2	0.2	0.2	0.2
AF_{recsa} (skin adherence factor - adult) mg/cm^2	0.07	0.07	0.07
AF_{recsa} (skin adherence factor - adult) mg/cm^2	0.07	0.07	0.07
City (Climate Zone) PEF Selection	Default	Default	Default
A_s (acres) PEF Selection	0.5	0.5	0.5
Q/C_{wp} (g/m^2-s per kg/m^3) PEF Selection	93.77	93.77	93.77
PEF (particulate emission factor) m^3/kg	1359344438	1359344438	1359344438
A (PEF Dispersion Constant)	16.2302	16.2302	16.2302
B (PEF Dispersion Constant)	18.7762	18.7762	18.7762
C (PEF Dispersion Constant)	216.108	216.108	216.108
V (fraction of vegetative cover) unitless	0.5	0.5	0.5
U_m (mean annual wind speed) m/s	4.69	4.69	4.69
U_t (equivalent threshold value)	11.32	11.32	11.32
F(x) (function dependant on U_m/U_t) unitless	0.194	0.194	0.194
City (Climate Zone) VF Selection	Default	Default	Default
A_s (acres) VF Selection	0.5	0.5	0.5
Q/C_{wp} (g/m^2-s per kg/m^3) VF Selection	68.18	68.18	68.18

Variable	Upland (limited access)	Upland (intermittent access)	Shoreline
foc (fraction organic carbon in soil) g/g	0.006	0.006	0.006
ρ$_b$ (dry soil bulk density) g/cm^3	1.5	1.5	1.5
ρ$_s$ (soil particle density) g/cm^3	2.65	2.65	2.65
θ$_w$ (water-filled soil porosity) L_{water}/L_{soil}	0.15	0.15	0.15
T (exposure interval) s	950000000	950000000	950000000
A (VF Dispersion Constant)	11.911	11.911	11.911
B (VF Dispersion Constant)	18.4385	18.4385	18.4385
C (VF Dispersion Constant)	209.7845	209.7845	209.7845

Source: RSL Calculator input parameter file; highlighted cells are site-specific values (not default).

Table B4. Output parameters and screening levels (SLs) from EPAs regional screening calculator for recreational soil exposures at Newcastle Beach Park, King County, Washington.

Chemical	Arsenic			Benzo[a]pyrene		
Scenario	**12 day**	**52 day**	**120 day**	**12 day**	**52 day**	**120 day**
CAS Number	7440-38-2	7440-38-2	7440-38-2	50-32-8	50-32-8	50-32-8
Mutagen	No	No	No	Yes	Yes	Yes
Volatile Organic Chemical	No	No	No	No	No	No
Ingestion Slope Factor (mg/kg-day)$^{-1}$	5.7	5.7	5.7	7.3	7.3	7.3
Ingestion Slope Factor Reference	U	U	U	I	I	I
Inhalation Unit Risk (IUR) (ug/m^3)$^{-1}$	4.30E-03	4.30E-03	4.30E-03	1.10E-03	1.10E-03	1.10E-03
IUR Ref	U	U	U	C	C	C
Chronic Reference Dose (RfD) (mg/kg-day)	3.00E-04	3.00E-04	3.00E-04	-	-	-
RfD Ref	U	U	U			
Chronic Reference Concentration (RfC) (mg/m^3)	1.50E-05	1.50E-05	1.50E-05	-	-	-
RfC Ref	U	U	U			
GIABS	1	1	1	1	1	1
ABS	0.03	0.03	0.03	0.13	0.13	0.13
rba	0.6	0.6	0.6	1	1	1
Volatilization Factor (m^3/kg)	-	-	-	-	-	-
Soil Saturation Concentration (mg/kg)	-	-	-	-	-	-
Particulate Emission Factor (m^3/kg)	1.4E+09	1.4E+09	1.4E+09	1.4E+09	1.4E+09	1.4E+09
Ingestion SL TR=1.0E-6 (mg/kg)	1.2E+01	2.8E+00	9.7E-01	2.0E+00	4.5E-01	1.1E-01
Dermal SL TR=1.0E-6 (mg/kg)	2.1E+02	4.8E+01	3.7E+00	1.5E+01	3.5E+00	1.7E-01
Inhalation SL TR=1.0E-6 (mg/kg)	1.9E+06	4.4E+05	5.4E+04	3.8E+06	8.7E+05	8.3E+04
Carcinogenic SL TR=1.0E-6 (mg/kg)	1.1E+01	2.6E+00	7.7E-01	1.7E+00	4.0E-01	6.6E-02
Ingestion SL (Child) HQ=1 (mg/kg)	2.6E+03	6.0E+02	2.6E+02	-	-	-
Dermal SL (Child) HQ=1 (mg/kg)	5.3E+04	1.2E+04	9.9E+02	-	-	-
Inhalation SL (Child) HQ=1 (mg/kg)	5.0E+07	1.1E+07	1.5E+06	-	-	-
Noncarcinogenic SL (Child) HI=1 (mg/kg)	2.5E+03	5.7E+02	2.1E+02	-	-	-
Ingestion SL (Adult) HQ=1 (mg/kg)	1.3E+04	2.9E+03	1.3E+03	-	-	-

