Health Consultation

PROPOSED SHELLFISH HARVESTING SITE

LIBERTY BAY, KITSAP COUNTY, WASHINGTON

EPA FACILITY ID: ILD053219259

MAY 20, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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

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

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HEALTH CONSULTATION

PROPOSED SHELLFISH HARVESTING SITE

LIBERTY BAY, KITSAP COUNTY, WASHINGTON

Prepared by:

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

Foreword

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

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

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

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Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Aquifer	An underground formation composed of materials such as sand, soil, or gravel that can store and/or supply groundwater to wells and springs.
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
Comparison value	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
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 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.
Indeterminate public health hazard	The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].
Ingestion rate	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
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**].
Monitoring wells	Special wells drilled at locations on or off a hazardous waste site so water can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.
No apparent public health hazard	A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.
No public health hazard	A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.
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.

Plume	A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.
Remedial investigation	The CERCLA process of determining the type and extent of hazardous material contamination at a site.
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**].
Volatile organic compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Purpose

This health consultation was prepared at the request of the Office of Food Safety and Shellfish Programs (OFSSP) at the Washington State Department of Health (DOH) to evaluate the potential health hazard posed by possible chemical contamination of shellfish harvested in an area of Liberty Bay. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background and Statement of Issues

OFSSP received an application to commercially harvest shellfish from an intertidal site in Liberty Bay adjacent to Lemolo Shore Drive near the city of Poulsbo, Kitsap County, WA. There is currently no commercial harvesting taking place in the area. OFSSP requested the health consultation due to concerns about nearby sources of chemical contamination.

The proposed harvest site is located in a low-density residential area on a narrow spit that juts into Liberty Bay. The majority of the houses in the area are located 200-300 feet from the shore except for two houses to the west of the proposed harvest beach that are directly adjacent to Liberty Bay. These homes have septic systems that provide the potential for biological contamination near the harvest area.

Hazardous waste sites and businesses regulated by the Washington State Department of Ecology within one mile of the proposed shellfish growing area were identified in order to determine if they could potentially impact the proposed shellfish harvest beach. The sites identified were the Poulsbo Landfill, the Lemolo Market, Fred Hill Materials, and the Naval Undersea Warfare Center in Keyport (Figure 1). These sites are described below.

Poulsbo Landfill

The Poulsbo Landfill is a 15-acre site located at Highway 305 and Stenbom Lane NE in Poulsbo, approximately 2600 feet north of the proposed harvest site. This municipal landfill was operated from 1937 to 1979 and accepted mixed municipal waste and sewage sludge. The site was closed and covered with soil in 1979. It is currently undeveloped and covered with thick brush. The waste was disposed of in a ravine. The ravine's drainage flows to an unnamed stream that in turn discharges to Liberty Bay about ¼ mile west of the Lemolo site. Records show that "1080" sodium flouracetate in 1949 was used to control rodents, and in the 1970s, warfarin and chlordane were used for pest control. In March 1999, the Bremerton-Kitsap County Health District (BKCHD) identified seeps from the landfill impacting the stream. These seeps were not tested for contaminants, but illustrated the potential for the migration of contaminants from the landfill to the creek.[1] In 2000, the landfill was placed on the list of known or suspected contaminated sites under the Model Toxics Control Act (MTCA).

Soil samples were collected in July 2001 by BKCHD from drainage areas and seep locations. Low levels of contaminants such as DDE, DDT, chlordane, PCBs, and SVOCs (semi-volatile organic hydrocarbons) were detected. Phthalates were detected, but their presence was attributed to laboratory contamination, because they were also detected in the laboratory blank. Samples from nearby drinking water wells did not reveal any contaminants. BKCHD recommended no further action under MCTA based in part on the sampling results.

Lemolo Market

The Lemolo Market is located at 16670 Lemolo Shore Drive in Poulsbo and is 3000 feet northwest from the Lemolo site. It was found to have leaking petroleum underground storage tanks in 1993.[2] The tanks were removed and much of the contaminated soil was excavated and stockpiled on site. The soil has since been removed. There is no information indicating that groundwater below the site was impacted.

Fred Hill Materials

Fred Hill Materials is located approximately 3700 feet from the proposed commercial shellfish harvest site. This company supplies sand, gravel, and other products to contractors. The facility near Lemolo Shore Drive has a permit to discharge storm water from the site.[3] Suspended solids leaving the Fred Hill Materials yard would be the main issue with stormwater discharge from this site.

