Human Health Evaluation of Contaminants in Resident Fish from the Hanford Reach of the Columbia River

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Prepared by

The Washington State Department of Health
Division of Environmental Public Health
Office of Environmental Public Health Sciences
Olympia, Washington

For more information or additional copies, please contact

David McBride, MS Toxicologist
Division of Environmental Public Health
Office of Environmental Public Health Sciences
P.O. Box 47846
Olympia, Washington 98504-7846

Toll free 1-877-485-7316
DOH 334-379

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Table of Contents **Page**

Tables — Page

Figures Page

Appendices **Page**

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UNITS OF MEASURE

g	gram
g/day	grams per day
kg	kilogram
mg	milligram
mg/l	milligrams per liter = parts per million in liquid
mg/kg	milligrams per kilogram = parts per million in solid
mg/kg/day	milligrams per kilogram of body weight per day
ppb	parts per billion
ppm	parts per million
µg	microgram
µg/kg	micrograms per kilogram = parts per billion in solid

GLOSSARY

Acute	Occurring over a short time. (Compare with *chronic*.)
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.
Bioaccumulation	The buildup of contaminants in an organism's tissues over time via ingestion of prey.
Bioconcentration	An increase in contaminant concentration in organisms relative to their environment.
Biomagnification	An increase in contaminant level concentration in predators relative to their prey.
Cancer Slope Factor	EPA's measure of the ability of a substance to cause cancer based on the dose of the substance received.
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 milligrams (amount) per kilogram (a measure of body weight) per day (a measure of time) when people come into contact with media containing the substance (e.g., drinking water, breathing air, consuming food, skin contact with soil, etc.). 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 gets into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Protection Agency (EPA)	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
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). Exposure to a substance occurs when an individual encounters environmental media containing that substance (e.g., inhaling air, drinking water, skin/soil contact, etc.).
Hazardous substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way. (See *route of exposure*.)
Ingestion Rate (IR)	The amount of an environmental medium that could be ingested, typically on a daily basis. Units for IR are usually liter/day for water and mg/day for soil.
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance, at or below which the substance is unlikely to pose a measurable risk of harmful (adverse), non-cancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects. (See *oral reference dose.*)
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, which if ingested on a daily basis over the course of a lifetime, would not be expected to cause adverse effects. These estimates (with uncertainty spanning perhaps an order of magnitude) are published by EPA.
Organic	Compounds that contain carbon, including materials such as solvents, oils, and pesticides.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express dilute 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 railroad tank car (13,200 gallons), the water will contain about 1 ppb of TCE.
Resection	Surgical removal of all or part of an organ, tissue, or structure.
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).
Unlimited	Meal restrictions based on contaminant concentrations that result in greater than eight meals per month.

ACRONYMS AND ABBREVIATIONS

AHA	American Heart Association
API	Asian & Pacific Islanders
ATSDR	Agency for Toxic Substances and Disease Registry
BW	Body weight
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CR	Consumption Rate
DDT	Dichlorodiphenyltrichloroethane
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food & Drug Administration
HHRA	Human Health Risk Assessment
HQ / HI	Hazard Quotient / Hazard Index
LOAEL	Lowest Observed Adverse Effect Level
MRL	Minimum Risk Level
MTCA	Model Toxics Control Act
NOAEL	No Observed Adverse Effect Level
NMFS	National Marine Fisheries Service
OEPHS	Office of Environmental Public Health Sciences
PBT	Persistent Bioaccumulative Toxins
PCB	Polychlorinated Biphenyl
PSEP	Puget Sound Estuary Program
RfD	Reference Dose
SL	Screening Level
TEQ / TEF	Toxic Equivalent / Toxic Equivalency Factor
UCF	Unit Conversion Factor
USDOE	U.S. Department of Energy

Executive Summary

Background

For nearly five decades, contaminants have been released into the Columbia River from the Hanford Reservation in Washington State. Waste disposal practices resulted in releases of contaminants to upland soil and into groundwater beneath the site with contaminants in groundwater ultimately moving to the Columbia River. In an effort to determine which contaminants are present in the surrounding environment, the U.S. Department of Energy (USDOE) began a remedial investigation (RI) to determine the nature and extent of past releases of Hanford Site contaminants to the Columbia River and how they have affected the surrounding environment. As part of the RI effort, USDOE evaluated contaminants in fish collected within the Columbia River near the Hanford Site. This report focuses on evaluation of these fish samples to determine if fish consumption advice is necessary for consumers of Columbia River resident fish.

The study site includes approximately 150 river miles that were sectioned into four subareas beginning with an upriver site, two river sections within the boundary of the Hanford Site, and a subarea down river of the site. Six resident fish species were collected from the study area during 2009-2010, including common carp, smallmouth bass, white sturgeon, bridgelip sucker, walleye, and mountain whitefish. With the exception of white sturgeon, which were evaluated by individual samples, fish tissue samples for each species were composited by location. Fish tissue samples were analyzed for the following contaminants of potential concern (COPCs): PAHs, chlorinated pesticides, PCBs, dioxin-like PCBs, and radionuclides. This assessment does not address radioactive contaminants.

Findings

All six resident fish species collected within the Hanford Reach study site have elevated concentrations of PCBs (as measured as total PCBs or dioxin-like PCBs) that warrant meal restrictions. Meal restrictions ranged from a one meal per month to a high of four meals per month. Mercury concentrations were elevated in four of the six resident fish species and resulted in meal restrictions of four to eight meals per month. Total DDT concentrations did not result in meal restrictions but were assessed along with mercury and total PCBs to determine meal restrictions based on multiple contaminants having similar neuro-developmental health endpoints. All other COPCs were below levels of concern. Based on Washington State Department of Health’s (DOH) finding, meal restrictions are warranted to protect sensitive populations (women of childbearing age and young children) and the general population from contaminants found in resident fish species from the Hanford Reach. Elevated PCBs and mercury concentrations in fish statewide are responsible for nearly all current fish advisories issued by DOH. Thus, findings in this report are consistent with statewide results for these two contaminants.

Recommendations

DOH encourages all Washingtonians to eat at least two fish or shellfish meals per week as part of a heart healthy diet in accordance with American Heart Association (AHA) recommendations. A variety of seafood is an important part of a balanced diet because:

- Seafood is an excellent source of protein, vitamins, and minerals.
- The oils in fish and shellfish are important for unborn and breast-fed babies.
- Eating a variety of seafood helps to reduce the chances of cardiovascular disease.
- Eating a variety of seafood helps to reduce exposure to contaminants of concern.

Most foods, regardless of source, contain some contaminants. Switching from seafood to other types of food may not eliminate contaminant exposure. One can safely continue to eat the American Heart Association's recommended two fish or shellfish meals per week by avoiding species that are high in contaminants. The following meal limits are meant to guide people toward making informed decisions when selecting seafood to eat.

Based on tissue concentrations, frequency of detection, and toxicity, DOH concludes that the public should limit consumption of resident fish caught in the Hanford Reach study site, which spans waters from behind the McNary Dam (Lake Wallula) upriver to where the I-90 bridge crosses the Columbia River. These restrictions do not include migratory salmon species. The following meal restrictions are species-specific and apply to all persons.

- Smallmouth bass: No more than four meals per month
- Common carp: No more than one meal per month
- White sturgeon: No more than one meal per month
- Bridgelip sucker: No more than two meals per month
- Walleye: No more than two meals per month
- Mountain whitefish: No more than one meal per month

Species	Recommended Meal Restrictions (Meals per Month)
Smallmouth Bass	4
Common Carp	1
White Sturgeon	1
Bridgelip Sucker	2
Walleye	2
Mountain Whitefish	1

- **NOTE:** Meal size equals eight ounces of uncooked shellfish for an average-sized adult.

Introduction

Washington Department of Health (DOH) works to protect and improve the health of people in Washington State. Part of this mission is to reduce or eliminate exposures to health hazards in the environment. Health's Office of Environmental Public Health Sciences (OEPHS) evaluates chemical hazards in the environment, develops strategies to reduce exposure to environmental contaminants, and provides education and outreach to communities to help minimize impacts to the public. One focus of OEPHS is on human health impacts from consuming contaminated seafood.

