Health Consultation

Evaluation of Selected Metals in Irondale Beach Park and Chimacum Creek Tidelands Shellfish Irondale, Jefferson County, Washington

July 28, 2008

Prepared by:
Washington State Department of Health
under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

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Foreword

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

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

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

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Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
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 Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Comparison value	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin (see route of exposure).
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on ATSDR's *minimal risk level* (MRL).

Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].
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	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
No 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 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.
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.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The RMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

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.

Summary and Statement of Issues

The Washington State Department of Health (DOH) prepared this health consultation to evaluate contaminants found in shellfish from Irondale Beach Park and Chimacum Creek Tidelands. The purpose of this health consultation is to fulfill a data gap based on a single composite sample from Jefferson County Public Health (JCPH). DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Irondale Beach Park is located along the sheltered Port Townsend Bay on the northeastern corner of the Olympic Peninsula in Irondale, Jefferson County, Washington State (see Figure 1). The city of Irondale was platted in 1909 with a population of 1500 and plans were made for a booming city of 20,000 in three years [1]. The community was named for an iron smelting plant. Irondale Furnace, Puget Sound Iron Company (Irondale Furnace) was built in 1880-1881 and operated a hot blast, open top furnace that produced # 1 foundry pig iron with an annual capacity of 10,000 tons [2]. Irondale Furnace operated through 1889 then closed. The smelting plant later reopened as Western Steel Company and smelting continued intermittently into the early 1900's.

Today, Irondale is an unincorporated community and is part of the "Tri-Area" of Irondale, Chimacum and Port Hadlock in central-east Jefferson County. In 2001, Jefferson County purchased the 13-acre former industrial site and shoreline area (Irondale Beach Park). In 2005, a citizen complained of oil on the beach and the Washington State Department of Ecology (Ecology) investigated and took three samples. These samples revealed the presence of severely weathered fuel oil that exceeded the state's Model Toxic Control Act (MTCA) cleanup level. In March 2006, Ecology placed the site on the suspected contaminated site list. Irondale Beach Park has been identified as a high-priority cleanup area as part of Governor Christine Gregoire's Puget Sound Initiative, to protect and restore Puget Sound and Hood Canal to good ecosystem health by 2020.

In December 2006, Irondale Beach Park was closed pending concerns about potential human health risks. Jefferson County Public Health (JCPH) conducted additional tests including a single multi-species composite shellfish sample. The shellfish tissue was analyzed for polycyclic aromatic hydrocarbons (PAHs) and metals. The sample results indicated that lead may be of concern to human health especially for young children, but the nature in which the sample was taken did not follow standard protocols. Therefore, DOH recommended additional shellfish sampling at the site. In April 2007, Irondale Beach Park was reopened to the public. However, JCPH and Jefferson County posted signs warning of possible risk to human health from consumption of intertidal shellfish harvested in the area. Currently, DOH Office of Shellfish and Water Protection has a marine biotoxin closure for butter clams in the Chimacum Creek Tidelands and Irondale Beach Park area.

The Washington State Department of Fish and Wildlife (WDFW) indicated that there are sufficient numbers of native littleneck clams (*Protothaca staminea*) at Irondale Beach Park. The WDFW also indicated the adjoining Chimacum Creek Tidelands has native littleneck clams, butter clams (*Saxidomus giganteus*), horse clams (*Tresus nuttalli* and *Tresus capax*) and eastern softshell clams (*Mya arenaria*). According to WDFW beach surveys, about 1,334 recreational harvesters collected shellfish from the Irondale Beach Park growing area in 2005.

Sample Collection, preparation, and analysis

Two different regions were sampled by DOH, Figure 2: (A) Irondale Beach Park and (B) Chimacum Creek Tidelands. Table 1 shows the species and sample location. All shellfish samples were collected during a low tidal cycle on June 14, 2007, as close to the water as practical. All clams taken for analysis were of legal size and all specimens were unbroken. Each sample of the primary species (Littleneck clams) consisted of 30 individual organisms with the exception of the two samples from Irondale Beach Park, which consisted of 23 and 24 individual of the same species. Each sample of the secondary species (Butter clams) consisted of 15 individual organisms of the same species. Each sample was placed in zipper-locked plastic bags, given a unique identifier, placed on ice, and hand delivered to Severn Trent Laboratories (STL) Seattle located in Fife. Samples were shucked, and then the tissues were homogenized and analyzed by STL. Tissues were analyzed for total arsenic, cadmium, chromium, copper, lead, and zinc.

Table1. Sample summary for shellfish sampled in Irondale beach and Chimacum Creek Tidelands, Irondale, Jefferson County, Washington. Note: each sample was composed of 15 to 30 individuals (see text above).