Naval Undersea Warfare Center in Keyport

The largest hazardous waste site in the area is the Naval Undersea Warfare Center (NUWC) in Keyport, which is located approximately 3000 feet South across Liberty Bay from the proposed harvest site. NUWC was included on the Superfund National Priorities List (NPL) in 1986. ATSDR reports that hazardous waste was generated at the site through painting, torpedo testing and maintenance, and torpedo fuel. Contaminants such as cyanide, solvents, fuel and paints were discharged into the bay up until 1980. [4] A chromate spill in the 1970s, an oil release in 1987, and a plating waste spill in 1988 occurred in one area of NUWC. Commonly consumed shellfish found in this portion of Liberty Bay include clams, crabs, mussels and rough piddocks.

Sampling of native littleneck clams in 2000 found concentrations of cadmium, chromium, lead, nickel and silver below levels of human health concern. Additionally, pentachlorophenol was found in one of seventeen samples. Pentachlorophenol is used as a wood preservative and may be from the wooden pilings used for piers. No pesticide, PCB, or volatile organic compound (VOC) analysis was conducted for this area. Sampling of littleneck clams and rough piddocks in 1989 and 1992 detected low concentrations of some metals and semivolatile organic compounds (SVOC).

Contaminated groundwater empties into tide flats near Dogfish Bay. This groundwater comes from the upper and intermediate aquifers located below the Keyport Landfill. The Keyport Landfill is approximately 9 acres and was utilized from the mid-1930s until 1973. Native littleneck clams, bent-nosed clams, mud clams, and manila clams have been identified in the Tide Flats and Dogfish Bay.

Sampling of native littleneck clams was conducted on three separate occasions in Dogfish Bay between 1989 and 2000. Various contaminants were found at low concentrations including PCBs and six metals.

Discussion

The two most relevant sites to this discussion are the Poulsbo Landfill and the Keyport NUWC because both sites are sources of environmental contamination that could impact Liberty Bay. The impact of these sites on the proposed shellfish growing area are unknown, but existing shellfish tissue samples from Liberty Bay can be used to evaluate potential exposure to contaminants in commercially harvested shellfish. Three composite samples consisting of approximately 90 native littleneck clams were collected and analyzed from Liberty Bay each year in 1992 and 1993 as part of the Puget Sound Ambient Monitoring Program (PSAMP). Additional samples were collected from Liberty Bay and Dogfish Bay as part of the Keyport NUWC Remedial Investigation (RI).

Contaminants of concern in shellfish were determined by employing a screening process. Maximum shellfish contaminant levels from Liberty Bay (both PSAMP and NUWC RI data) were screened against comparison values that were calculated based on an upper-bound estimate of subsistence shellfish consumption (about 3/4 pound per day for a 70 kilogram (kg) adult). The screening process is detailed further in Appendix A. The following table shows the contaminants of concern relative to their comparison value. In general, if a contaminant's maximum concentration is greater than its comparison value, then the contaminant is evaluated further.

Table 1. Maximum reported contaminant concentrations in Liberty Bay shellfish compared to screening value.

Contaminants of Concern	Maximum Concentration (ppm)	Calculated Screening Value (ppm)	Contaminant of Concern
2-Methylphenol	0.033	none	[a]
di-n-butyl phthalate	1.411	21.7	No
butyl benzyl phthalate	0.03	43.5	No
bis(2-ethylhexl) phthalate	0.68	0.36	No[b]
benzoic acid	3.1	870	No
Arsenic 10%	0.27	0.003	Yes
Cadmium	0.32	0.04	Yes
Copper	3	None	[a]
Mercury	0.029	0.02	Yes
Lead	0.63	IEUBK model	Yes
Zinc	16	65	No
Chromium	1	0.65	Yes
Nickel	0.91	4.3	No
Selenium	0.73	1.1	No
Silver	0.48	1.1	No
Methyl Parathion	0.01	0.05	No
Pentachlorophenol	4.3	0.02	Yes
PCBs	0.013	0.004	Yes

a Contaminant not evaluated in this health consultation due to toxicological uncertainty
b Presence of this contaminant appeared to be a laboratory contaminant

Table 2. Mean and Maximum contaminant levels for Contaminants of Concern in Liberty Bay shellfish - Kitsap County, WA

Chemical	**Liberty Bay average (ppb)** source: PSAMP	**Max value (ppb)** Source: PSAMP and Keyport RI
Arsenic	2,300	2,700
Cadmium	190	300
Chromium	NA	1,000
Mercury	20	29
PCBs	ND	13
Pentachlorophenol	ND	4.3
BEHP	680	680

NA = Not analyzed
ND = Not detected

Non-cancer Hazard Evaluation

In order to evaluate the potential for *non-cancer* adverse health effects that might result from exposure to contaminants in shellfish harvested from the Lemolo Shores site, estimated doses for average and high-end consumers were calculated. These estimated doses were then compared to EPA's oral reference doses (RfDs). RfDs are doses below which non-cancer adverse health effects are not expected to occur (so called "safe" doses).[5] RfDs are derived from toxic effect levels obtained from human population and laboratory animal studies. This toxic effect level is divided by multiple "safety factors" to give the lower, more protective RfD. A dose that exceeds the RfD indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded by the exposure dose. If the estimated exposure dose is only slightly above the RfD, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the RfD, the closer it will be to the toxic effect level.