For nearly five decades, contaminants have been released into the Columbia River from the Hanford Reservation. Waste disposal practices resulted in releases of contaminants to upland soil and into groundwater beneath the site. Over time, contaminants in groundwater ultimately moved to the Columbia River. In an effort to understand which contaminants are present in the environment, the U.S. Department of Energy (USDOE) began a remedial investigation (RI) to determine the nature and extent of past releases of Hanford Site contaminants to the Columbia River and how they have impacted surrounding environmental media (DOE/RL-2007, DOE/RL-2010). As part of the RI effort, USDOE evaluated contaminants in resident fish collected within the Columbia River near the Hanford Site. This report focuses on evaluation of these fish samples to assess if fish consumption advice is necessary to consumers of Columbia River resident fish.

The Hanford study site included approximately 150 river miles that were sectioned into four subareas beginning with an upriver site, two river sections within the boundary of the Hanford Site, and a subarea down river of the site. Six resident fish species were collected from the study area during 2009-2010, including common carp (*Cyprinus carpio*), smallmouth bass (*Micropterus dolomieu*), white sturgeon (*Acipenser transmontanus*), bridgelip sucker (*Catostomus columbianus*), walleye (*Stizostedion vitreum*) and mountain whitefish (*Prosopium williamsoni*) (WCH-387). With the exception of white sturgeon, fish tissue samples for each species were composited by location. White sturgeon were evaluated as individuals. Fish tissue samples were analyzed for the following contaminants of potential concern (COPCs): metals, PAHs, chlorinated pesticides, PCBs, dioxin-like PCBs, and radionuclides. This assessment focuses only on non-radioactive contaminants.

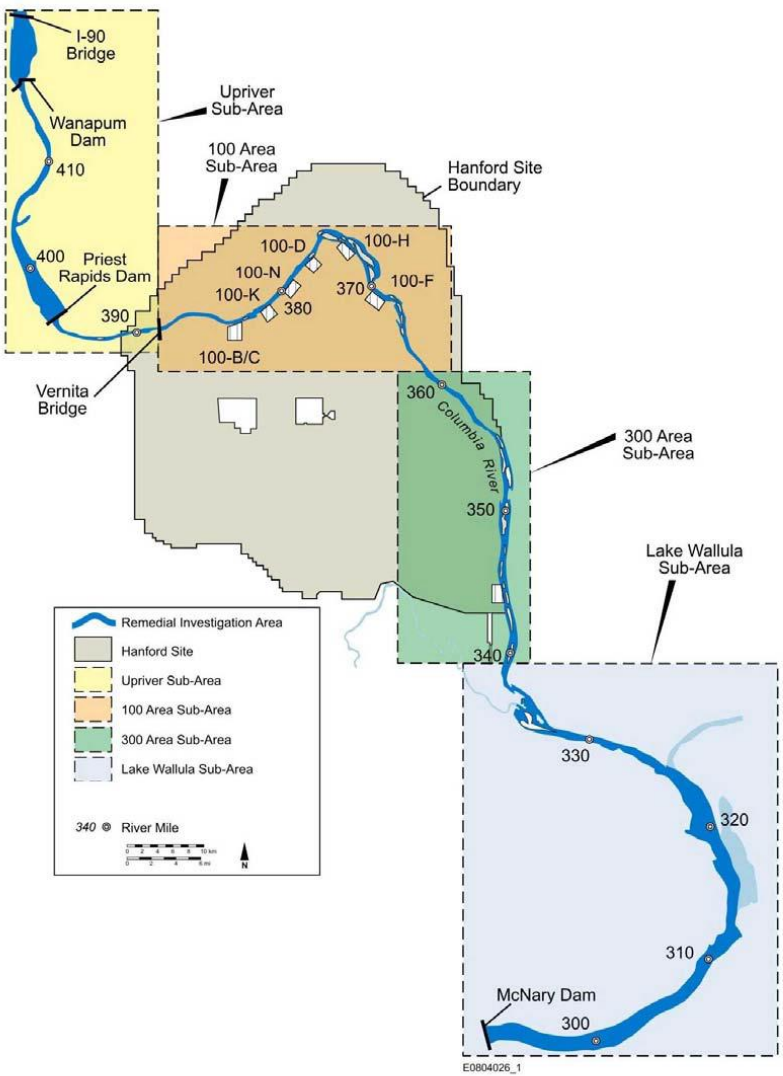
The purpose of this report is to review and evaluate potential health risks that may result from exposure to toxic contaminants through the consumption of resident fish caught near the Hanford site using data collected by USDOE. PCBs, DDT, dieldrin, heptachlor and mercury are assessed for non-cancer endpoints, and cancer health endpoints are discussed. In addition, DOH considers chemical toxicity, potential exposure (based on estimated consumption rates), and the overall health benefits of eating seafood. Together, these factors are weighed by DOH to provide final guidance for consuming fish.

Background

The Columbia River extends over 1200 miles from the headwaters in British Columbia south and westward through Washington and Oregon before emptying into the Pacific Ocean. Within

Washington, the river flows through the USDOE Hanford Reservation and is referred to as the Hanford Reach Study Site (Figure 1). The Hanford Site was the location of plutonium production during World War II, which continued until the 1980's. Many of the liquid effluents from plutonium production were discharged directly into the Columbia River (DOE/RL-2010). This along with upland groundwater contamination led to concerns that the site was adversely affecting the Columbia River ecosystem.

Figure 1. Hanford Reach Study Site



Contaminants in the sediment and water column may accumulate in organisms through bioaccumulation and bioconcentration. Further, some contaminants may biomagnify or concentrate in organisms higher on the food chain. Bioaccumulative chemicals are generally hydrophobic and have an affinity for carbon, either in sediments or in the lipids of aquatic organisms. Many bioaccumulative contaminants end up in sediments because the organic carbon content of sediments is higher than that of the water column. PCBs are an example of bioaccumulative chemicals that adhere to the surfaces of organic particles in the water column resulting in their eventual deposition and accumulation in sediments. Since most particles end up within the sediment in aquatic systems, these sediment-associated contaminants may affect the health of resident fish such as largescale suckers and sturgeon and/or other species that eat bottom-dwelling prey. Highest PCB concentrations are typically found in fine-grained, organically rich sediments (NRC 2001).

Resident fish support a number of fisheries in the Columbia River basin. Contaminants in these fish species are of particular interest to those communities that rely on these fisheries. They include various tribal fisheries, non-tribal recreational fisheries and subsistence fisheries. The tribal treaty fishing right is a federally protected right to fish in all “usual and accustomed fishing areas.” The Hanford Reach is considered a usual and accustomed location for many tribes in Washington, Oregon and Idaho (CRITFC).

Methods

Fish Collection

Six resident fish species were collected from the study area during 2009-2010, including common carp (*Cyprinus carpio*), smallmouth bass (*Micropterus dolomieu*), white sturgeon (*Acipenser transmontanus*), bridgelip sucker (*Catostomus columbianus*), walleye (*Stizostedion vitreum*) and mountain whitefish (*Prosopium williamsoni*). As described by USDOE, these six fish species are year-round resident fish that reflect a range of trophic levels and have a high rate of harvest and consumption among the local population. As described in the RI Work Plan (DOE/RL-2008-11), salmon were not sampled as part of this study because they spend a majority of their life cycle in the ocean as opposed to the Hanford Site Study Area and therefore are not representative of local river conditions. Numbers of fish tissue samples collected during 2009 to 2010 are shown (Table 1), and fish collection locations are listed below (Table 2).

Table 1. Number of Fish Tissue Samples Collected

Location & Sample Type		Bass	Carp	Sturgeon	Sucker	Walleye	Whitefish
Upriver Sub-Area	Individual fish	25	21	5	25	25	27
	Composites	5	5	0	5	5	5
	Number of samples	5	5	5	5	5	5
100 Area Sub-Area	Individual fish	25	25	9	25	26	25
	Composites	5	5	0	5	6	5
	Number of samples	5	5	9	5	6	5
300 Area Sub-Area	Individual fish	25	25	10	25	25	27
	Composites	5	5	0	5	5	5
	Number of samples	5	5	10	5	5	5
Lake Wallula Sub-Area	Individual fish	25	25	6	25	27	26
	Composites	5	5	0	5	5	5
	Number of samples	5	5	6	5	5	5
Total number of samples per species	131	20	20	30	20	21	20