Chemical	Arsenic			Benzo[a]pyrene		
Scenario	**12 day**	**52 day**	**120 day**	**12 day**	**52 day**	**120 day**
Dermal SL (Adult) HQ=1 (mg/kg)	2.0E+05	4.5E+04	4.9E+03	-	-	-
Inhalation SL (Adult) HQ=1 (mg/kg)	5.0E+07	1.1E+07	1.5E+06	-	-	-
Noncarcinogenic SL (Adult) HI=1 (mg/kg)	1.2E+04	2.8E+03	1.0E+03	-	-	-
Screening Level (mg/kg)	1.1E+01	2.6E+00	7.7E-01	1.7E+00	4.0E-01	6.6E-02
Toxicity Endpoint	cancer	cancer	cancer	cancer	cancer	cancer

The following dose equations were used to estimate exposure doses from direct contact with sediment and soils at the park. Exposure parameters are defined in Table B5.

$$\boldsymbol{Total\ Dose\ from\ Sediment = Ingested\ Dose\ + Dermally\ Absorbed\ Dose}$$

Ingested Dose (ID)

$$ID_{non.cancer} = \frac{C \times CF \times IR \times EF \times ED}{BW\ \times\ AT_{non.cancer}}$$

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

Dermal Absorbed Dose (DAD)

$$DAD_{non.cancer} = \frac{DT \times SA \times EF \times ED}{BW \times AT_{non.cancer}}$$

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

Where dermal transfer (DT) is,

$$DT = \frac{C \times AF \times ABS \times AD \times CF}{ORAF}$$

Table B5. Exposure Assumptions for exposure to contaminants in sediment samples from beaches along Lake Washington at Newcastle Beach Park, King County, Washington.