The biokinetics of lead are different than most toxicants because it is stored in bone and remains in the body long after it is ingested. Children's exposure to lead is evaluated through the use of the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) developed by the EPA. This is described in a separate section on page 12.

Adult and children's average and high-end exposure doses associated with consumption of shellfish from Liberty Bay were calculated for the contaminants of concern (Appendix B). The maximum contaminant levels found in shellfish samples were used to calculate exposure doses in order to represent a worst-case exposure to shellfish consumers. General population scenarios were used as opposed to a subsistence scenario because the area may potentially be used as a commercial growing area for sale into general market. The average shellfish consumption scenario was based on an adult consuming 2 grams per day (g/day) and the high-end scenario assumed a shellfish consumption rate of 74.2 g/day. [5],[6] These consumption rates represent the mean and 99th percentile marine shellfish consumption estimate for the U.S. population older than 18 years. It should be noted that marine shellfish are not widely consumed by the vast majority of the U.S. population. The high-end general shellfish consumption scenario evaluated in this health consultation borders on being representative of an average subsistence consumption rate (Table 3).

Although specific marine shellfish consumption rates are not reported for children, they consume proportionately more seafood than adults. The average adult consumes about 0.28 gram of all fish combined per kilogram of body weight per day (g/kg/day) whereas children aged 3-5 years consume about 1.5 times as much per body weight (0.43 g/kg/day). If the same trend is true for shellfish, then children in the general U.S. population receive a 50% higher dose of contaminants in shellfish than adults. This trend does not hold for Puget Sound Tribal shellfish consumption where adults eat proportionately more shellfish than children (Table 3).

Table 3. Comparison of U.S. adult shellfish consumption rates with Puget Sound tribal and Asian Pacific Islander consumption

Population	**Adult Mean** (g/kg/day)	**Adult Upper percentile** (g/kg/day)	**Child Mean** (g/kg/day)	**Child Upper percentile** (g/kg/day)
U.S. General Population [a]	0.03	1.1 (99th)	0.055	2.0
Suquamish Tribe	1.7	7.7 (95th)	0.80	5.0
Tulalip/Squaxin Tribes	0.27	1.3 (95th)	0.18	0.57
Asian Pacific Islanders	0.87	1.7 (90th)	NA	NA

a – Assumes a 70 kg body weight for U.S. adults. Child shellfish rate adjusted from adult rate (appendix B Table B2)

Hazard Calculation

Exposure doses are compared to the RfD to obtain a hazard quotient (HQ) where:

HQ = Estimated dose/RfD

This provides a convenient method to measure the relative health risk associated with a dose. As the hazard quotient exceeds one and approaches an actual toxic effect level, the dose becomes more of a health concern.

None of the hazard quotients for child or adult average shellfish consumers exceeds one. Appendix B Table B3 shows the hazard quotients for all contaminants of concern and exposure scenarios. The hazard quotient for arsenic reaches 1.0 for high-end adult shellfish consumers, and both arsenic and PCB hazard quotients are greater than 1 for high-end child shellfish consumers. These exceedances, however, are well below actual toxic effect levels. Furthermore, worst-case exposure scenarios were used to calculate exposure doses, and actual exposure is likely to be lower. Adverse non-cancer health effects from average and high-end consumption of Liberty Bay shellfish are not likely to occur in the general population.

Exposure to lead in shellfish

EPA's IEUBK model assumes that children younger than seven years consume about three micrograms of lead per day (μg/day) in their diet. This assumption is based on data from the U.S. Food and Drug Administration (FDA) total diet study and food consumption data from the National Health and Nutrition Examination Survey (NHANES III). [7] Children consuming shellfish at average and high-end rates from Liberty Bay that contain the maximum reported lead concentration (0.63 ppm) would increase their lead intake by 0.5 and 16 μg/day respectively.

Assumptions used to customize the IEUBK model to fit a general population average and high-end exposure scenarios are shown in Appendix B Table B3. The model predicts that 1.3 percent of children consuming shellfish at an average rate would exceed a blood lead level of 10 micrograms per deciliter (μg/dl), the level that the Centers for Disease Control and Prevention (CDC) considers excessive. Approximately 11% of high-end shellfish consuming children would exceed this level. By comparison, 2.2% of children in the U.S. between 1-5 years old have an elevated blood lead level.[8] This worst-case scenario indicates that high-end consumers of shellfish may be exposed to lead in shellfish at levels that would increase their blood lead levels above levels of concern. It should be noted, however, that the average lead level of PSAMP littleneck clams in Liberty Bay was about 0.12 ppm (Table 2). This value is more than five times less than what was used in the IEUBK model (0.63 ppm). Re-running the model using average lead levels predicts only 2.3% of the children exceed a blood lead level of 10 μg/dl.