Table 2. Fish Species and Collection Locations

Recreational Fishing Location	Species					
	Bass	Carp	Sturgeon	Suckers	Walleye	Whitefish
Upriver						
Wanapum Pool	X	X	X	X	X	X
Priest Rapids Dam Pool	X	X	NA	X	X	X
100 Area						
100-B/C Hole	X	X	X	X	X	X
100-K Hole	X	X	X	X	X	X
100-N Hole	X	X	X	X	X	X
100-D Hole	NA	X	X	X	X	X
White Bluffs Hole 1	NA	X	X	X	X	X
White Bluffs Hole 2	NA	X	X	X	X	X
300 Area						
Hanford Townsite Hole 1	NA	X	X	X	X	X
Hanford Townsite Hole 2	NA	X	X	X	X	X
Ringold	X	NA	NA	NA	X	NA
Taylor Flats	X	X	NA	X	X	X
300 Area Hole 1	NA	X	X	X	X	X
Lake Wallula						
Yakima River Delta	X	X	X	X	X	X
Finley Slough	NA	NA	X	NA	X	X
Burbank Slough	NA	NA	NA	NA	X	X
Wallula Gap	NA	NA	X	NA	X	NA

For all species except sturgeon, fish tissue samples were composite samples composed of tissue from approximately five fish. Generally, five samples of each fish species were collected from each sub-area, and each sample included separate fillet, carcass (which included the head and skeleton of the fish), and combined liver and kidney tissue for analysis. Fillet samples for all of these species except sturgeon were prepared with the skin on. Sturgeon samples were analyzed individually and with skin off rather than composited. Twenty-five sturgeon were collected from the 100 Area, 300 Area, and Lake Wallula Sub-Areas, while five reference sturgeon were collected from upriver of Wanapum Dam.

For the Study Areas and the Reference Area, fish samples were obtained where they were available rather than at specific sampling points. As described in the USDOE report, the constraints of fish sampling make it impractical to conduct sampling in a statistically random fashion. The degree to which fish collections are representative of the population of fish is unknown. Thus, the fish sample analytical results are considered to be suitable for assessment for fish advisories.

Chemicals of Potential Concern

Contaminants of potential concern (COPCs) were chemicals selected for the quantitative Human Health Risk Assessment (HHRA) as described in the USDOE Remedial Investigation Work Plan (DOE/RL-2008-11). In summary, chemicals and radionuclides (radionuclides were not evaluated in this assessment) were selected based on detection frequency, concentrations relative to risk-based benchmarks, essential nutrient status, and whether the contaminant was considered a known Hanford Site-related contaminant in soil or groundwater. The following table outlines chemicals USDOE analyzed in resident fish species in the Hanford Site investigation with a detection frequency of 10% or greater (Table 3).

Table 3. Chemicals of Potential Concern (COPC)

Chemical	CAS	Class	Bass	Carp	Sturgeon	Sucker	Walleye	Whitefish
Aluminum	7429-90-5	Metal						x
Arsenic	7440-38-2	Metal						x
Arsenic (inorganic)	7440-38-2	Metal		x	x	x	x	
Barium	7440-39-3	Metal	x	x		x	x	x
Boron	7440-42-8	Metal						x
Cadmium	7440-43-9	Metal		x				x
Chromium (VI)	18540-29-9	Metal	x	x	x	x	x	x
Chromium (III)	16065-83-1	Metal						
Cobalt	7440-48-4	Metal	x				x	
Copper	7440-50-8	Metal		x		x		x
Iron	7439-89-6	Metal	x	x	x	x	x	x
Lead	7439-92-1	Metal		x				
Lithium	7439-93-2	Metal		x	x		x	
Manganese	7439-96-5	Metal	x	x	x	x	x	x
Mercury	7439-97-6	Metal	x	x	x	x	x	x
Methylmercury	22967-92-6	Metal			x			
Selenium	7782-49-2	Metal	x	x	x	x	x	x
Strontium	7440-24-6	Metal	x	x	x	x	x	x
Tin	7440-31-5	Metal	x	x		x	x	x
Vanadium	7440-62-2	Metal	x	x	x	x	x	x
Zinc	7440-66-6	Metal	x	x	x	x	x	x
beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-HCH)	319-85-7	Pesticide	x	x	x		x	
Delta-BHC	319-86-8	Pesticide				x		
Gamma-BHC (Lindane)	58-89-9	Pesticide					x	
Dichlorodiphenyldichloroethane (DDD)	72-54-8	Pesticide	x	x	x	x	x	x
Dichlorodiphenyldichloroethylene (DDE)	72-55-9	Pesticide	x	x	x	x	x	x
Dichlorodiphenyltrichloroethane (DDT)	50-29-3	Pesticide			x		x	
Total DDT	50-29-3	Pesticide						
Dieldrin	60-57-1	Pesticide						x
Heptachlor	76-44-8	Pesticide					x	
Total PCBs	1336-36-3	PCB	x	x	x	x	x	x
Total Dioxin-Like PCBs		PCB	x	x	x	x	x	x
Chemicals found in fish fillet tissue at >10% Detection Frequency								
Note:Based on DOE Hanford COC.xlsx (some of these will drop out because they do not exceed SL)								

As detailed in the Data Summary Report (WCH-398), all fish tissue samples were analyzed for PCB congeners, metals, pesticides, and radionuclides. Fillet and carcass samples were analyzed for total inorganic arsenic (TIAs) in addition to total arsenic. Sturgeon samples were analyzed for methyl mercury and hexavalent chromium. Fish tissue results are reported in wet weight. Specific analytical details for all fish tissue analysis are provided in the Data Summary Report (WCH-398).

Sample results include various levels of data validation. With the exception of samples qualified as rejected ("R"-flagged), all U- (nondetect) and J- (estimated) qualified data were considered to be usable for purposes of risk assessment. Data that had been qualified as "rejected" during the data quality assessment process were omitted from the data sets. The data assessment process and resulting data qualification actions for the RI data set are described in WCH-381. Sample results qualified in any other way (e.g., estimated values qualified with a "J") were used as reported in this statistical analysis.

PCBs were analyzed in two different methodologies: one provides results for individual Aroclor mixtures (e.g., Aroclor- 1260), while the other provides results for PCB congeners. Congener analysis is a more sensitive analytical method than Aroclor analysis that provides more accurate quantification of PCB concentrations, and has lower detection limits. Although Aroclors were infrequently detected among samples, PCB congeners were detected in all samples analyzed for this parameter. Rather than evaluate each of the 209 PCB individual congeners, results from PCB congeners were combined to calculate total PCB concentrations for use in the HHRA. Non-detected PCB samples were analyzed using the detection limit rather than setting assigning a value of zero or one half the detection limit. This approach is more conservative (i.e., health protective) and will likely overestimate potential risk.

Detailed fish tissue sample collection methodology is described in the *2010 Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington, Collection of Fish Tissue Samples* (WCH-387) report. The fish tissue sample collection program was developed by the U.S. Department of Energy, The U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). Requirements for sampling methods, sampling handling and custody, and analytical methods are detailed in *Sampling and Analysis Instruction for the Remedial Investigation of Hanford Site Releases to the Columbia River* (WCH-286). The following summarizes sampling and analysis methodologies used in this effort.

Fish were targeted for sampling to characterize the nature and extent of Hanford Site-related contaminants located within the Columbia River and to assess the current risk to ecological and human health.

The primary sample collection area on the Columbia River extended from just above Wanapum Dam (river mile [RM] 420) to McNary Dam (RM 292). The fish collection area was divided into sub-areas based on proximity to the Hanford Site (Figure 1):

- Upriver Sub-Area (RM 420 to RM 388)
- 100 Area Sub-Area (RM 388 to RM 365)
- 300 Area Sub-Area (RM 365 to RM 339)
- Lake Wallula Sub-Area (RM 339 to RM 292)

Fish were sampled within the Hanford Reach of the Columbia River and downstream to McNary Dam, due to historical releases of contaminants from the Hanford Site into the river and the potential accumulation of contaminants in resident fish. The objective of the fish-sampling project is to obtain tissue samples for analysis of contaminants identified as originating from the Hanford Site. The primary use of fish sampling data is to determine the potential health risk to nearby residents who eat these fish as a part of their diet. These data are also used by DOH to evaluate whether fish advisories are necessary.

Fish collection occurred in 2009 and 2010. Sampling periods occurred during recreational fishing seasons for each target species but after spawning season to minimize impacts on spawning fish. For all fish other than sturgeon, 100 fish/species were targeted. For sturgeon, a total of 30 fish were collected with 25 from various locations within the three study sub-areas (100 Area, 300 Area, and Lake Wallula). The remaining five sturgeon were collected in the upriver control sub-area.