Parameter and Abbreviation		Value	Unit	Comments
Body weight – adult	BW	72	kg	Adult mean body weight
Body weight – older child		41		Older child mean body weight
Body weight – child		15		Young child average body weight (0-5 years)
Averaging Time (non-cancer)	ATnc	Variable	days	Equal to exposure duration × 365 days/year
Averaging Time (cancer)	ATc	27375		75 years
Exposure frequency (sidewalk)	EF	120	days/year	Area resident (every day for two months of the summer)
Exposure frequency (swale)	EF	12	days/year	Area resident (once a month or 12 times a year in the swale)
Exposure duration	ED	30 (5, 10,15)	years	Number of years at one residence (child, older child, adult)
Soil/Sediment Ingestion and Dermal Parameters				
Concentration in soil or sediment	Cs	Variable	mg/kg	Maximum detected value
Conversion factor	CF	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion rate – adult	IRs	50	mg/day	EPA Exposure Factors Handbook (24)
Ingestion rate – older child		100		
Ingestion rate – child		200		
Surface area – adult feet	SA	6600	cm^2	EPA EFH (feet, lower legs, hands) (25)
Surface area – older child feet		3721		
Surface area – child feet		1642		
Adherence factor – child, older child	AF	0.2	mg/cm^2	EPA RAGS (26)
Adherence factor – adult		0.07		
24 hr. absorption factor – Arsenic	ABS	0.03	unitless	EPA (Chemical Specific) Arsenic (25)
24 hr. absorption factor – PAHs; TPH		0.13		EPA (Chemical Specific) PAH (25)
Adherence duration	AD	1	days	EPA RAGS (26)
Oral route adjustment factor	ORAF	1	unitless	Non-cancer (nc) / cancer (c) -default
Water Ingestion and Dermal Parameters				
Concentration in water	Cw	Variable	µg/L or ppb	Maximum detected value per area
Exposure time	ET	0.25	hours/day	Time spent in ditch or walking on the pathway
Event frequency	EV	1	events/day	Once per day
Surface area wading – adult	SAwa	6600	cm^2	EPA EFH (feet, lower legs, hands) (25)
Surface area wading – older child		3721		EPA EFH (feet, lower legs, hands) (25)
Surface area wading – child		1642		EPA EFH (feet, lower legs, hands) (25)
Ingestion rate swimming	IRsw	0.050	Liters	EPA default
Ingestion rate wading	IRwa	0.0037	Liters	EPA EFH
Fraction of absorbed water	FA	Chem. specific	unitless	EPA RAGS E, Appendix B (26)
Skin permeability coefficient	Kp	Chem. specific	cm/hour	EPA RAGS E, Appendix B (26)

Parameter and Abbreviation		Value	Unit	Comments
Lag time	τ (tau)	Chem. specific	hour	EPA RAGS E, Appendix B (26)
Time of each event	t	Chem. specific	Hours/event	EPA RAGS E, Appendix B (26)
Dimensionless ratio for permeability coefficient of compound through the stratum corneum relative to epidermis	B	Chem. specific		EPA RAGS E, Appendix B; (26) For TPH B estimated as $Kp \times \frac{\sqrt{MW}}{2.6}$

Sources: EPA 2004 (Risk Assessment Guideance for Superfund sites Part E (RAGS E); EPA 2011 (Exposure Factor Handbook)
Abbrevations not defined in table:

Table B6. Non-carcinogenic hazard calculations resulting from exposure to arsenic in sediments and soils at Newcastle Beach Park, King County, Washington.

Contaminant	Upland Concentration (mg/kg-day)	Scenario	Estimated Dose from Soil (mg/kg-day)			NOAEL (mg/kg-day)	MRL (mg/kg-day)	Potential for Harm
			Incidental Ingestion	Dermal Contact	Total Dose			
Arsenic	Upland 32.4	Child	1.4E-05	7.0E-07	1.5E-05	8E-4	3E-4	No
		Older child	2.6E-06	5.8E-07	3.2E-06			No
		Adult	7.4E-07	2.0E-07	9.4E-07			No

Table B7. Carcinogenic hazard calculations resulting from exposure to arsenic and polycyclic aromatic hydrocarbons (PAHs) in soil or sediments at points of contact, Newcastle Beach Park, King County, Washington.

Contaminant	Upland Concentration mg/kg	EPA Cancer Group	Cancer Potency Factor	Scenario	Increased Cancer Risk		
					Incidental Ingestion	Dermal Contact	Total Cancer Risk
Arsenic	32.4 (once a month in the swale)	A	5.7	Child	5.4E-06	2.7E-07	5.7E-06
				Older child	20E-06	4.4E-07	2.4E-06
				Adult	8.4E-07	2.3E-07	1.1E-06
cPAH BaP-EQ	0.1016 (120 days a year on sidewalk)	B2	7.3	Child x10*	2.2E-06	4.6E-07	2.6E-06
				Older child x 3*	2.4E-07	2.3E-07	4.8E-07
				Adult	3.4E-08	4.1E-08	7.5E-08
						Lifetime	**1.2E-05**

Abbreviations:
mg/kg – milligrams chemical per kilogram soil.
cPAH-BaP Eq – Benzo(a)pyrene equivalents of all carcinogenic polycylic aromatic hydrocarbons
EPA – U.S. Environmental Protection Agency

Appendix C – Summary of Surface Water Chemical Data and Screening Analysis

Appendix C contains a summary of surface water quality data, a description of the screening method, and a screening analysis. Surface water data screened included lake water, stream water, wetland water, ponded water, seeps, and interflow water (i.e., ditch, swale and cross drain water) (Table C1). Groundwater data were not included in this evaluation because it is not used for drinking water or available to people recreating at the park. Surface water at the park is not potable and should not be used as a drinking water source. DOH screens data that meet adequate sampling and analytical standards to identify chemicals of potential concern. DOH screened data in two steps as described below.