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 suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen will give a very small 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. More 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.[9]

This document describes cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight and no significant increase in cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands exposed over a lifetime and a slight estimate would require an exposed population of several hundreds of thousands to result in a single case. DOH considers cancer risk to be not significant when the estimate results in less than one cancer per one million 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 risks quantified in this document are an upper-bound theoretical estimate. Actual risks are likely to be much lower.

Cancer is a common illness and its occurrence in a population increases with age. Depending on the type of cancer, a population with no known environmental exposure could be expected to have a substantial number of cancer cases. There are many different forms of cancer that result from a variety of causes; not all are fatal. Approximately 25% to 33% of people living in the United States will develop cancer at some point in their lives.[10]

Cancer risks were calculated for adult and child shellfish consumers' exposure to contaminants of concern that potentially cause cancer in humans: arsenic, PCBs, bis (2ethylheyxl) phthalate, and pentachlorophenol. Cancer risk estimates for exposure to contaminants from average shellfish consumption are slight (5 cancers estimated per 1,000,000 exposed). High-end exposure risk is low (2 cancers estimated per 10,000 exposed).

Arsenic makes up the bulk of the cancer risk. Cancer is the primary concern for adverse health effects associated with arsenic exposure. However, this concern is based on human exposure to inorganic arsenic in drinking water. It should be noted that important differences exist between exposure to arsenic in drinking water and exposure to arsenic in fish, including amount and type of arsenic absorbed.[11] Estimating an arsenic dose from fish consumption is particularly problematic because results are reported as total arsenic, with no distinction between inorganic or organic forms. Inorganic arsenic is thought to be the most toxic, while organic forms are less toxic. Some forms of organic arsenic, however, may be more toxic than others, or they may be converted to inorganic arsenic in the body. Available data indicate that the percentage of total arsenic in fish/shellfish that is inorganic arsenic varies widely between 0.1-41percent. Recent shellfish sampling conducted by ATSDR on Marrowstone Island indicated a ten-fold difference in inorganic arsenic content between horse and native littleneck clams.[12,13] This assessment assumes that of the total arsenic reported in shellfish samples, ten percent consists of inorganic arsenic, an assumption that is consistent with current EPA guidance.[14]

It is important to consider that many of the listed contaminants occur naturally in a range of species over a wide area. For this reason, it is important to compare contaminant levels in Liberty Bay with those from the rest of Puget Sound. The average arsenic level in Liberty Bay native littleneck clams (2.3 ppm) is higher than Puget Sound as a whole (1.9 ppm). Of 29 PSAMP shellfish sampling locations across Puget Sound, only five other locations had higher arsenic levels in shellfish than Liberty Bay.[15] Levels of cadmium, lead, and mercury in Liberty Bay shellfish are similar to other areas within Puget Sound.

PCBs were found in shellfish near NUWC and Dogfish Bay, but were not found in any other Puget Sound native littlenecks. The lipid content in Native littleneck clams may be lower than other types of shellfish, which may influence the amount of lipophilic contaminants like PCBs that accumulate in the organism. Other types of shellfish may have higher lipid content providing the potential for greater accumulation of contaminants.

The potential for the migration of contaminants from nearby hazardous waste sites to the proposed shellfish harvest location is still uncertain. OFSSP has stated that chemical contaminants in shellfish rarely reach levels that would prohibit commercial harvesting and that biological agents are most often the reason for the rejection of shellfish harvest applications. While existing shellfish data reveals that contaminants in Liberty Bay do not appear to pose a significant health risk to shellfish consumers in the general population, subsistence consumers may be at some risk. For example, high-end shellfish consumption rates from the nearby Suquamish Tribe are reported to be at least seven times higher than the high-end scenario used to quantify exposure in this health consultation.

Child Health Considerations

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

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

Special consideration was given to children's exposure to contaminants in this health consultation by assuming that children eat proportionately more shellfish than adults. Children's exposure to lead was also evaluated with use of EPA's IEUBK model. Children from the general population that consume shellfish from the proposed shellfish harvest site are not likely to experience adverse health effects related to chemical contamination.

Conclusions

1. Exposure to chemical contaminants from consumption of intertidal shellfish harvested at the Lemolo Shores site is categorized as a *no apparent public health hazard* to the general population.