All collection activities were conducted under WDFW Scientific Collection and National Oceanographic and Atmospheric Administration (NOAA) Fisheries Section 10 Authorization for Incidental Take of Endangered Species. Coordinates of each capture location were determined using a hand-held global positioning system (GPS) and documented in Washington State Plane coordinates. Methods used to capture specimens included the following:

- Electrofishing (whitefish, suckers, carp)
- Hook and line (bass, walleye, sturgeon, suckers, carp)
- Long-line (sturgeon)

Methods for sample collection were developed by the USDOE, EPA, and Ecology. The scope of the sampling effort was based on the outcome of the data quality objectives process, *DQO Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River* (WCH-265). Analytical methods are detailed in *Sampling and Analysis Instructions for the Remedial Investigation of Hanford Site Releases to the Columbia River* (WCH-286).

Sample Preparation and Analysis

Prior to sample processing, the individual fish that were to make up each sample composite were determined. For each of the four sub-areas, five composite samples composed of at least five fish each were to be prepared. Fish of each species were grouped into composites of five or more individuals based on geographic proximity within each sub-area with secondary consideration given to consistency of fish size within and among the composites, as discussed in Section 2.4.4.3 of the SAP (DOE/RL-2008-11, Appendix A). Fillets for each composite sample were combined and homogenized in a commercial-grade food grinder. Sample bottles were filled by taking a number of systematic sub-samples across the composited sample material. Samples were weighed and frozen for at least 24 hours prior to shipment. For all species except sturgeon, fish tissue samples were composite samples composed of tissue from approximately five fish. Generally, five samples of each fish species were collected from each sub-area. Fillet samples for all of these species except sturgeon were prepared with the skin on, since skin for these types of fish is often left on during preparation and consumed. Sturgeon samples were not composited, and thus samples represent tissue from individual fish. Twenty-five sturgeon were collected from the 100 Area, 300 Area, and Lake Wallula Sub-Areas, while five reference sturgeon were collected from upriver of Wanapum Dam.

Fish tissue samples were analyzed for a wide variety of constituents. All fish tissue samples were analyzed for PCB congeners, metals, pesticides, and radionuclides. Fillet and carcass samples were analyzed for total inorganic arsenic (TIAS) in addition to total arsenic. Sturgeon samples were also analyzed for methyl mercury and hexavalent chromium. Specific analytical details for all medium types are provided in the Data Summary Report (WCH-398).

Fish tissue results are reported in wet weight. Sediment results were received from the laboratory in wet weight and converted to dry weight using percent moisture data, as described in the Data Summary Report (WCH-398).

Sample results include various levels of data validation. With the exception of samples qualified as rejected ("R"-flagged), all U- (nondetect) and J- (estimated) qualified data were considered to be usable for purposes of risk assessment. Data that had been qualified as "rejected" during the data quality assessment process were omitted from the data sets. The data assessment process and resulting data qualification actions for the RI data set are described in WCH-381. Sample results qualified in any other way (e.g., estimated values qualified with a "J") were used as reported in this statistical analysis.

PCBs were analyzed in two different methodologies: one provides results for individual Aroclor mixtures (e.g., Aroclor- 1260), while the other provides results for PCB congeners. Congener analysis is a more sensitive analytical method than Aroclor analysis that provides more accurate quantification of PCB concentrations, and has lower detection limits. Although Aroclors were infrequently detected among samples, PCB congeners were detected in all samples analyzed for this parameter. Rather than evaluate each of the 209 PCB individual congeners, results from PCB congeners were combined to calculate total PCB concentrations for use in the HHRA. Non-detected PCB samples were analyzed using the detection limit rather than assigning a value of zero or one half the detection limit. This approach is more conservative (i.e., health protective) and will likely overestimate the potential risk.

Fillet, carcass, liver/kidney, and viscera samples were collected from six fish species under the RI sampling program. Fillet, carcass, and liver/kidney are considered to be the consumable portions of fish, whereas viscera is not. For this assessment, only fillet fish tissue data were used because fillet tissue is preferentially consumed, whereas carcass and organ meat are assumed to comprise only a small fraction of the total amount of fish consumed by humans. Viscera data were not considered to be relevant.

DOH Evaluation of Chemicals in Fish Tissue

DOH's evaluation of chemicals in fish tissue for possible advisories follows the methodology recommended by EPA for the assessment of cancer and noncarcinogenic toxicity (EPA 2000a). One difference from the EPA methodology is that when evaluating contaminants in fish, DOH does not necessarily calculate potential non-cancer or cancer risks. Fish advisories are not intended to determine risk but rather give advice to consumers if contaminant levels exceed an establish health benchmark (exceeding a reference dose or unacceptable cancer risk). If a contaminant is above a health benchmark, a risk threshold has been exceeded and intervention in the form of a fish advisory may be warranted to mitigate potential exposures. The following is an overview of the steps used by DOH to determine whether consumers of resident fish near the Hanford Reservation are potentially overexposed to levels of contaminants, and methods used to develop meal recommendations for consuming these species.

- Determine mean concentrations of chemicals of potential concern in resident fish species.

- Compare tissue chemical concentrations with corresponding screening level (SL) concentrations (see Appendix A. Table 1). DOH has established screening levels for non-cancer and cancer health effects for both the general population and for high fish consumers. If resident fish tissue concentrations of chemicals of potential concern exceed SLs, continue to evaluate risk and develop possible meal restrictions. If tissue concentrations are below SLs, no further evaluation is required.

- If a population is exposed to levels that exceed health benchmarks, DOH calculates acceptable meal limits based on non-cancer endpoints and possibly cancer endpoints. In a further step, health calculates acceptable meal limits based on exposure to multiple chemicals, if appropriate, to account for combined toxicity of chemicals acting on the same organ systems or having similar health endpoints.

DOH considers results of the above analyses to formulate health messages to communicate to the public. Other factors are also considered, such as the health benefits of eating fish, availability of less contaminated fish or food from other sources, whether contaminants can be reduced by cleaning and cooking techniques, and background concentrations of contaminants. Advice from this evaluation will be geared toward people who regularly eat resident fish from the Mid-Columbia River.

Screening Levels

Fish tissue chemical screening levels (SLs) were developed to assist in evaluating chemical levels in fish that warrant further scrutiny. SLs for each chemical contaminant are defined as the concentration of the chemical in fish tissue that is of potential public health concern. SLs are used as threshold values against which tissue residue levels of a contaminant in seafood can be compared. SLs were calculated based on non-carcinogenic effects of the chemical contaminant for both the general and high fish consumer groups, which are discussed in detail in Volume 1 of EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (EPA 2000b).

For this evaluation, DOH calculated SLs based on a consumption rate of 8 and 23 meals per month, which is equivalent to 59.7 and 175 grams of fish per day, respectively. The first consumption rate corresponds to advice from the American Heart Association that recommends that people consume two meals per week to gain heart health benefits from consuming seafood. The second consumption rate corresponds to a value the Washington State Department of Ecology proposed in setting Federal Clean Water Act (CWA) Standards. This consumption rate is also used by the state of Oregon for compliance with the CWA and is further supported by the Columbia River Inter-Tribal Fish Commission (CRITFC). Twenty-three meals a month is approximately the 95^{th} percentile consumption rate of its tribal members (CRITFC 1994). While DOH does not give restrictions on fish consumption rates greater than two meals per week, DOH provides calculated meal recommendations for all available contaminant concentrations measured in a given species for individuals who exceed this consumption rate and have additional questions or concerns.

From the initial list of chemicals evaluated, those with a detection frequency of 10% or greater (as shown in Table 3) were carried forward in the evaluation. They were also carried forward if they had been assigned a U.S. EPA Integrated Risk Information System (IRIS) oral reference dose (RfD). In addition, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) were used to evaluate specific health endpoints for total PCBs in combination with other contaminants that share similar health endpoints (ATSDR 2000). SLs for chemicals with reference values were calculated based on both a 59.7 and 175 gram per day (g/day), corresponding to 8 and 23 meals per month, respectively. The general equation to derive a screening value is as follows:

Non-carcinogens:

$$\text{Screening Level } (SL_{nc}) = RfD \times BW \times UCF / CR$$

Where:
SL_{nc} = chemical specific non-cancer screening concentration (mg/kg)
RfD = chemical specific oral reference dose (mg/kg-day)
BW = average body weight of an child, adult, or woman of childbearing age (kg)
UCF = unit conversion factor ($1x10^3$ g/kg)
CR = consumption rate (g/day)

Non-cancer screening levels for chemicals used for comparison with measured contaminant concentrations were determined for this assessment (Appendix A, Table 1).