Step 1 Screening
In the first screening, DOH compared chemical concentrations in surface with ATSDR health-based comparison values (CV) for drinking water. Again, surface water at the park is not potable and should not be used as a drinking water. This conservative approach screened data to identify chemicals for a more thorough screening for a recreational exposure scenario. The drinking water CVs are derived in a uniform way using health guidelines and standard default exposure assumptions. The default exposure assumptions generally represent high estimates of exposure (greater than the mean, approaching the 90th percentile) based on observed ranges of child activity patterns (e.g., ingestion rates, residence times, etc.). ATSDR CVs used in the screening analyses include:

- **Environmental Media Evaluation Guides (EMEGs):** EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR minimal risk levels (MRL) and conservative child assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.
- **Cancer Risk Guides (CREGs):** CREGs are estimated contaminant concentrations that would be expected to cause no more than 1 excess cancer in 1,000,000 (10^{-6}) persons exposed during their lifetime (70 years). ATSDR's CREGs are calculated from EPA's cancer slope factors (CSFs) for oral exposures or unit risk values for inhalation exposures. These values are based on EPA evaluations and assumptions about hypothetical cancer risks at low levels of exposure for residents.
- **Reference Dose Media Evaluation Guides (RMEGs):** ATSDR derives RMEGs from EPA's oral reference doses (RfD, see description below), which are developed based on EPA evaluations. RMEGs represent the concentration in water at which daily human exposure is unlikely to result in adverse non-carcinogenic effects.

ATSDR CVs used to screen surface water are found in Table C1. In the absence of ATSDR CVs, residential EPA regional screening levels (RSLs) (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search) or cleanup standards developed under the Washington State Model Toxics Control Act (MTCA) were used to determine if levels pose a potential health impacts. Maximum concentrations measured at the park were compared to CVs. If a maximum concentration was above the health-based CV, it does not mean that adverse health effects will

occur. Exceeding a CV identifies a chemical for further site-specific exposure evaluation in the recreational exposure scenario.

Table C2. Range of concentrations of chemicals found in surface water at Newcastle Beach Park, King County, Washington with drinking water health-based comparison values.