    - The calculated exposure doses present minimal adverse health risk to the general population

        - Worst-case exposure scenarios were used to calculate exposure to the general population.

    - Arsenic is the contaminant that contributes the most to health risk. This contaminant is not associated with nearby hazardous waste sites.

    - Lipophyllic organic pollutants found in nearby hazardous waste sites are less likely to accumulate in shellfish due to their low lipid content.

        - Littleneck clams monitored as part of PSAMP may have lower lipid content than other types of shellfish that are commercially harvested.

2. Levels of contaminants in Liberty Bay shellfish and other areas of Puget Sound may be of concern for subsistence consumers.

    - Shellfish consumption by nearby Suquamish Tribe is reported to be higher than the high-end general population.

Recommendations

Sampling of shellfish for lipophilic contaminants is recommended if longer lived and higher lipid content shellfish (relative to native littleneck clams) are to be grown and harvested.

Public Health Action Plan

Planned Actions

a. Copies of this health consultation will be forwarded to OFSSP.
b. DOH will evaluate any additional data generated at this site.
c. OFSSP will test the water column for the presence of biological contaminants.

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Figure 1. Ecology and EPA sites identified within a one-mile radius of the proposed Lemolo Shore Drive shellfish harvest area - Kitsap County, Washington

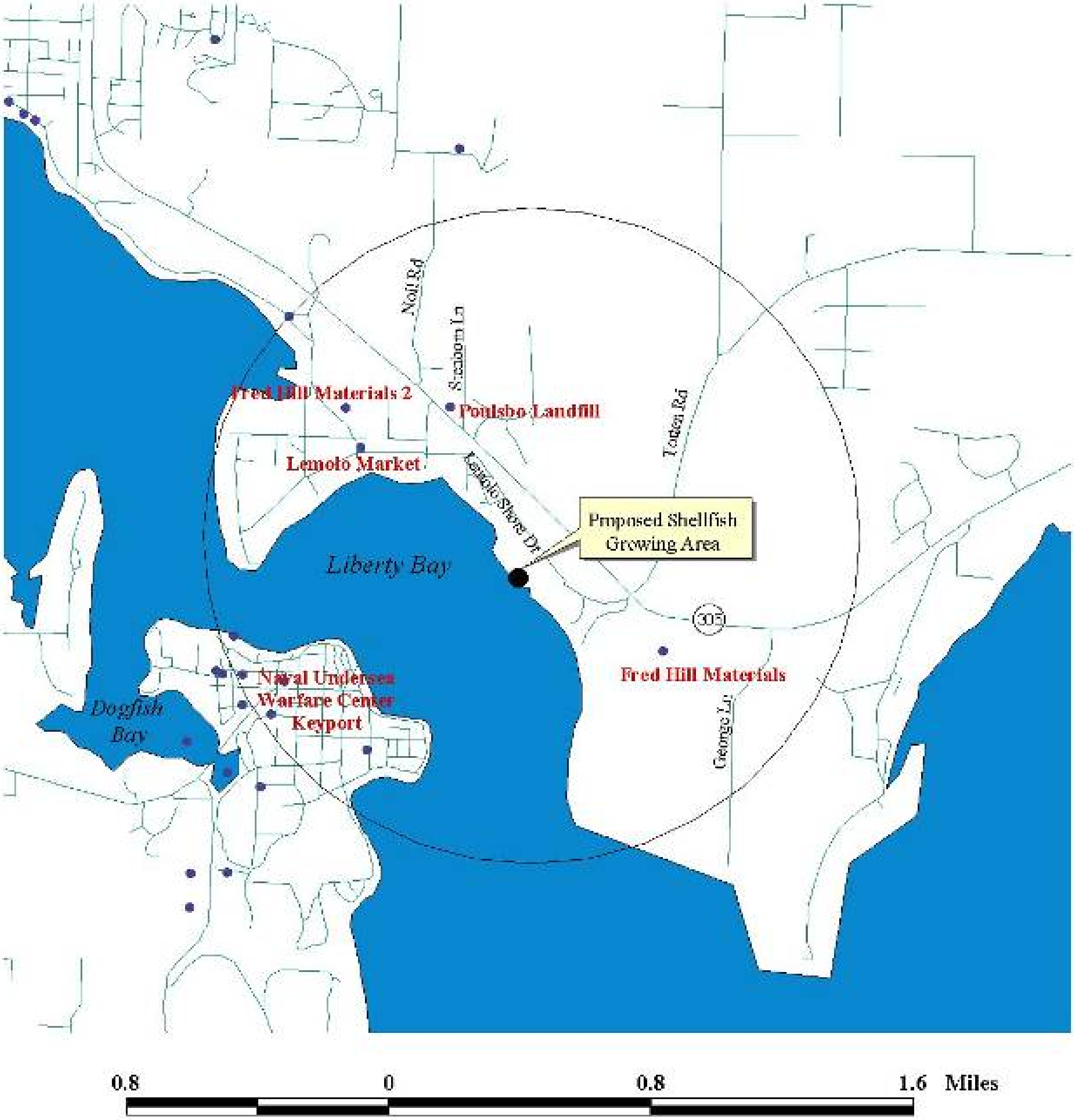
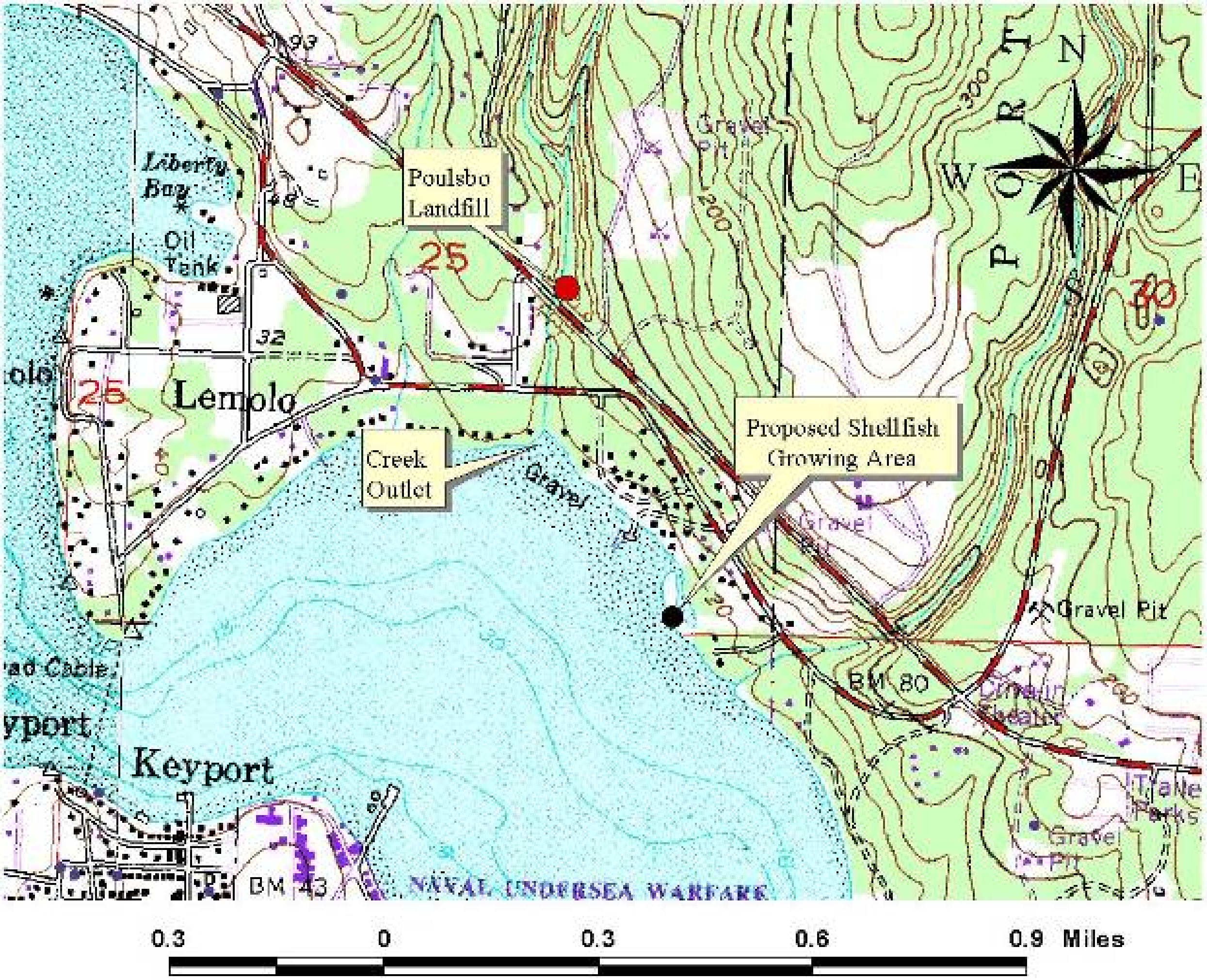


Figure 2: Location of Poulsbo Landfill relative to proposed shellfish harvest beach and creek that flows from Poulsbo Landfill to Liberty Bay - Kitsap County Washington



Certification

This Health Consultation was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation were begun.

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

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Appendix A: Contaminant Screening Process

The information in this section describes how the contaminants of concern in shellfish were chosen from a set of many contaminants. A contaminant's maximum shellfish concentration was compared to a screening value (comparison value), and if the contaminant's concentration is greater than that value, then it is considered further.