Sample species	Number of samples	
	Irondale	Chimacum
Littleneck clams	2	3
Butter clams	2	1

Results

Results of the shellfish analyses are presented in Tables 2 - 5. The mean and maximum concentrations for each species are shown in Tables 4 and 5. There were no obvious differences in metal concentrations between sample locations where Littleneck clams were taken. However, there may be differences in metals (arsenic, cadmium and copper) concentrations between species (Table 2). Due to small sample size from each area, variances in species differences were not calculated. When compared to the mean range for metals found in littleneck clams in the Puget Sound, the littleneck clam means from Irondale Beach Park and Chimacum Creek Tidelands are within the Puget Sound range (Table 3).

Table 2: Analytical results for sample taken from Irondale Beach Park and Chimacum Creek Tidelands in Irondale, Washington.

Littleneck	Arsenic (ppm)	Cadmium (ppm)	Chromium (ppm)	Copper (ppm)	Lead (ppm)	Zinc (ppm)
1	1.7	0.24	0.11 J	1.4	0.13 J	13 B
2	1.9	0.27	0.14 J	1.4	0.061 J	13 B
3	2.1	0.44	0.084 J	1.3	0.027 J	16 B
4	1.7	0.27	0.12 J	1.2	0.029 J	14 B
5	1.9	0.28	0.074 J	1.2	0.030 J	17 B
Butter	**Arsenic (ppm)**	**Cadmium (ppm)**	**Chromium (ppm)**	**Copper (ppm)**	**Lead (ppm)**	**Zinc (ppm)**
1	2.8	0.060 J	0.52	1.8	0.11 J	12 B
2	2.7	0.084 J	0.52	2.1	0.14 J	13 B
3	2.5	0.083 J	0.36	2.1	0.056 J	15 B

J - Result is less than the reporting limit but greater than or equal to the method detection limit and the concentration is an approximate value.
B - Compound was found in the blank and sample.
PPM – parts per million

Table 3: Comparison of the Irondale Beach Park and Chimacum Creek Tidelands littleneck clam mean to the Puget Sound littleneck clam mean range, Washington.

Location	Arsenic (ppm)	Cadmium (ppm)	Copper (ppm)	Lead (ppm)	Zinc (ppm)
Puget Sound Littleneck clams mean range	1.36 – 2.54	0.16 – 0.33	0.73 – 1.8	0.0 – 0.24	10.32 – 15.08
IBP & CCT Littleneck clams mean	1.9	0.3	1.3	0.06 J	15.0 B

J - Result is less than the reporting limit but greater than or equal to the method detection limit and the concentration is an approximate value.
B - Compound was found in the blank and sample.
PPM – parts per million

Discussion

Contaminants of Concern

Contaminants of concern (COC) in shellfish were determined by employing a screening process. Screening values (SV) were developed according to EPA guidance and are used to narrow the focus of evaluation to contaminants that are present at potential levels of public health concern [3]. Maximum shellfish contamination levels from each contaminant were screened against SV for cancer and non-cancer health effects (see Table 4, 5 and Appendix A).

For chemicals that cause cancer, SV represent levels that are calculated to increase the risk of cancer by about one in one hundred thousand. With the exception of lead, SV for chemicals that do not cause cancer represent levels that are not expected to cause any health problems. These types of SV often form the basis for cleanup. In general, if a contaminant's maximum concentration is greater than its SV, then the contaminant is evaluated further. However, for lead the evaluation is based on the goal of keeping blood lead levels in most children below 10 micrograms per deciliter (μg/dl).

The contaminants of concern are highlighted in bold in Table 4 and 5 below. These contaminants will be evaluated in the following section. Other contaminants are not present at levels of concern and are not evaluated in this document.

Table 4: Mean and maximum metal concentrations found in shellfish and screening value used in evaluating shellfish from Irondale beach, Irondale, Jefferson County, Washington.

Metals	**Littleneck clams** Concentration (ppm)		**Butter clams** Concentration (ppm)		**Screening Value** Concentration (ppm)		Contaminant of concern
	Mean	Maximum	Mean	Maximum	Non-Cancer	Cancer	
Total Arsenic	1.8	1.9	2.75	2.8	NA	NA	NA
Inorganic Arsenic 1 % of total	**0.018**	**0.019**	**0.0275**	**0.028**	0.065	**0.00038**	**Yes**
Cadmium	**0.255**	**0.27**	0.072	0.084 J	**0.22**	NA*	**Yes**
Chromium	0.125	0.14 J	0.52	0.52	0.65	NA	No
Copper	1.4	1.4	1.95	2.1	8.7	NA	No
Lead	0.096	0.13 J	0.125	0.14 J	NA**	NA**	**Yes**
Zinc	13.0	13.0 B	12.5	13.0 B	65.2	NA	No

NA- Not applicable
* Cadmium cancer risk is based on inhalation not ingestion.
**IEUBK - Integrated Exposure Uptake Biokinetic Model for Lead in Children is used to predict blood lead in children.
J - Result is less than the reporting limit but greater than or equal to the method detection limit and the concentration is an approximate value.
B - Compound was found in the blank and sample.
PPM – parts per million

Table 5: Mean and maximum metal concentrations found in shellfish and screening value used in evaluating shellfish from Chimacum Creek Tidelands, Irondale, Jefferson County, Washington.