Approach for Assessing Lead Exposures in Children

Potential health effects due to lead exposure were assessed for children and adults. Young children (aged 6-84 months) are usually the sub-population of chief concern for lead exposure. This is because: 1) young children tend to have higher intakes of environmental media per unit body weight than adults (especially for soil and dust); 2) young children tend to absorb a higher fraction of ingested lead than adults; and 3) young children are inherently more susceptible to the adverse effects of lead, since their nervous systems are still developing. The biokinetics of lead are different from most toxicants because lead is stored in bone and remains in the body long after it is ingested. Therefore, EPA has not developed an RfD for lead. Lead exposures must be evaluated differently than for other chemicals such as PCBs and mercury.

Lead exposure is evaluated using a biokinetic model and risk is interpreted in terms of blood lead concentration rather than a Hazard Quotient. To evaluate the potential for harm, public health agencies often use a computer model that can estimate blood lead levels in children younger than seven years of age who are exposed to lead. In this evaluation, children’s exposure to lead is evaluated using the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) developed by the EPA. The IEUBK model predicts blood lead levels in a distribution of exposed children based on the amount of lead that is in environmental media (e.g., soil, air, water, or diet) (EPA 2002). The model uses results to evaluate the risk of lead poisoning for an average child.

It is currently difficult to identify what degree of lead exposure, if any, can be considered safe in young children. Some studies report subtle signs of lead-induced neurobehavioral effects in children beginning at blood lead levels around 10 μg/dL or even lower. In 2012, CDC updated its recommendations on children's blood lead levels and defined a reference value of 5 μg/dL to identify children with elevated blood lead levels. This reference range value is based on the 97.5th percentile of the 2007-2010 National Health and Nutrition Examination Survey's (NHANES) blood lead distribution in children. In evaluating lead concentrations in Hanford Reach resident fish, the IEUBK model was used to estimate the percentage of children that could have elevated blood lead levels if they frequently eat lead-contaminated seafood. For children who are regularly exposed to lead-contaminated seafood, the IEUBK model can estimate the probability that any child could have a blood lead concentration that exceeds 5 μg/dL due to their diet. Exceedance of lead exposure will be based on EPA's goal that no individual will have greater than a 5% probability of having a blood lead concentration above the target value of 5 μg/dL.

The EPA IEUBK model specifies default input parameters that include lead soil concentrations, outdoor and indoor dust lead concentrations, outdoor air lead concentration, lead drinking water concentrations, dietary lead intake as well as default lead bioavailability values when site specific values are not available. This assessment, however, focuses primarily on lead exposure from the consumption of Hanford Reach resident fish and whether lead concentrations present in any of these species would result in exceedance of CDC's target value. Outdoor soil lead concentrations were set at 13.1 ppm based on eastern Washington's 90^{th} percentile background area wide soil monitoring results (Ecology 1994). Other default parameters (i.e. outdoor air lead concentration of 0.1 $\mu g/m^3$, and drinking water lead concentration of 4 μg/L) were retained. Default bioavailability values were also used to estimate the percentage of lead uptake from the gut or lungs. To assess the lead hazard associated with seafood consumption, the IEUBK model requires information on the percentage of total seafood consumption consisting of locally caught fish (i.e., average-end recreational estimate for a child or non-tribal high-end consumers) as a percentage of a child's overall meat diet as well as the average lead concentration in those fish tissue. This evaluation uses conservative (i.e. protective) exposure assumptions by utilizing a seafood ingestion rate of 46.7 g/day that encompasses 50% of a child's total meat intake and contains the mean lead concentration of Hanford Reach resident fish.

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. The IEUBK model was also not designed to assess the short-term, periodic, or acute exposures, or the deliberate ingestion (e.g., pica) of soil in which there are excessive soil ingestion rates. Instead, the role of the IEUBK model is to simulate blood lead (PbB) concentrations associated with continuous exposures of sufficient duration to result in a quasi-steady state (EPA 2002). Infrequent and non-continuous exposures (i.e., less than one day per week over a minimum duration of 90 days) would be expected to produce oscillations in blood lead concentrations associated with the absorption and subsequent clearance of lead from the blood between each exposure event. The IEUBK model, therefore, can only provide an approximation of quasi-steady-state PbB concentrations during non-continuous exposure scenarios (EPA, 2003). 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.

Approach for Assessing Lead Exposures in Adults

The adult lead model (ALM, Version June 2009) was used to estimate the probability that a fetus born to a mother who frequently eats lead-contaminated seafood could have elevated blood lead levels (BLL). The EPA's adult blood lead model is useful to predict blood lead levels in adults and their fetuses. The adult model uses well established default values and differs from the Children's IEUBK Model in that the adult model estimates fetal exposure based on maternal exposure to lead. The adult model considers lead exposure through the ingestion of soil and food. In this application, ingestion of lead from the consumption of Hanford Reach resident fish species was used to represent maternal exposure. The dose of lead received through this pathway is then converted to a blood lead level by using the ratio of blood lead to lead dose, the Biokinetic Slope Factor (BKSF). As part of the model, the default maternal BLL in the absence of site specific lead exposure pathways (1.0 µg/dL) was incorporated into the calculation. The adult exposure was based on consuming 59.7 g/day of seafood along with the mean lead tissue concentration of any of Hanford Reach resident fish species, 365 days per year.

Calculating Meal Limits for Individual Chemical Exposures

When estimated exposures for any given population exceed comparison values considered to be protective (i.e. RfDs or acceptable cancer risks), meal limits are calculated to inform any advice that might be provided to consumers. DOH calculates allowable meal limits based on EPA's RfD, ATSDR's Minimal Risk Level (MRL), or EPA's CSF, the average body weight of an individual, and the known contaminant concentration in seafood. These calculations allow DOH to formulate advice that will be useful to consumers.

By using the known concentration of a contaminant in a seafood species, it is possible to calculate a meal limit for that species that will result in a dose equivalent to the RfD for that contaminant. In this approach, the RfD is used to calculate the quantity of seafood a person of a given body weight can safely consume given varying contaminant concentrations found in seafood tissue. The equation used to calculate a safe consumption rate is shown below, with exposure parameters as defined in Table 4 (EPA 2000b):

Non-cancer meal equation:

$$Meal\ per\ month = \frac{RfD\ x\ BW\ x\ CF1\ x\ CF2}{MS\ x\ C}$$

Table 4. Exposure Parameters for Calculating Fish Meal Limits

Parameter	Value	Units	Comments	Source
Reference Dose (RfD)	Variable	mg/kg-day	Chemical specific	EPA IRIS or ATSDR MRL or TTD
Body Weight (BW)	60 or 70	Kg	70 kg adult, 60 kg adult female	EPA Exposure Factors Handbook
Conversion Factor (CF1)	30.44	Days/month		
Conversion Factor (CF2)	1000	gm/kg		
Meal Size (MS)	227	Gm	8 oz. meal	DOH
Concentration in fish (C)	Mean contaminant concentration	mg/kg	Specific to species	USDOE

Calculating Non-Cancer Meal Limits Based on Multiple Chemical Exposures

Consuming seafood can expose a person to more than one chemical at a time. Assessing the combined effect is more difficult because it is not possible to measure all possible interactions between chemicals. The potential exists for many chemicals to interact in the body and increase or decrease the potential for adverse health effects. Individual cancer risk estimates can be added since they are measures of probability. However, when estimating non-cancer risk, similar toxic effects must exist between the chemicals if the doses are to be added (ATSDR 2004).

In addition to individual contaminant effects discussed above, this assessment also considers the additive non-cancer endpoints of mercury, DDT, and PCB exposure. Because mercury, DDT, and PCBs can have similar toxic endpoints (neurological and developmental health endpoints), the preceding equation can be adapted to calculate meal limits that account for additive toxic effects. The adapted equation is shown, below:

$$Meals\ per\ month = \left(\frac{BW\ x\ CF}{MS}\right) x \left(1/\left(\left(\frac{C_{mercury}}{RfD_{mercury}}\right) + \left(\frac{C_{DDT}}{TTD_{DDT}}\right) + \left(\frac{C_{PCB}}{MRL_{PCB}}\right)\right)\right)$$

Where: BW = body weight adult, or woman of childbearing age
CF = Conversion Factor (30.44 days/month)
MS = Meal Size (0.227 kg/meal)
RfD = EPA derived chemical specific oral Reference Dose (mg/kg-day)

MRL = ATSDR derived chemical specific Minimal Risk Level (mg/kg-day)
TTD = ATSDR derived Target-organ Toxicity Dose comparable to an MRL (mg/kg-day)
C = Chemical concentration of mercury, PCBs, DDT in fish tissue (mg/kg)

It should be noted that both DDT and PCBs have been assigned an RfD and an MRL. In both cases, the health endpoints assessed by the RfD and MRL are different. The RfD for PCBs is based on immunological effects that would apply to the general population and an MRL that is protective of neurological effects to the sensitive population. The RfD for DDT is based on adverse liver effects to the general population and the TTD is protective of neurological effects to the sensitive population. The derived TTD is based on an acute-duration oral exposure for DDT based on effects on perinatal development of the nervous system in neonatal mice with behavioral neurotoxicity manifested in the adult animals. Because developmental effects are influenced by time of dose as well as dose level, it is not clear that a longer exposure period would contribute additionally to the effects observed (ATSDR 2004).