Chemical	Range of Concentrations (ppm or ppb)	Number Detected Above CV	CV	Type of CV	Further Analysis
Total Metals (ppb)					
Antimony	0.1–1.61	0/4	4	RMEG	No
Arsenic	0.71–86.8		0.023	CREG	Yes
Barium	39.6	0/1	2000	cEMEG	No
Beryllium	0.06–0.10	0/4	20	cEMEG	No
Cadmium	0.10– **<4 .4**	0/8 (2)	5	RMEG	No
Chromium	0.50– **<11**	0/8	30 15000	RMEG (CrVI) RMEG (CrIII)	No
Cobalt	7.8	0/1	100	iEMEG	No
Copper	0.60–84.8	0/22	100	iEMEG	No
Iron	93–81600	0/16		NA	No
Lead	0.10–7.93	0/8	15	MCL	No
Manganese	12–196	0/5	500	RMEG	No
Mercury	0.00001–0.05	0/4	3	RMEG ($HgCl_2$)	No
Molybdenum	1.63	0/1	50	RMEG	No
Nickel	0.44–22	0/8	200	RMEG	No
Silver	0.10–11	0/8	50	RMEG	No
Selenium	0.50–0.59	0/4	50	cEMEG	No
Thallium	0.10–0.25	0/4	2	MCL	No
Vanadium	10.1	0/1	100	iEMEG	No
Zinc	1.0–80	0/9			No
Petroleum Hydrocarbons (ppm)					
Heavy Oil Range (>C24)	0.13–**2.7**	5/23 (4)	0.5	MTCA A	**Yes**
Diesel Range (>C12-C24)	0.05–**1.6**	3/23	0.5	MTCA A	**Yes**
Gasoline Range (C7-C12)	< 0.001–<0.1	0/16	1000	MTCA A no BTEX	No
Benzene	< 0.001	0/14	0.64	CREG	No
Tolulene	< 0.001	0/14	800	RMEG	No
Ethyl benzene	< 0.001	0/14	1000	RMEG	No
Xylene, m,p-	< 0.001	0/3	2000	cEMEG (Total Xylene)	No
Xylene, o-	< 0.001	0/3	2000	cEMEG (Total Xylene)	No
Xylene, Total	< 0.001	0/1	2000	cEMEG	No
Semi-Volatile Organic Compounds; Non-carcinogenic Polycyclic Aromatic Hydrocarbons (ppb)					
Acenapthene	<0.095 – <2.0	0/17	600	RMEG	No
Acenaphthylene	<0.095 – <2.0	0/17	600	RMEG (acenaphthene)	No
Anthracene	<0.095 – <2.0	0/17	3000	RMEG	No
Benzo(g,h,i)perylene	<0.0095 – <2.0	0/17	300	RMEG (pyrene)	No
Fluoranthene	<0.095 – <2.0	0/17	400	RMEG	No
Fluorene	<0.095 – <2.0	0/17	400	RMEG	No
1-Methylnapthalene	<0.095 – <2.0	0/7	400	RMEG	No

Chemical	Range of Concentrations (ppm or ppb)	Number Detected Above CV	CV	Type of CV	Further Analysis
2-Methylnapthalene	<0.095 – <2.0	0/17	400	RMEG	No
Napthalene	<0.095 – <2.0	0/7	200	RMEG	No
Phenanthrene	<0.095 – <2.0	0/17	300	RMEG (pyrene)	No
Pyrene	<0.095 – <2.0	0/17	300	RMEG	No
Semi-Volatile Organic Compounds; Carcinogenic Polycyclic Aromatic Hydrocarbons (ppb)					
Benzo(a)anthracene (0.1)	<0.0095 – <2.0	0/17	**0.0048**	CREG (BaP)	**Yes**
Benzo(b)fluoranthene (0.1)	<0.0095 – <2.0	0/17			
Benzo(k)fluoranthene (0.01)	<0.0095 – <2.0	0/17			
Benzo(a)pyrene (BaP) (1)	<0.0095 – <2.0	0/17			
Chrysene (0.001)	<0.0095 – <2.0	0/17			
Dibenz(a,h)anthracene (1)	<0.0095 – <2.0	1/17			
Indeno(1,2,3-c,d)pyrene (0.1)	<0.0095 – <2.0	2/17			
Total BaP-EQ (ND=1/2DL)	**<0.011–<2.31**	2/17 (14)			
Other Semi-Volatile Organic Compounds (ppb)					
Bis(2-ethylhexyl)phthalate	1.09	0/1	2.5	CREG	No
Butyl benzyl phthalate	1.00	0/1	2000	RMEG	No
Chlorpyrifos	0.10	0/1	10	cEMEG	No
Diazonon	0.10	0/1	7	cEMEG	No
Dichlobenil	0.10	0/1	-	NA	No
Diethyl phthalate	1.00	0/1	8000	RMEG	No
Dimethyl phthalate (DMP)	1.00	0/1	1000	RMEG (1,4-DMP)	No
D-n-butyl phthalate	1.00	0/1	1000	RMEG	No
Di-n-octyl phthalate	1.0–1.2	0/11	4000	iEMEG	No
Malathion	0.10	0/1	200	cEMEG	No
Pentachlorphenol	1.00	0/1	10	cEMEG	No
Prometon	0.10	0/1	40	RMEG	No

Source:

Note: Use of drinking water comparison values is a conservative approach considering that the surface and interflow water at the park is not potable and groundwater at the park is not used for drinking. Exeedence of a CV does not indicate that a health effect will occur and requires a more thorough exposure evaluation.