Metals	**Littleneck clams** Concentration (ppm)		**Butter clams** Concentration (ppm)	**Screening Value** Concentration (ppm)		**Contaminant of concern**
	Mean	Maximum	Maximum	Non-Cancer	Cancer	
Total Arsenic	1.9	2.1	2.5	NA	NA	NA
Inorganic Arsenic 1 % of total	**0.019**	**0.021**	**0.025**	0.065	**0.00038**	**Yes**
Cadmium	**0.33**	**0.44**	0.083 J	**0.22**	NA*	**Yes**
Chromium	0.093	0.12 J	0.36	0.65	NA	No
Copper	1.23	1.3	2.1	8.7	NA	No
Lead	0.029	0.03 J	0.056 J	NA**	NA**	No
Zinc	15.7	17.0 B	15.0 B	65.2	NA	No

NA- Not applicable
* Cadmium cancer risk is based on inhalation not ingestion.
**IEUBK - Integrated Exposure Uptake Biokinetic Model for Lead in Children is used to predict blood lead in children.
J - Result is less than the reporting limit but greater than or equal to the method detection limit and the concentration is an approximate value.
B - Compound was found in the blank and sample.
PPM – parts per million

Chemical Specific Toxicity

Lead – *Occurrence, Health Concerns, and Risks*

Lead is a naturally occurring chemical element that is normally found in soil. In Washington, normal soil background concentrations rarely exceed 20 ppm [4]. However, the widespread use of certain products (such as leaded gasoline, lead-containing pesticides, and lead-based paint) and the emissions from certain industrial operations (such as smelters) has resulted in significantly higher levels of lead in soil in many areas of the state.

Elimination of lead in gasoline and solder used in food and beverage cans has greatly reduced exposure to lead. Currently, the main pathways of lead exposure in children are ingestion of paint chips, contaminated soil and house dust, and drinking water in homes with old plumbing.

Children less than seven years old are particularly vulnerable to the effects of lead. Compared to older children and adults, they tend to ingest more dust and soil, absorb significantly more of the lead that they swallow, and more of the lead that they absorb can enter their developing brain. Pregnant women and women of childbearing age should also be aware of lead in their environment because lead ingested by a mother can affect the unborn fetus.

Health effects

Exposure to lead can be monitored by measuring the level of lead in the blood. In general, blood lead rises 3-7 µg/dl for every 1,000 ppm increase in soil or dust concentration [5]. For children, the Centers for Disease Control and Prevention (CDC) has defined an elevated blood lead level (BLL) as greater than or equal to 10 micrograms of lead per deciliter of blood (µg/dl) [6]. However, there is growing evidence that damage to the central nervous system resulting in learning problems can occur at blood lead levels less than 10 µg/dl. About 2.2 percent of children in the U.S. have blood lead levels greater than 10 µg/dl.

Lead poisoning can affect almost every system of the body and often occurs with no obvious or distinctive symptoms. Depending on the amount of exposure a child has, lead can cause behavioral and learning problems, central nervous system damage, kidney damage, reduced growth, hearing impairment, and anemia [7].

In adults, lead can cause health problems such as high blood pressure, kidney damage, nerve disorders, memory and concentration problems, difficulties during pregnancy, digestive problems, and pain in the muscles and joints [7]. These have usually been associated with blood lead levels greater than 30 µg/dl.

Because of chemical similarities to calcium, lead can be stored in bone for many years. Even after exposure to environmental lead has been reduced, lead stored in bone can be released back into the blood where it can have harmful effects. Normally this release occurs relatively slowly. However, certain conditions, such as pregnancy, lactation, menopause, and hyperthyroidism can cause more rapid release of the lead, which could lead to a significant rise in blood lead level [8].

Arsenic

Arsenic is a naturally occurring element in the earth's soil. Background soil arsenic concentrations in Puget Sound Basin range from about 1.5 to 17.1 ppm [4]. However, the widespread use of arsenic-containing pesticides and emissions from certain smelters has resulted in significantly higher levels of arsenic on many properties in the state. There are two forms of arsenic - organic and inorganic. The EPA established oral reference dose (RfD) for arsenic is 0.0003 mg/kg/day based on skin color changes and excessive growth of tissue (human data) [9]. EPA classifies the inorganic form of arsenic as a human carcinogen. The recent EPA IRIS review draft presented a cancer slope factor for combined lung and bladder cancer of 5.7 per mg/kg/day [10]. The slope factor calculated from the work by the National Research Council is about 21 per mg/kg/day [11]. These slope factors could be higher if the combined risk for all arsenic-associated cancers (bladder, lung, skin, kidney, liver, etc.) were evaluated. For this health consultation, DOH used a slope factor of 5.7 per mg/kg/day, which appears to reflect EPA's most recent assessment.