Comparison values were calculated using chronic EPA's reference doses (RfDs) and cancer slope factors (CSFs). RfDs represent an estimate of daily human exposure to a contaminant below which non-cancer adverse health effects are unlikely.

This screening method ensured consideration of contaminants that may be of concern for shellfish consumers. The equations below show how comparison values were calculated for both non-cancer and cancer endpoints associated with consumption of shellfish.

$$CV_{non\text{-}cancer} = \frac{RfD * BW}{SIR * CF}$$

$$CV_{cancer} = \frac{Risk\ Level * BW}{SIR * CF}$$

Table A1. Parameters used to calculate comparison values used in the shellfish contaminant screening process. Liberty Bay - Kitsap County, Washington

Abbreviation	Parameter	Units	Value	Comments
CV	Comparison Value	mg/kg	Calculated	
RfD	Reference Dose	mg/kg-day	Chemical Specific	EPA
BW	Body Weight	kg	70	Adult body weight
SIR	Shellfish Ingestion Rate	g/day	322	Suquamish
CF	Conversion Factor	kg/g	0.001	kilograms per gram
CPF	Cancer Potency Factor	kg-day/mg	Chemical Specific	EPA

Appendix B: Exposure dose calculations and assumptions

Average and upper-bound general population exposure scenarios were evaluated for consumption of shellfish from Liberty Bay. Exposure assumptions given in Table B1 below were used with the following equations estimate contaminant doses associated with shellfish consumption.

$$Dose_{(non\text{-}cancer\ (mg/kg\text{-}day))} = \frac{C \times CF_1 \times IR \times CF_2 \times EF \times ED}{BW \times AT_{non\text{-}cancer}}$$

$$Dose_{(cancer\ (mg/kg\text{-}day))} = \frac{C \times CF_1 \times IR \times CF_2 \times EF \times ED}{BW \times AT_{cancer}}$$

Table B1. Exposure Assumptions

Parameter	Value	Unit	Comments
Concentration (C) – High-end	Variable	ug/kg	Maximum detected value.
Conversion Factor$_1$ (CF_1)	0.001	mg/ug	Converts contaminant concentration from micrograms (ug) to milligrams (mg)
Ingestion Rate (IR) – Average adult	2.0	g/day	Average and 99th percentile U.S. population adult shellfish consumption estimate
Ingestion Rate (IR) - High-end adult	74.2		
Ingestion Rate (IR) - High-end older child	0.95		Body weight-adjusted consumption rates to account for children eating only 81% as much fish per body weight as do adults (only used for cancer scenario)
Ingestion Rate (IR) - High-end older child	35.3		
Ingestion Rate (IR) – Average child	0.67		Body weight-adjusted consumption rates to account for children eating nearly 1.6 times as much fish per body weight as do adults (see table B2)
Ingestion Rate (IR) - High-end child	24.9		
Conversion Factor$_2$ (CF_2)	0.001	kg/g	Converts mass of fish from grams (g) to kilograms (kg)
Exposure Frequency (EF)	365	days/year	Assumes daily exposure consistent with units of ingestion rate given in g/day.
Exposure Duration (ED)	30	years	Number of years eating shellfish.
Body Weight (BW) - adult	70	kg	Adult mean body weight
Body Weight (BW) – older child	41		Older child mean body weight
Body Weight (BW) - child	15		0-6 year-old child average body weight
Averaging Time$_{non\text{-}cancer}$ (AT)	10950	days	30 years
Averaging Time$_{cancer}$ (AT)	25550	days	70 years
Minimal Risk Level (MRL) or Oral Reference Dose (RfD)	Contaminant-specific	mg/kg/day	Source: ATSDR, EPA
Cancer Potency Factor	Contaminant-specific	mg/kg-day^{-1}	Source: EPA

Table B2. Derivation of child and older child shellfish consumption rates for the general U.S. population.

Row	Parameter	Adult	Older Child (6-17 yrs)	Child (1-5 yrs)
1	Reported All Fish Consumption Rate-gram fish per kg bodyweight per day (g/kg/day)	0.277	0.225	0.433
2	Ratio to Adult All Fish Consumption Rate	1	0.81	1.6
3	Reported Shellfish Consumption (g/day)	2.00 (average) 74.2 (high-end)	Not Reported	Not Reported
4	Average Body Weight (kg)	70	41	15
5	Ratio to Adult BW	1	0.59	0.21
6	Adjusted Shellfish Consumption Rates (g/day) = Row 2 x Row 3 x Row 5	2.00 (average) 74.2 (high-end)	0.95 (average) 35.4 (high-end)	0.67 (average) 24.9 (high-end)