Single contaminant meal calculations are assessed using the most restrictive health criteria (e.g. the RfD for PCBs results in more restrictive meal limits than the use of the MRL for PCBs). To evaluate the interactive effect of the potential meal restrictions based on similar health endpoints, DOH combines the appropriate health criteria (i.e. either the RfD, TTD, or MRL) as outlined above to determine meal limits. As with single contaminant meal calculations, calculated meal limits based on multiple contaminants are also rounded up or down to fit one of the six meal rate categories used by DOH (no consumption, one, two, four, eight meal per month, or unlimited consumption) to address ease of messaging.

As mentioned previously, considerations are given to factors in addition to calculated meal limits that will influence consumption recommendations. These include but are not limited to chemical background concentrations, the ability to reduce chemical concentrations through cleaning and cooking techniques, chemical concentrations in other food, known benefits of fish consumption, and ease of messaging.

Assessing Dioxin-like PCBs

Polychlorinated biphenyls may be categorized as either “dioxin-like” or “nondioxin-like” in their toxicity. Congener results were used to calculate a total “dioxin-like” PCB concentration and a total “nondioxin” PCB concentration for each sample. Dioxin-like PCBs are those congeners that exhibit a toxicological mode of action common to chlorinated dibenzo-p-dioxins and dibenzofurans. Nondioxin-like PCB congeners were assumed to have similar toxicity and mode of action to PCB Aroclors.

When calculating a total “dioxin-like” PCB concentration, it is assumed that each congener has a toxicity equivalent to some fraction of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic TCDD. Individual congener concentrations (per sample) are first multiplied by a toxic equivalence factor (TEF), if available, to calculate a weighted congener concentration (Table 5). The dioxin TEFs for PCB congeners used in this assessment are values published by the World Health Organization (Van den Berg et al. 2006). These values are recommended for use in risk assessments by both EPA (EPA 2010) and Ecology (Ecology 2008). The individual TEF-weighted congener concentrations are then summed together to calculate a weighted “total TCDD equivalent” concentration.

Table 5. Dioxin-like PCB Toxicity Equivalence Factors

Class	Congener	CASRN	Mammal Toxicity Equivalence Factor (TEF)
Co-planar PCBs	3,3',4,4'-TCB (77)	32598133	0.0001
	3,4,4',5-TCB (81)	70362504	0.0003
	3,3',4,4'-5-PeCB (126)	57465288	0.1
	3,3',4,4',5,5'-HxCB (169)	32774166	0.03
Mono-ortho PCBs	2,3,3',4,4'-PeCB (105)	32598144	0.00003
	2,3,4,4',5-PeCB (114)	74472370	0.00003
	2,3',4,4',5-PeCB (118)	31508006	0.00003
	2',3,4,4',5-PeCB (123)	65510443	0.00003
	2,3,3',4,4',5-HxCB (156)	38380084	0.00003
	2,3,3',4,4',5'-HxCB (157)	69782907	0.00003
	2,3',4,4',5,5'-HxCB (167)	52663726	0.00003
	2,3,3',4,4',5,5'-HpCB (189)	39635319	0.00003

Results

All 19 metals, eight pesticides, and PCBs were detected in at least one fish species at a detection frequency of greater than 10%. A summary of range (minimum and maximum) values for the six fish species are displayed (Table 6). Highlighted values indicate the highest concentration for a given chemical in any of the six fish species. Minimum, maximum, and mean contaminant concentrations for tissue samples having a detection frequency of 10% or greater for each fish species are displayed in Appendix B (Tables B1-B6).

Table 6. Range of Contaminant Concentrations in Muscle Tissue of Resident Fish from the Hanford Reach of the Columbia River

Chemical	Range of Concentrations (mg/kg wet weight)					
	Bass	Carp	Sturgeon	Sucker	Walleye	Whitefish
Aluminum	ND	ND	ND	ND	ND	2.99 - 5.1
Arsenic (total)	ND	ND	0.327 - 1.13	ND	ND	0.211 - 0.926*
Arsenic (inorganic)	ND	0.003* - 0.005	ND	0.003* - 0.004	ND	ND
Barium	0.194 - 1.390	0.147 - 0.782	0.078 - 0.472	0.267 - 1.13	0.090 - 1.08	0.082 - 0.877
Boron	ND	ND	ND	ND	ND	1.32* - 3.86
Cadmium	ND	0.033 - 0.169*	ND	ND	ND	0.038 - 0.196*
Chromium	ND	0.161 - 1.34	0.125 - 1.47	0.148 - 0.674	0.141 - 0.928	0.144 - 2.03
Cobalt	0.793 - 1.92*	ND	ND	ND	0.065* - 1.3	ND
Copper	ND	0.547 - 1.03	ND	0.381 - 1.0*	ND	0.439 - 0.932
Iron	3.51 - 15.2	9.86 - 23.1	3.02 - 17.5*	4.24 - 26.5	2.76 - 13.4	5.93 - 18.5
Lead	ND	0.237 - 0.865	ND	ND	ND	ND
Lithium	ND	0.374 - 1.98*	0.371 - 2.45*	ND	0.206* - 1.25*	ND
Manganese	0.552 - 5.85	0.298 - 1.6	0.152 - 4.24*	0.937 3.99	0.217 - 1.04	0.258 - 2.3
Mercury	0.035 - 0.122	0.060 - 0.180	0.013 - 0.612	0.073 - 0.172	0.098 - 0.721	0.015 - 0.099
Methymercury	NA	NA	0.014 - 0.239	NA	NA	NA
Selenium	0.760 - 1.140	0.499 - 1.43	0.755 - 2.92	0.554 - 1.06	0.51 - 0.754	0.718 - 1.28
Strontium	1.99 - 22.8	1.03 - 7.96	0.091 - 0.909*	0.923 - 4.49	0.372 - 15.3	0.353 - 8.91
Tin	ND	5.34* - 64.7	ND	1.51* - 9.04	1.41 - 22.9	5.14 - 161.0
Vanadium	0.166 - 2.120	0.268 - 1.98	0.185 - 2.45*	0.283 - 2.5*	0.152 - 0.399	0.155 - 2.31*
Zinc	6.97 - 30.1	18.2 - 38.2	2.82 - 4.83	9.21 - 19.6	5.02 - 15.7	6.44 -17.7
Delta-BHC	ND	ND	ND	0.012* - 0.076	ND	ND
beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.003 - 0.019	0.0003* - 0.318	0.005* - 0.115	ND	0.005 - 1.87	ND
Dichlorodiphenyldichloroethane (DDD)	0.006* - 0.251	0.002 - 0.355	0.007 - 0.144	0.017 - 0.243	0.005* - 0.197	0.010 - 0.124
Dichlorodiphenyldichloroethylene (DDE)	0.012 - 0.239	0.009 - 1.19	0.041 - 0.833	0.085 - 0.329	0.014 - 0.655	0.074 - 0.592
Dichlorodiphenyltrichloroethane (DDT)	ND	ND	0.005* - 0.015	ND	0.005* - 0.018*	ND
Dieldrin	ND	ND	ND	ND	ND	0.008 - 0.039
Gamma-BHC (Lindane)	ND	ND	ND	ND	0.005* - 0.075	ND
Heptachlor	ND	ND	ND	ND	0.005* - 0.025	ND
Total PCBs	0.023 - 0.234	0.101 - 0.559	0.081 - 0.386	0.059 - 0.247	0.018 - 0.600	0.067 - 3.76
Total Dioxin-Like PCBs	1.3E-6 - 1.0E-5	3.5E-6 - 2.5E-5	3.4E-7 - 1.6E-5	2.1E-6 - 8.5E-6	1.9E-6 - 2.6E-5	1.5E-7 - 2.1E-4

* = reported at detection limit
NA = not assessed
ND = not detected or detected at less than 10% of samples
Shaded values indicate highest concentration for a given chemical

Exceedances of Screening Levels

Mean chemical concentrations were compared to screening levels to determine whether further assessment was warranted. A comparison with general population or high consumer screening levels for those chemicals with detection frequencies greater than 10% are shown (Appendix C, Tables 1-7). Values above the corresponding SL for a particular contaminant are highlighted in each table. Seven chemicals – inorganic arsenic, mercury, methylmercury, total DDT, heptachlor, dieldrin, and total PCBs - exceed a given cancer or non-cancer SL in one or more fish species. SLs for mercury, total DDT, and total PCBs were exceeded for all species. A summary of COCs that exceeded screening levels are presented (Table 7). Also shown are their associated RfDs, general population and high consumer population screening levels, and the critical health effect of that contaminant. A summary of screening levels that were exceeded based on average concentrations from the four locations were also determined (Table 8).