Studies have shown inorganic arsenic is much more harmful than organic arsenic. Therefore, DOH will base this health evaluation on the levels of inorganic arsenic present in shellfish samples. Generally, inorganic arsenic in fish and shellfish normally ranged from about 1-20% of the total arsenic [9, 11, 12, 13]. Ecology's evaluation of shellfish in the Puget Sound indicated that less than 1% of the total arsenic found was in the inorganic form of arsenic [14]. For this health consultation, DOH assumed that 1% of the total arsenic detected was inorganic arsenic. Therefore, 1% of the concentration was used to calculate the estimated dose from exposure to inorganic arsenic in shellfish.

Cadmium

Cadmium is a naturally occurring element in the earth's crust. Cadmium is used mainly in batteries, pigments, metal coatings, and metal alloys. Cadmium is found in most foods at low levels, with the lowest levels found in fruits and the highest found in leafy vegetables and potatoes. Shellfish have higher cadmium levels (up to 1 ppm) than other types of fish or meat. Cadmium is stored in the liver and kidneys and slowly leaves the body in the urine and feces [15]. However, high levels of cadmium will cause kidney damage, and causes bones to become fragile and break easily. Occupational exposure to inhaled cadmium is suspected to be a cause of lung cancer in workers, while animal studies have confirmed the ability of cadmium to cause lung tumors via the inhalation route. Studies of workers exposed to airborne cadmium also suggest a link with prostate cancer. The ability of cadmium to cause cancer via the oral route is disputed. The RfD for cadmium that is ingested with food is 0.001 mg/kg/day.

Evaluating non-cancer hazards

Exposure assumptions for estimating contaminant doses from shellfish exposure are found in Appendix B, Table B1 – B2. In order to evaluate the potential for non-cancer adverse health affects that may result from exposure to contaminated media (i.e., air, water, soil, and sediment), a dose is estimated for each contaminant of concern. These doses are calculated for situations (scenarios) in which area residents or vacationers might be exposed to the contaminated media. The estimated dose for each contaminant under each scenario is then compared to EPA's oral reference dose (RfD). RfDs are doses below which non-cancer adverse health effects are not expected to occur (so-called "safe" doses). They are derived from toxic effect levels obtained from human population and laboratory animal studies. These toxic effect levels can be either the lowest-observed adverse effect level (LOAEL) or a no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse health effect is seen, while the NOAEL is the highest dose that did not result in any adverse health effects.

Because of uncertainty in these data, the toxic effect level is divided by "safety factors" to produce the lower and more protective RfD. If a dose exceeds the RfD, this indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded. If the estimated exposure dose is only slightly above the

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 actual toxic effect level. This comparison is called a hazard quotient (HQ) and is given by the equation below:

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

Estimated exposure doses, exposure assumptions, and hazard quotients are presented in Appendix B for COCs (arsenic and cadmium) found in shellfish. Based on exposure estimates quantified in Appendix B, the general population (adults and children) are not likely to experience adverse non-cancer health effects from exposure to chemical contaminants in shellfish. High end consumption, estimated doses from exposure to cadmium in shellfish species from Irondale Beach Park and Chimacum Creek Tidelands, resulted in hazard quotients in excess of one (see Appendix B, Table B3). However, as mentioned above, if the estimated exposure dose is only slightly above the RfD, then that dose will likely fall well below the toxic effect level. The higher the estimated dose is above the RfD, the closer it will be to the actual toxic effect level. In addition, based on the Suquamish Tribe shellfish species-specific consumption rate for 90th percentile consumers only, high-end consumption would not result in hazard quotients in excess of one.

Evaluating exposure to lead

The biokinetics of lead are different from 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. The IEUBK predicts blood lead levels in a distribution of exposed children based on the amount of lead that is in environmental media (e.g. shellfish) [16]. It is important to note that the IEUBK model is not expected to accurately predict the blood lead level of a child (or a small group of children) at a specific point in time. In part, this is because a child (or group of children) may behave differently, and therefore have different amounts of exposure to contaminated soil and dust, than the average group of children used by the model to calculate blood lead levels. For example, the model does not take into account reductions in exposure that could result from community education programs. Despite this limitation, the IEUBK model is a useful tool to help prevent lead poisoning because of the information it can provide about the hazards of environmental lead exposure. For children who are regularly exposed to lead-contaminated shellfish, the IEUBK model can estimate the percentage of young children who are likely to have blood lead concentrations that exceed a level that may be associated with health problems (usually 10 μg/dl).