Abbreviations:

ATSDR – Agency of Toxic Substances and Disease Registry
BaP-EQ – Benzo(a)pyrene equivalents
BDE – brominated diphenyl ethers
BHC - hexachlorocyclohexane
cEMEG – Environmental media evaluation guide based on child chronic exposures; comparison value developed by ATSDR
CREG – Cancer Risk Guides
CV – health based comparison values
DL – detection limit
DMP – dimethyl phthalate
DW – dry weight
EPA – U.S. Environmental Protection Agency
iEMEG - Environmental media evaluation guide based on child intermediate exposures; ATSDR comparison value
MTCA A – Washington State Model Toxics Control Act clean up standards for unrestricted Land use (Method A)
NA – not available
ND – non-detect
PAH – Polycyclic aromatic hydrocarbons
ppb – parts per billion (same as µg/kg)
ppm – parts per million (same as mg/kg)
RfD – Reference dose (developed by U.S. EPA)
RMEG – RfD Media Evaluation Guide; comparison value developed by ATSDR
RPF – relative potency factor
RSL – U.S. EPA regional screening level

Table C2. Comparison of recreational screening levels with surface water concentrations at specific locations in Newcastle Beach Park, King County, Washington.

Chemical	Location	Concentration	SL	Type of SL	Further Analysis
Arsenic (ppb)	Lake	0.71–0.89	0.93	RSL Calculator	No
	Upland (intermittent contact)	2.66–86.6	220	RSL Calculator	No
cPAH (BaP-EQ) (ppb)	Lake	< 0.011–< 0.12	0.23	RSL Calculator	No
	Upland (intermittent contact)	< 0.011– 0.44	46	RSL Calculator	No
TPH (heavy oils) (ppm)	Lake	< 0.62–1.4	3.2E+6	RSL Calculator	No
	Upland (intermittent contact)	0.65–2.7	3.6E+8	RSL Calculator	No
TPH (diesel) (ppm)	Lake	1.6	11,000	RSL Calculator	No
	Upland (intermittent contact)	0.54–0.95	1.2E+6	RSL Calculator	No

Abbreviations:

BaP-EQ Benzo(a)pyrene equivalents for all cPAH compounds
cPAH Polycyclic aromatic hydrocarbons associated with carcinogenic effects
EPA U.S. Environmental Protection Agency
ppm parts per million or milligrams chemical per kilograms sediment (mg/kg)
RSL Screening levels from EPA's regional screening calculator for recreational soil exposures (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search); see Tables B3 and B4 for input parameters and model output.
S Southern sample location outside of the park between Interstate 405 and the bike trail
N Northern sample location outside of the park between Interstate 405 and the bike trail

Table C3. Input parameters in the EPA Regional Screening Level Calculator for recreational exposures to surface water at Newcastle Beach Park, King County, Washington.

Variable	Upland (limited access)	Upland (intermittent access)	Shoreline
TR (target cancer risk) unitless	0.000001	0.000001	0.000001
THQ (target hazard quotient) unitless	1	1	1
$EF_{0\text{-}2}$ (exposure frequency) day/year	0	0	120
$EF_{2\text{-}6}$ (exposure frequency) day/year	12	52	120
$EF_{6\text{-}16}$ (exposure frequency) day/year	12	52	120
$EF_{16\text{-}30}$ (exposure frequency) day/year	12	52	120
EF_{recwc} (exposure frequency - child) day/year	12	52	120
EF_{recwa} (exposure frequency - adult) day/year	12	52	120
$ED_{0\text{-}2}$ (exposure duration) year	0	0	2
$ED_{2\text{-}6}$ (exposure duration) year	4	4	4
$ED_{6\text{-}16}$ (exposure duration) year	10	10	10
$ED_{16\text{-}30}$ (exposure duration) year	14	14	14
ED_{recwc} (exposure duration - child) year	6	6	6
ED_{recwa} (exposure duration - adult) year	24	24	24
ED_{recw} (exposure duration - recreator) year	30	30	30
LT (lifetime - recreator) year	70	70	70
EV_{recwa} (adult) events/day	1	1	1
EV_{recwc} (child) events/day	1	1	1
$EV_{0\text{-}2}$ events/day	0	0	1