Table 7. Chemicals of Concern that Exceeded Non-Cancer Screening Levels

Analyte	RfD (mg/kg-day)	General Population SL (ppm)	High Consumer SL (ppm)	Critical Effect
Mercury*	1.0×10^{-4}	0.101	0.034	Neurological/Developmental effects
Total DDT	5.0×10^{-4}	0.503	0.171	Liver lesions
Total DDT*	2.0×10^{-3}**	2.010	0.686	Neurological/Developmental effects
Dieldrin	5.0×10^{-5}	0.059	0.020	Liver lesions
Heptachlor	5.0×10^{-4}	0.586	0.200	Increased liver weight
Total PCBs	2.0×10^{-5}	0.023	0.008	Immune effects
Total PCBs*	3.0×10^{-5}***	0.0302	0.010	Neurological/Developmental effects
Dioxin-like PCBs	7.0×10^{-10}	8.20E-07	2.80E-07	Aryl hydrocarbon receptor (AhR) binding
				Decreased sperm production
* based on 60 kg BW				
** ATSDR TTD				
***ATSDR MRL				

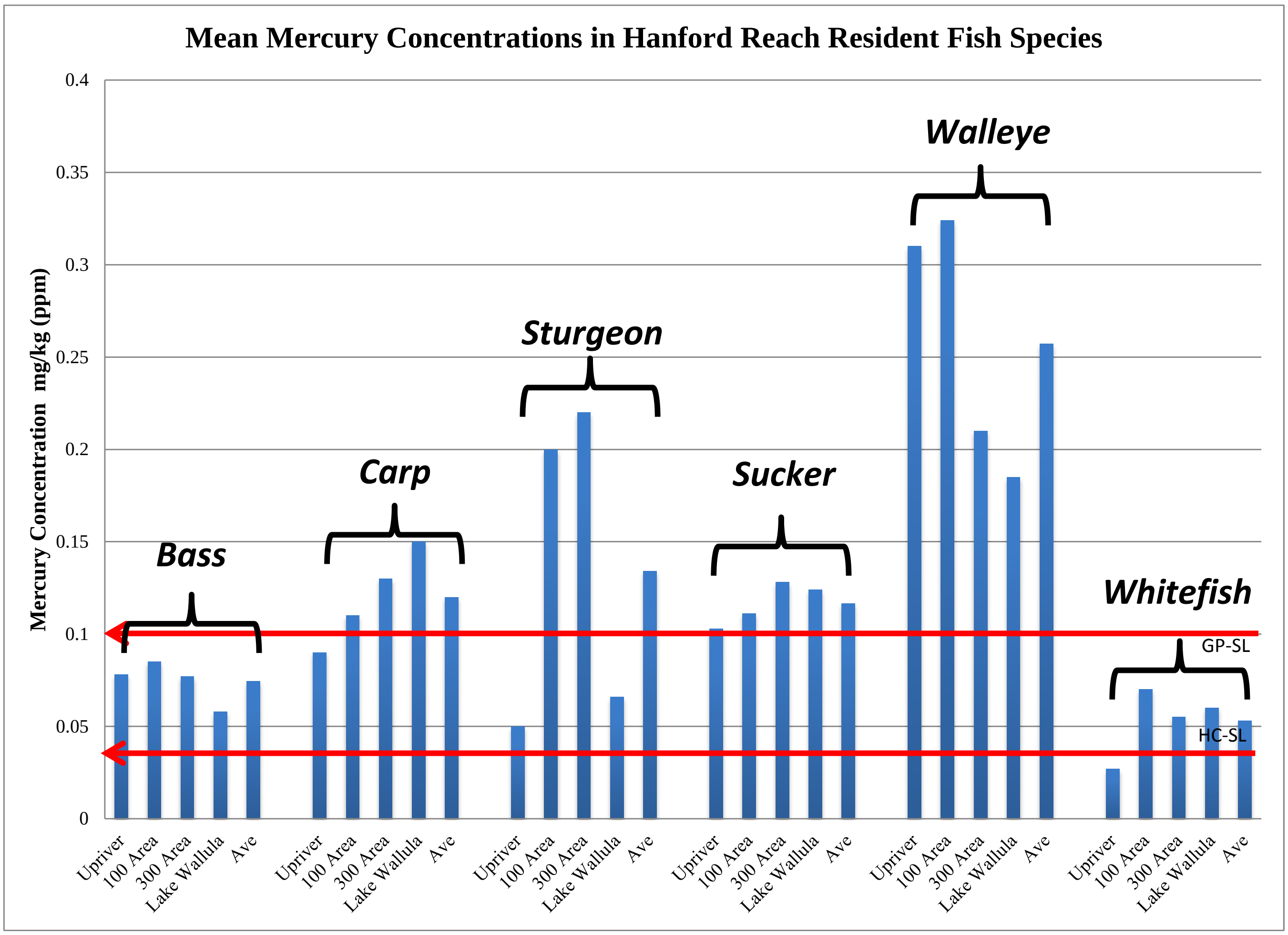
Table 8. Screening Level Exceedance

Species	Location	Chemical	Concentration mg/kg (ppm)	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Bass	All	Mercury	0.075	NO	**YES**	NA	NA
Bass	All	Total DDT	0.159	NO	NO	**YES**	**YES**
Bass	All	Total PCBs	0.073	**YES**	**YES**	**YES**	**YES**
Carp	All	Arsenic (inorganic)	0.007	NO	NO	**YES**	**YES**
Carp	All	Mercury	0.120	**YES**	**YES**	NA	NA
Carp	All	Total DDT	0.581	NO	**YES**	**YES**	**YES**
Carp	All	Total PCBs	0.296	**YES**	**YES**	**YES**	**YES**
Sturgeon	All	Mercury	0.134	**YES**	**YES**	NA	NA
Sturgeon	All	Methylmercury	0.092	NO	**YES**	NA	NA
Sturgeon	All	Total DDT	0.267	NO	**YES**	**YES**	**YES**
Sturgeon	All	Total PCBs	0.206	**YES**	**YES**	**YES**	**YES**
Sucker	All	Arsenic (inorganic)	0.0019	NO	NO	**YES**	**YES**
Sucker	All	Mercury	0.117	**YES**	**YES**	NA	NA
Sucker	All	Total DDT	0.118	NO	**YES**	**YES**	**YES**
Sucker	All	Total PCBs	0.144	**YES**	**YES**	**YES**	**YES**
Walleye	All	Arsenic (inorganic)	0.002	NO	NO	**YES**	**YES**
Walleye	All	Mercury	0.257	**YES**	**YES**	NA	NA
Walleye	All	Total DDT	0.403	NO	**YES**	**YES**	**YES**
Walleye	All	Heptachlor	0.006	NO	NO	**YES**	**YES**
Walleye	All	Total PCBs	0.156	**YES**	**YES**	**YES**	**YES**
Whitefish	All	Mercury	0.053	NO	**YES**	NA	NA
Whitefish	All	Total DDT	0.209	NO	**YES**	**YES**	**YES**
Whitefish	All	Dieldrin	0.023	NO	**YES**	**YES**	**YES**
Whitefish	All	Total PCBs	0.398	**YES**	**YES**	**YES**	**YES**
NA = not assessed							
Highlighted values indicate exceedance of screening level							

A further evaluation of contaminants in all six resident fish species by location and mean contaminant concentrations for the four of the most common contaminants (mercury, total DDT, total PCBs, and dioxin-like PCBs) are shown (Figures 2-5). Aggregate averages of those locations are shown as well. In addition to mean contaminant concentrations, screening level for mercury, total DDT, and total PCBs are presented corresponding to the general and high consuming populations as horizontal arrows. Dioxin-like PCB TEQ concentrations are presented in the next section.