Average shellfish lead concentrations and estimated blood lead levels

The IEUBK model was used to estimate the percentage of children that could have elevated blood lead levels if they frequently eat lead contaminated shellfish. Exposure assumptions for estimating blood lead from shellfish exposure are found in Appendix C, Table C1. Default parameters were used for all other model inputs [16]. Exposure were based on a general population scenario of children eating 0.57 g/day or Tribal high-end consumer scenario of children eating 34.8 g/day of shellfish containing the average or maximum concentration of lead. Based on these scenarios, the model indicates no children would exceed the EPA's criteria of no more than 5% of the community with BLLs above 10 µg/dL (see Appendix C, Table C1 – C2).

The adult lead model was used to estimate the percentage of fetus that would have elevated blood lead levels if women frequently ate lead contaminated shellfish. Exposure assumptions for estimating blood lead from shellfish exposure are found in Appendix C, Table C3 – C4. Exposures were based on a general population scenario of adults eating 17.5 g/day or Tribal high-end consumer scenario of adults eating 322 g/day of shellfish containing the average or maximum concentration of lead. Based on these scenarios, the model indicates only Tribal high-end consumer (mothers) fetus would exceed the EPA's criteria of no more than 5% of the community with BLLs above 10 µg/dL (see Appendix C, Table C3). However, based on the Suquamish Tribe shellfish species-specific consumption rate for the 90^{th} percentile consumers only, high-end consumption would not result in over 5 % of fetuses with blood lead levels greater than 10 µg/dl (see Appendix C, Table C4).

Evaluating Cancer Risk

Some chemicals have the ability to cause cancer. Cancer risk is estimated by calculating a dose similar to that described above and multiplying it by a cancer potency factor, also known as the cancer slope factor (CSF). 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.

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

Current regulatory practice suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen will result in 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 [17].

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 insignificant 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 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 1/4 to 1/3 of people living in the United States will develop cancer at some point in their lives [18].

Cancer risk from exposure to shellfish was calculated for arsenic only (see Appendix B, Table B4 – B5). The lifetime increase of cancer risk associated with exposure to arsenic at maximum in shellfish is low to slight (4.51×10^{-4}) or (5 in 10,000) to (2.63×10^{-6}) or (3 in 1,000,000). However, based on the Suquamish Tribe shellfish species-specific consumption rate for the 90th percentile consumers only, high-end consumption would result in a lifetime increase of cancer risk ranging from low to very low (2.62×10^{-5}) or (3 in 100,000) to (2.09×10^{-5}) or (2 in 100,000) for butter and littleneck clams respectively. These risks do not exceed the range of cancer risks considered acceptable by EPA (1×10^{-4} to 1×10^{-6}).

No cancer risk was calculated for cadmium because cancer caused via the oral route by cadmium is disputed. In addition, the CSF for cadmium is for cadmium via the inhalation route, which is not a likely exposure route in this case.

Children's Health Concerns

ATSDR recognizes that infants and children may be more vulnerable to exposures than adults may, 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 will be given to children's exposure to contaminants by assuming that children eat proportionately more shellfish than adults do.

Conclusions

1. Exposure to arsenic, cadmium and lead in Irondale Beach Park and Chimacum Creek Tidelands shellfish represents *no apparent public health hazard.*

    i. Maximum arsenic concentration would result in a lifetime cancer risk for high-end (subsistence) consumers of about 5 in 10,000, assuming all shellfish consumed contains the maximum level of arsenic and are from this area only. However, based on the Suquamish Tribe shellfish species-specific consumption rate for the 90^{th} percentile consumers only, subsistence consumption would result in a lifetime cancer risk of about 2 in 100,000. The average or background total arsenic level for littleneck clams at Irondale Beach Park and Chimacum Creek Tidelands is similar to that in the rest of the Puget Sound at about 1.9 ppm.

    ii. Adults and children consuming shellfish from Irondale Beach Park and Chimacum Creek Tidelands that contain the maximum reported lead concentration (0.14 ppm) would not be expected to have elevated blood lead levels. On the other hand, fetuses of subsistence consumers would exceed the EPA's criteria of no more than 5% of the community with BLLs above 10 µg/dL. However, based on the Suquamish Tribe shellfish species-specific consumption rate for the 90^{th} percentile consumers only, subsistence consumer fetuses would not result in elevated blood lead levels.

- Average or subsistence consumption of shellfish from Irondale Beach Park and Chimacum Creek Tidelands is not likely to result in non-cancer health effects.

Recommendations

The Department of Health's Office of Shellfish and Water Protection (OSWP), JCPH and Jefferson County should use this health consultation to guide their decision for recreational harvesting of shellfish in the Irondale Beach Park and Chimacum Creek Tidelands area.

Public Health Action Plan

Actions completed

1. Sampling and analysis of clam for inorganic contaminants has been conducted to determine whether or not chemical contaminants are present at levels of health concern.