Variable	Upland (limited access)	Upland (intermittent access)	Shoreline
$EV_{2\text{-}6}$ events/day	1	1	1
$EV_{6\text{-}16}$ events/day	1	1	1
$EV_{16\text{-}30}$ events/day	1	1	1
$ET_{0\text{-}2}$ (exposure time) hr/event	0	0	0.5
$ET_{2\text{-}6}$ (exposure time) hr/event	0.25	0.25	1
$ET_{6\text{-}16}$ (exposure time) hr/event	0.25	0.25	1
$ET_{16\text{-}30}$ (exposure time) hr/event	0.25	0.25	1
ET_{recwc} (exposure time - child) hr/event	0.25	0.25	1
ET_{recwa} (exposure time - adult) hr/event	0.25	0.25	1
$ET_{recwa\text{-}adj}$ (exposure time – age-adj) hr/event	0.25	0.25	1
$ET_{recw\text{-}madj}$ (exposure time – mut age) hr/event	0.25	0.25	1
$BW_{0\text{-}2}$ (body weight) kg	0	0	10
$BW_{2\text{-}6}$ (body weight) kg	17	17	17
$BW_{6\text{-}16}$ (body weight) kg	44	44	44
$BW_{16\text{-}30}$ (body weight) kg	70	70	70
BW_{recwc} (body weight - child) kg	17	17	14.667
BW_{recwa} (body weight - adult) kg	59.167	59.167	59.167
$IRW_{0\text{-}2}$ (water intake rate) L/hr	0	0	0.05
$IRW_{2\text{-}6}$ (water intake rate) L/hr	0.0037	0.0037	0.05
$IRW_{6\text{-}16}$ (water intake rate) L/hr	0.0037	0.0037	0.05
$IRW_{16\text{-}30}$ (water intake rate) L/hr	0.0037	0.0037	0.05
IRW_{recwc} (water intake rate - child) L/hr	0.004	0.004	0.05
IRW_{recwa} (water intake rate - adult) L/hr	0	0	70.8
SA_{recwc} (skin surface area - child) cm^2	490	490	2250
SA_{recwa} (skin surface area - adult) cm^2	1320	1320	5283.333
$SA_{0\text{-}2}$ (skin surface area - mutagenic) cm^2/	0	0	1750
$SA_{2\text{-}6}$ (skin surface area - mutagenic) cm^2/	490	490	2500
$SA_{6\text{-}16}$ (skin surface area - mutagenic) cm^2/	1250	1250	4700
$SA_{16\text{-}30}$ (skin surface area - mutagenic) cm^2/	1370	1370	5700
I_{sc} (apparent thickness of stratum corneum) cm	0.001	0.001	0.001
$IFW_{rec\text{-}adj}$ (age-adjusted water ingestion factor) L/kg	0.003	0.012	4.478
$DFW_{rec\text{-}adj}$ (age-adjusted water dermal factor) L/kg	7808.733	33837.841	367622.401
$IFWM_{rec\text{-}adj}$ (mutagenic age-adjusted water ingestion factor) L/kg	0.018	0.076	15.526
$DFWM_{rec\text{-}adj}$ (mutagenic age-adjusted water dermal factor) L/kg	17665.861	76552.064	1153110.16

Table C4. Output parameters and screening levels (SLs) from EPAs regional screening calculator for recreational surface water exposures at Newcastle Beach Park, King County, Washington.