Table B3. Health risk calculations from exposure to contaminants of concern in shellfish sampled from Liberty Bay - Kitsap County, Washington. (1989-2000)

Chemical	Max Concentration (ppb)	RfD (mg/kg/day)	Hazard Quotient Adult		Hazard Quotient Child		Cancer Slope Factor (kg-day/mg)	Cancer Risk Adult		Cancer Risk Exposure starting at childhood [a]	
			Average	High-end	Average	High-end		Average	High-end	Average	High-end
Arsenic (inorganic)	270	0.0003	0.03	1.0	0.04	1.5	1.5	5e-06	2e-04	5e-06	2e-04
BEHP	630	0.02	<0.01	0.04	<0.01	0.05	0.014	1e-07	4e-06	1e-07	4e-06
Cadmium	300	0.001	0.01	0.3	0.01	0.5	NA	NA	NA	NA	NA
Chromium	1000	0.003	0.01	0.4	0.02	0.5	NA	NA	NA	NA	NA
Mercury	29	0.0001	0.01	0.3	0.01	0.5	NA	NA	NA	NA	NA
PCBs	13	0.00002	0.02	0.7	0.03	1.1	2	3e-07	1e-05	3e-07	2e-05
Pentachloro-phenol	4.3	0.03	<0.01	<0.01	<0.01	<0.01	0.12	6e-09	2e-07	7e-09	2e-07

a – assumes 30 year exposure beginning as a child

Table B4. Assumptions used to customize the IEUBK model for children's exposure to lead in Liberty Bay shellfish. Kitsap County, WA

Parameter	Value	Units
Lead Concentration	0.63	ppm
Average consumption rate	0.7	g/day
High-end consumption rate	24.9	g/day
Percentage of total meat consumption [a]	0.7(average) 26.5(high-end)	percent

a- assumes that children eat a total of 93.5 grams of meat per day [7]

References

[1] Bremerton-Kitsap County Health District. Site Hazard Assessment for Poulsbo Landfill. 30 October 2001.

[2] Cascade Environmental Service Inc. Letter to Washington State Department of Ecology concerning Lemolo Market. 15 January 1993.

[3] Washington State Department of Ecology. Facility/Site Detail for Fred Hill Materials. Available at URL http://apps.ecy.wa.gov/fs/fsstart.html [cited December 2003].

[4] Agency for Toxic Substances and Disease Registry. Public Health Assessment Keyport Naval Undersea Warfare Center. 27 September 2001.

[5] U.S Environmental Protection Agency. Exposure Factors Handbook Volume II Food Ingestion Factors. EPA/600/P-95/002Fb. August 1997.

[6] U.S. Environmental Protection Agency. Estimated Per Capita Fish Consumption in the United States. August 2002. Available at URL http://www.epa.gov/waterscience/fish/consumption_report.pdf [cited January 2004].

[7] U.S. Environmental Protection Agency. Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic Model for Lead in Children (v.0.99d). EPA 540/R-94/040. December 1994.

[8] Centers for Disease Control. Children's Blood Lead Levels in the United States. Available at URL http://www.cdc.gov/nceh/lead/research/kidsBLL.htm [cited January 2004].

[9] US Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment (Review Draft). NCEA-F-0644 July 19991999 Jul. Web address: Available at http://www.epa.gov/NCEA/raf/cancer.htm.

[10] Agency for Toxic Substances and Disease Registry. ATSDR Fact Sheet: Cancer. Updated August 30, 2002. Atlanta: US Department of Health and Human Services. Available at internet: http://www.atsdr.cdc.gov/COM/cancer-fs.html.

[11] Washington State Department of Health Office of Environmental Health Assessments. Memo regarding Arsenic in Shellfish. 30 March 2000.

[12] Agency for Toxic Substances and Disease Registry. Public health assessment, Port Hadlock Detachment (US Navy), Port Hadlock, Jefferson County, Washington. CERCLIS NO. WA4170090001. Atlanta: US Department of Health and Human Services; 1999 Dec 21.

[13] Agency for Toxic Substances and Disease Registry. Health consultation—exposure

investigation: shellfish contamination at Marrowstone Island, Washington associated with Port Hadlock Detachment (US Navy), Port Hadlock, Jefferson County, Washington. CERCLIS NO. WA4170090001. Atlanta: US Department of Health and Human Services; 1998 Sep 22.

[14] United States Environmental Protection Agency. EPA Region 10's comments on ATSDR's public health assessment for the Lower Duwamish Waterway. 2002 Mar.

[15] Washington State Department of Health. Puget Sound Ambient Monitoring Program: 1992 and 1993 Shellfish Chemical Contaminant Data Report. 1996 May.