2. Butter and Littleneck clams inorganic contaminant data has been evaluated by DOH and presented within this health consultation.

Action Planned

1. The OSWP will use this health consultation as part of the pollution source evaluation for this area.

2. DOH will send copies of the health consultation to concerned parties and provided hard copies to repository located: Jefferson County Rural Library District - 620 Cedar Ave, Port Hadlock, WA 98339 (360) 385-6544.

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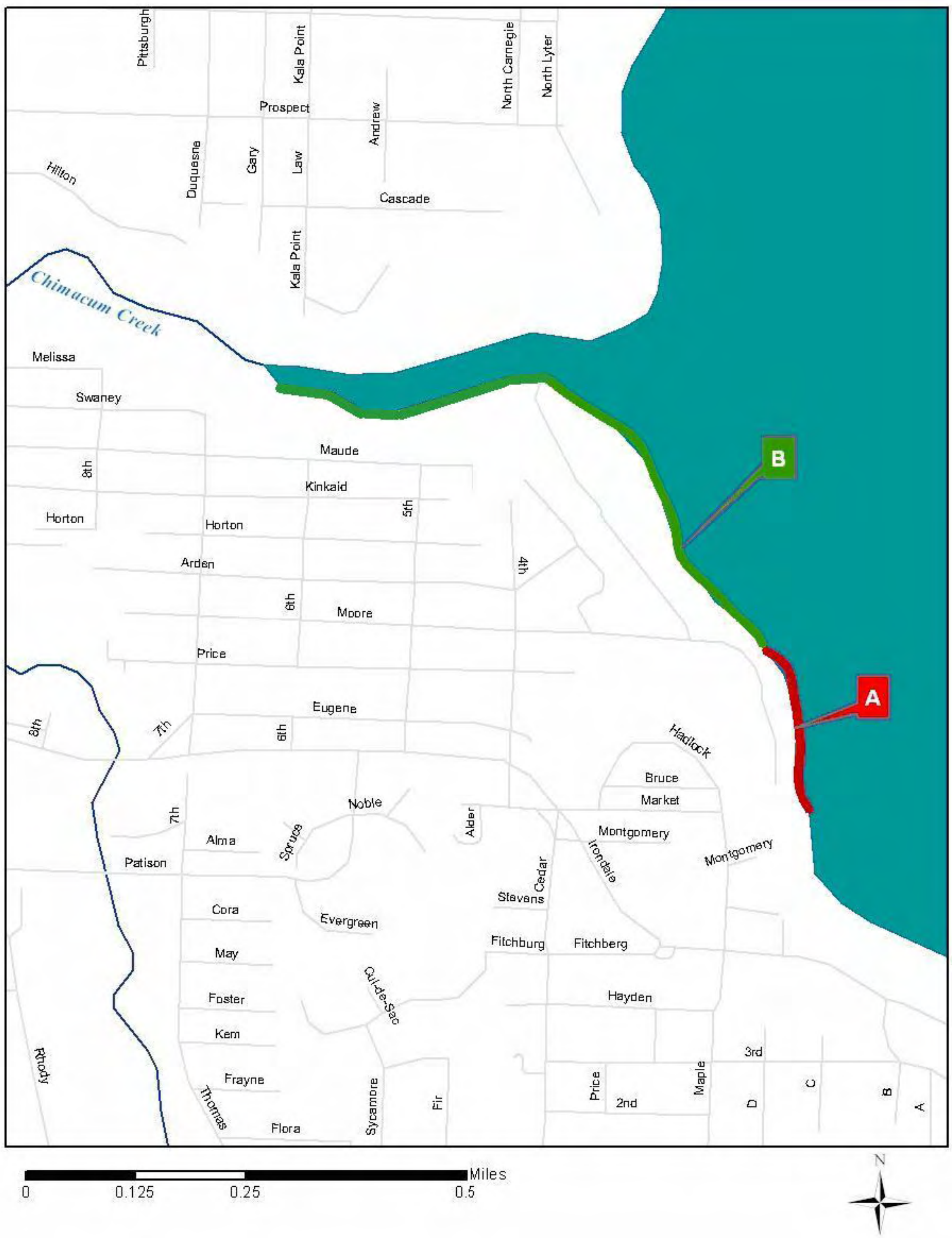
Figure 1. Port Townsend Bay, Irondale Beach Park Shellfish Growing area, Jefferson County Washington State

Figure 2. Irondale Beach Park (A) and adjacent Chimacum Creek Tidelands (B) shellfish collection area, Jefferson County Washington State



Appendix A

Screening Value Calculations

For Non-cancer Health Effects

SV = [(MRL or RfD)*BW]/CR

SV = Screening value (mg/kg or ppm)
MRL = Minimal risk level (mg/kg/day)
RfD = Reference dose (mg/kg/day)
BW = Mean body weight (kg)
CR = Suquamish Tribe 90th percentile adult (all shellfish) daily consumption rate (kg/day) [19]

BW = 70kg
CR = 0.322 kg/day

If maximum concentration is greater than screening value, further evaluation is required.