Chemical	Arsenic, Inorganic			Benzo[a]pyrene			Total Petroleum Hydrocarbons (Aliphatic High)			Total Petroleum Hydrocarbons (Aliphatic Medium)		
	12 day	52 day	120 day	12 day	52 day	120 day	12 day	52 day	120 day	12 day	52 day	120 day
CAS Number	7440-38-2	7440-38-2	7440-38-2	50-32-8	50-32-8	50-32-8	NA	NA	NA	NA	NA	NA
Mutagen	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No
Volatile Organic Chemical	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Chemical Type	Inorganic	Inorganic	Inorganic	Organic	Organic	Organic	Organic	Organic	Organic	Organic	Organic	Organic
Ingestion Slope Factor $(mg/kg\text{-}day)^{-1}$	5.7E+00	5.7E+00	5.7E+00	7.3	7.3	7.3	-	-	-	-	-	-
Ingestion Slope Factor Reference	U	U	U	I	I	I						
Chronic Reference Dose (mg/kg-day)	3.0E-04	3.0E-04	3.0E-04	-	-	-	3.0E+00	3.0E+00	3.0E+00	1.0E-02	1.0E-02	1.0E-02
Chronic Reference Dose Reference	U	U	U				U	U	U	U	U	U
RAGSe GIABS (unitless)	1	1	1	1	1	1	1	1	1	1	1	1
kp	0.001	0.001	0.001	0.713	0.713	0.713	1.96	1.96	1.96	1.7	1.7	1.7
mw	74.922	74.922	74.922	252.32	252.32	252.32	170.34	170.34	170.34	128.26	128.26	128.26
fa	1	1	1	1	1	1	1	1	1	1	1	1
In EPD	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
DAeventc	5.7E-04	1.3E-04	1.2E-05	-	-	-	-	-	-	-	-	-
DAeventnc	3.2E-01	7.3E-02	5.9E-03	-	-	-	-	-	-	-	-	-
DAeventna	4.1E-01	9.4E-02	1.2E-02	-	-	-	-	-	-	-	-	-
Ingestion SL TR=1.0E-6 (µg/L)	1.5E+03	3.7E+02	1.0E+00	1.9E+02	4.6E+01	2.3E-01	-	-	-	-	-	-
Dermal SL TR=1.0E-6 (µg/L)	2.3E+03	5.3E+02	1.3E+01	-	-	-	-	-	-	-	-	-
Carcinogenic SL TR=1.0E-6 (µg/L)	9.1E+02	2.2E+02	9.3E-01	1.9E+02	4.6E+01	2.3E-01	-	-	-	-	-	-
Ingestion SL (Child) HQ=1 (µg/L)	1.6E+05	3.6E+04	3.2E+02	-	-	-	1.6E+09	3.6E+08	3.2E+06	5.2E+06	1.2E+06	1.1E+04
Dermal SL (Child) HQ=1 (µg/L)	1.3E+06	2.9E+05	7.1E+03	-	-	-	-	-	-	-	-	-

Chemical	Arsenic, Inorganic			Benzo[a]pyrene			Total Petroleum Hydrocarbons (Aliphatic High)			Total Petroleum Hydrocarbons (Aliphatic Medium)		
	12 day	52 day	120 day	12 day	52 day	120 day	12 day	52 day	120 day	12 day	52 day	120 day
Noncarcinogenic SL (Child) HQ=1 (µg/L)	1.4E+05	3.2E+04	3.1E+02	-	-	-	1.6E+09	3.6E+08	3.2E+06	5.2E+06	1.2E+06	1.1E+04
Ingestion SL (Adult) HQ=1 (µg/L)	-	-	1.1E+03	-	-	-	-	-	1.1E+07	-	-	3.6E+04
Dermal SL (Adult) HQ=1 (µg/L)	1.6E+06	3.8E+05	1.0E+04	-	-	-	-	-	-	-	-	-
Noncarcinogenic SL (Adult) HQ=1 (µg/L)	1.6E+06	3.8E+05	9.8E+02	-	-	-	-	-	1.1E+07	-	-	3.6E+04
Screening Level (µg/L)	9.1E+02	2.2E+02	9.3E-01	1.9E+02	4.6E+01	2.3E-01	1.6E+09	3.6E+08	3.2E+06	5.2E+06	1.2E+06	1.1E+04
Toxicity Endpoint	ca	ca	Cancer	Cancer	Cancer	Cancer	Non-cancer	Non-cancer	Non-cancer	Non-cancer	Non-cancer	Non-cancer

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