For Cancer Health Effects

Cadmium cancer risk is based on inhalation and not ingestion therefore; cadmium would not be evaluated for cancer risk.

SV = (Risk Level * BW) / (CR * CPF)

Risk Level = an assigned level of maximum acceptable individual lifetime risk (e.g., RL = 10-5 for a level of risk not to exceed one excess case of cancer in 100,000 individual exposed over a 70 yr lifetime.

If maximum concentration is greater than screening value, further evaluation is required.

Appendix B

This section provides calculated exposure doses and assumptions used for exposure to chemicals in shellfish from Irondale Beach Park and Chimacum Creek Tidelands. These exposure scenarios were developed to model exposures that might occur. These scenarios were devised to represent exposures to the general population and Suquamish Tribe. The following exposure parameters and dose equations were used to estimate exposure doses from ingestion with chemicals in shellfish.

Ingestion Route

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

$$\text{Cancer Risk} = \frac{C \times CF_1 \times IR \times CF_2 \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Table B1. Exposure Assumptions used in exposure evaluation to contaminants in shellfish samples taken from Irondale Beach Park and Chimacum Creek Tidelands, in Irondale, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	ug/kg	Average detected value
Conversion Factor (CF_1)	0.001	mg/ug	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Conversion Factor (CF_2)	0.001	kg/g	Converts mass of shellfish from grams (g) to kilograms (kg)
Ingestion Rate (IR)	0.57	g/day	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)	34.8	g/day	90^{th} percentile Suquamish Tribe child (all shellfish) [19]
Ingestion Rate (IR)	0.81	g/day	Body weight-adjusted consumption rates to account for an older child eating 0.81 times as much fish per body weight as do adults (see table B2)
Ingestion Rate (IR)	188.6	g/day	Based on 90^{th} percentile Suquamish Tribe adult - older child eating at the same rate as an adult (body weight adjusted consumption rate)
Ingestion Rate (IR)	1.7	g/day	Average general population adult
Ingestion Rate (IR)	322	g/day	90^{th} percentile Suquamish Tribe adult (all shellfish) [19]
Exposure Frequency (EF)	365	Days/year	Assumes daily exposure
Exposure Duration (ED)	6	years	Number of years at one residence (child)
Exposure Duration (ED)	30	years	Number of years at one residence (adult)
Body weight (BW)	15	kg	Mean body weight child
Body weight (BW)	70	kg	Mean body weight adult
Averaging $\text{Time}_{\text{non-cancer}}$ (AT)	Variable	days	Equal to Exposure Duration
Averaging $\text{Time}_{\text{cancer}}$ (AT)	25550	days	70 years
Cancer Potency Factor (CPF)	Variable	mg/kg-day^{-1}	Source: EPA – Chemical specific

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 (0-5 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)	1.70 (average)	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	1.70 (average)	0.81 (average)	0.57 (average)

Table B3. Exposure dose and Non-cancer risk from ingesting shellfish at maximum concentration of contaminant from Irondale Beach Park and Chimacum Creek Tidelands in Irondale, Washington.

Contaminant	Maximum Concentration (ppm)		Estimated Dose (mg/kg/day)		RfD (mg/kg/day)	Hazard quotient Average population	Hazard quotient 90th percentile Suquamish Tribe
			Average population	90th percentile Suquamish Tribe			
Arsenic	0.028	Child	1.06E-6	6.50E-5	3.00E-4	0.004	0.22
		Older child	5.53E-7	1.29E-4		0.002	0.43
		Adult	6.80E-7	1.29E-4		0.002	0.43
Cadmium	0.44	Child	1.67E-5	1.02E-3	1.00E-3	0.02	1.02
		Older child	8.69E-6	2.02E-3		0.01	2.02
		Adult	1.07E-5	2.02E-3		0.01	2.02

PPM – parts per million

Table B4. Cancer risk from ingesting shellfish at maximum concentration of contaminant from Irondale Beach Park and Chimacum Creek Tidelands in Irondale, Washington.

Contaminant	Maximum Concentration (ppm)	Cancer Potency Factor (mg/kg-day^{-1})		Increased Cancer Risk		Total Cancer Risk Average population	Total Cancer Risk 90th percentile Suquamish Tribe
				Average population	90th percentile Suquamish Tribe		
Arsenic	0.028	5.7	Child	5.20E-7	3.17E-5	2.63E-6	4.51E-4
			Older child	4.50E-7	1.05E-4		
			Adult	1.66E-6	3.15E-4		

PPM – parts per million

Table B5. Cancer risk from ingesting shellfish at maximum arsenic concentration from Irondale Beach Park and Chimacum Creek Tidelands, based on the Suquamish Tribe shellfish species-specific consumption rate for the 90th percentile consumers only, Washington.

Clam Species	Species-specific consumption rate (g/day)	Maximum Concentration (ppm)	Cancer Potency Factor (mg/kg-day^{-1})		Increased Cancer Risk	Total Cancer Risk
Littleneck	11.4	0.021	5.7	Child	7.80E-6	2.09E-5
				Older child	4.75E-6	
				Adult	8.35E-6	
Butter	10.7	0.028		Child	9.76E-6	2.62E-5
				Older child	5.95E-6	
				Adult	1.05E-5	

PPM – parts per million

Appendix C

Lead exposure shellfish ingestion scenario used in the IEUBK model

This section provides inputs for the IEUBK model. The following inputs to the model were used to account for the average shellfish ingestion lead exposure from Irondale Beach Park and Chimacum Creek Tidelands, Irondale, Washington.
Consumption rates: General population (Gen.) child – 0.57 g/day: Suquamish Tribe (Sub) Child – 34.8 g/day.
IEUBK model assumes that a child's total meat intake is 93.5 g/day. EPA's target cleanup goal is no more than 5 % of the community with BLLs above 10 µg/dL. Default assumptions were used unless noted.

Table C1. Blood lead values determined using the IEUBK model for lead in shellfish from Irondale Beach Park, Irondale, Washington.

Clam Species	Average Concentration (ppm)		Percent meat intake as shellfish (%)		Blood Lead level in percent above 10ug/dl Age range 0 - 84 months			
					Mean		Max	
	Mean	Max	Gen Child	Sub Child	Gen Child	Sub Child	Gen Child	Sub Child
Littleneck	0.096	0.13	0.61	37.2	1.21	2.3	1.22	2.8
Butter	0.125	0.14			1.22	2.7	1.22	3.0

PPM – parts per million

Table C2. Blood lead values determine using the IEUBK model for lead in shellfish from Chimacum Creek Tidelands, Irondale, Washington.

Clam Species	Average Concentration (ppm)		Percent meat intake as shellfish (%)		Blood Lead level in percent above 10ug/dl Age range 0 - 84 months			
					Mean		Max	
	Mean	Max	Gen Child	Sub Child	Gen Child	Sub Child	Gen Child	Sub Child
Littleneck	0.029	0.03	0.61	37.2	1.2	1.4	1.2	1.4
Butter	NA	0.056			NA		1.2	1.7

PPM – parts per million

Lead exposure shellfish ingestion scenario used in the Adult lead model

This section provides inputs for the Adult lead model. The following inputs to the model were used to account for the average shellfish ingestion lead exposure from Irondale Beach Park and Chimacum Creek Tidelands, Irondale, Washington.
Consumption rates: General population (Gen.) 1.7 g/day: Suquamish Tribe (Sub) 322 g/day
EPA's target cleanup goal is no more than 5 % of the community with BLLs above 10 µg/dL.
Default assumptions were used unless noted.

Table C3. Blood lead values determined using the Adult lead model for lead in shellfish from Irondale Beach Park, Irondale, Washington.

Clam Species	Average Concentration (ppm)		Average Mother Blood Lead concentration in ug/dl Fetus Blood Lead in percent above 10ug/dl				
	Mean	Max		Mean		Max	
				Gen	Sub	Gen	Sub
Littleneck	0.096	0.13	mother	1.5	3.0	1.5	3.5
			fetus	0.4	3.8	0.4	**6.0**
Butter	0.125	0.14	mother	1.5	3.4	1.5	3.7
			fetus	0.4	**5.7**	0.4	**6.7**

PPM – parts per million

Table C4. Blood lead values determined using the Adult lead model for lead in shellfish from Chimacum Creek Tidelands, Irondale, Washington.

Clam Species	Average Concentration (ppm)		Average Mother Blood Lead concentration in ug/dl Fetus Blood Lead in percent above 10ug/dl				
	Mean	Max		Mean		Max	
				Gen	Sub	Gen	Sub
Littleneck	0.029	0.03	mother	1.5	1.9	1.5	2.0
			fetus	0.3	0.9	0.4	1.0
Butter	NA	0.056	mother	NA		1.5	2.4
			fetus			0.4	1.9

PPM – parts per million

Table C5. Blood lead values determined using the Adult lead model for lead in shellfish from Irondale Beach Park, Irondale based on the Suquamish Tribe shellfish species-specific consumption rate for the 90th percentile consumers only.

Clam Species	species-specific consumption rate (g/day)	Average Concentration (ppm)	Average Mother Blood Lead concentration in ug/dl Fetus Blood Lead in percent above 10ug/dl	
		Maximum		Maximum
				Sub
Littleneck	11.4	0.13	mother	1.6
			fetus	0.4
Butter	10.7	0.14	mother	1.6
			fetus	0.4

PPM – parts per million

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 was 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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