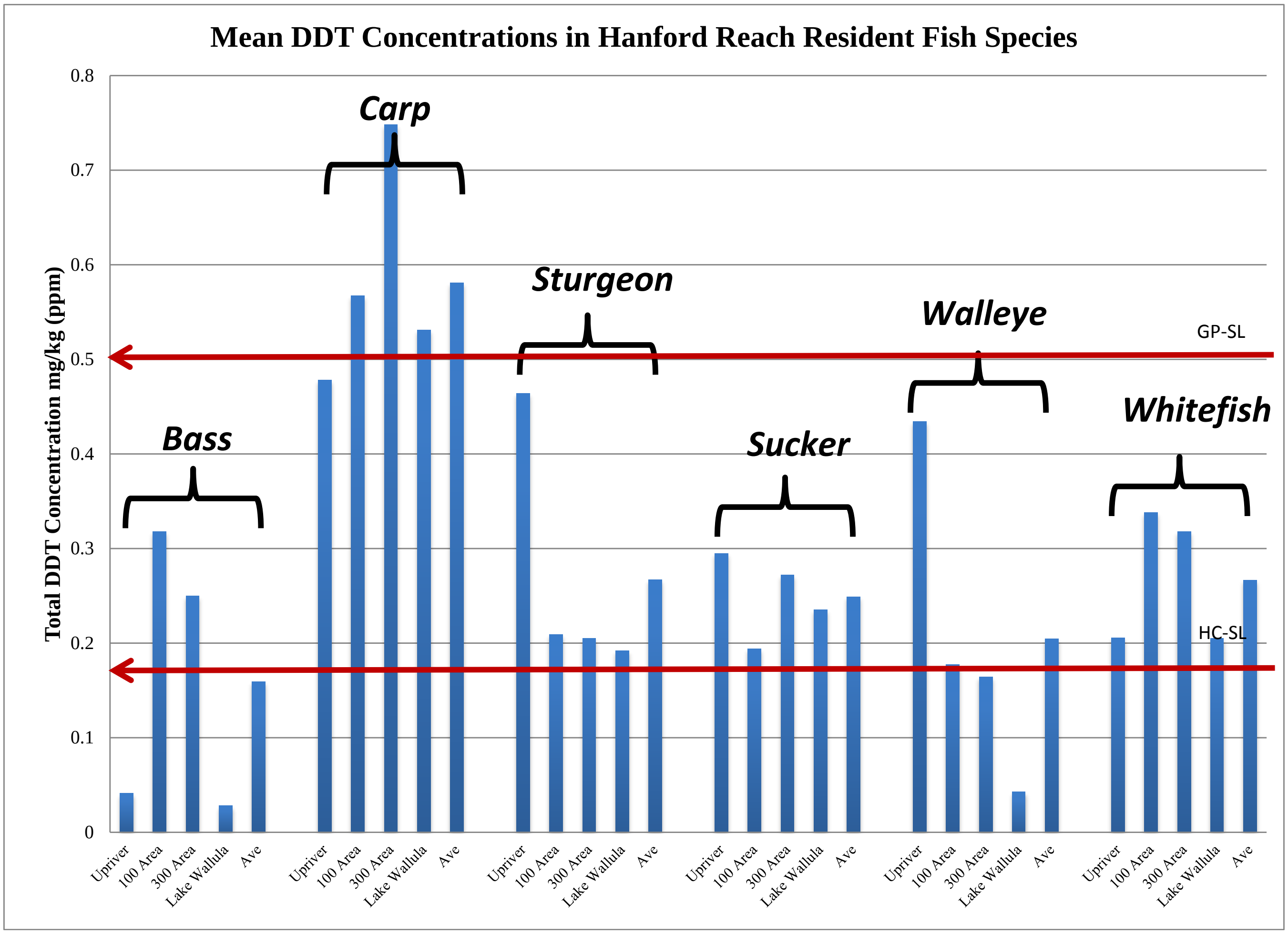
With the exception of bass and whitefish, mean mercury concentrations based on averaging of the four study locations exceeded the general population screening level (Figure 2). Averaged locations for all resident fish species exceeded the high consumer screening level.

Figure 2. Mean Mercury Tissue Concentrations



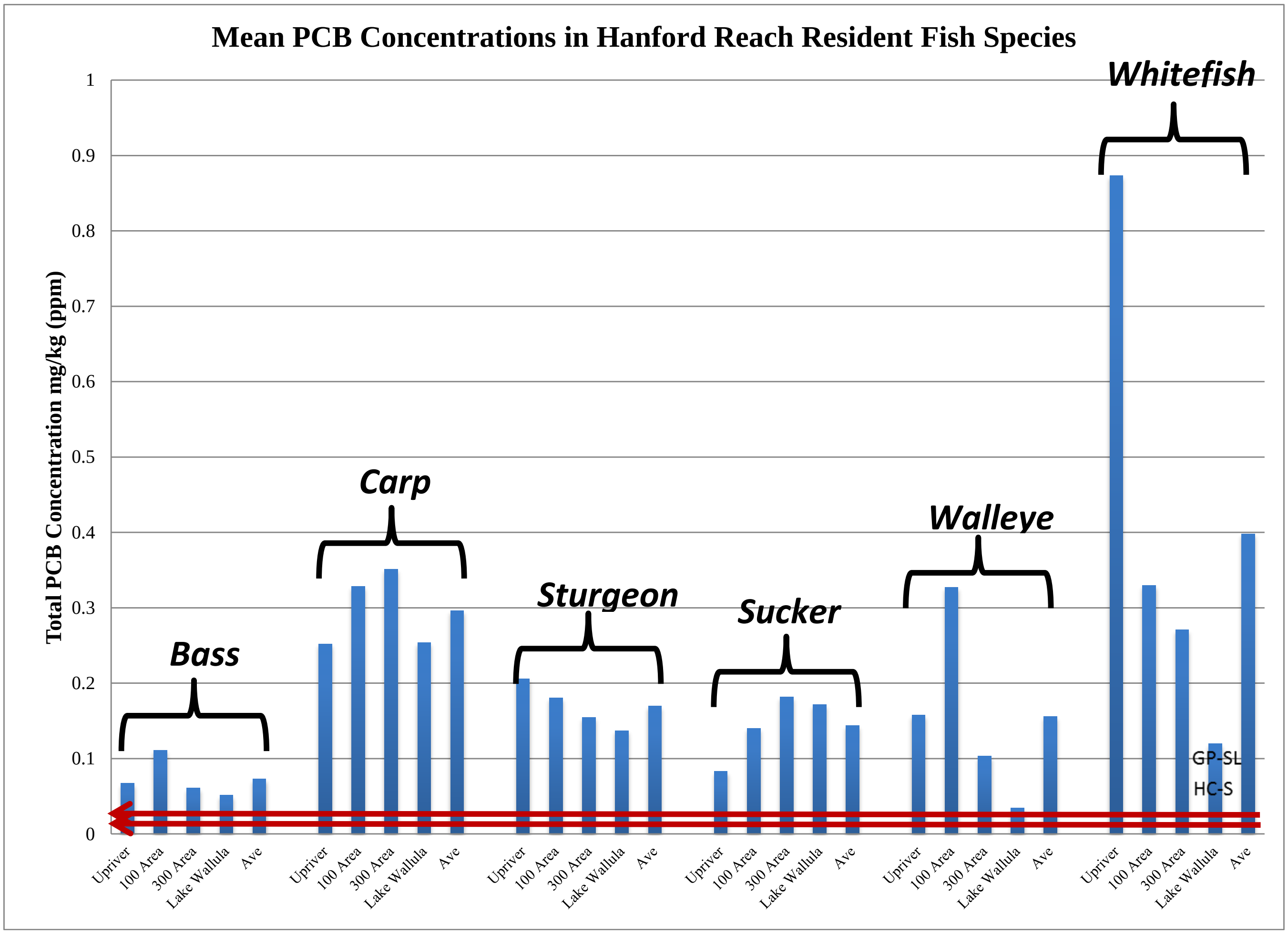
Total DDT general population screening level concentrations were only exceeded by common carp. Study site averaged total DDT concentrations exceeded the high consumer screening level in all resident fish species except for bass (Figure 3).

Figure 3. Mean Total DDT Tissue Concentrations



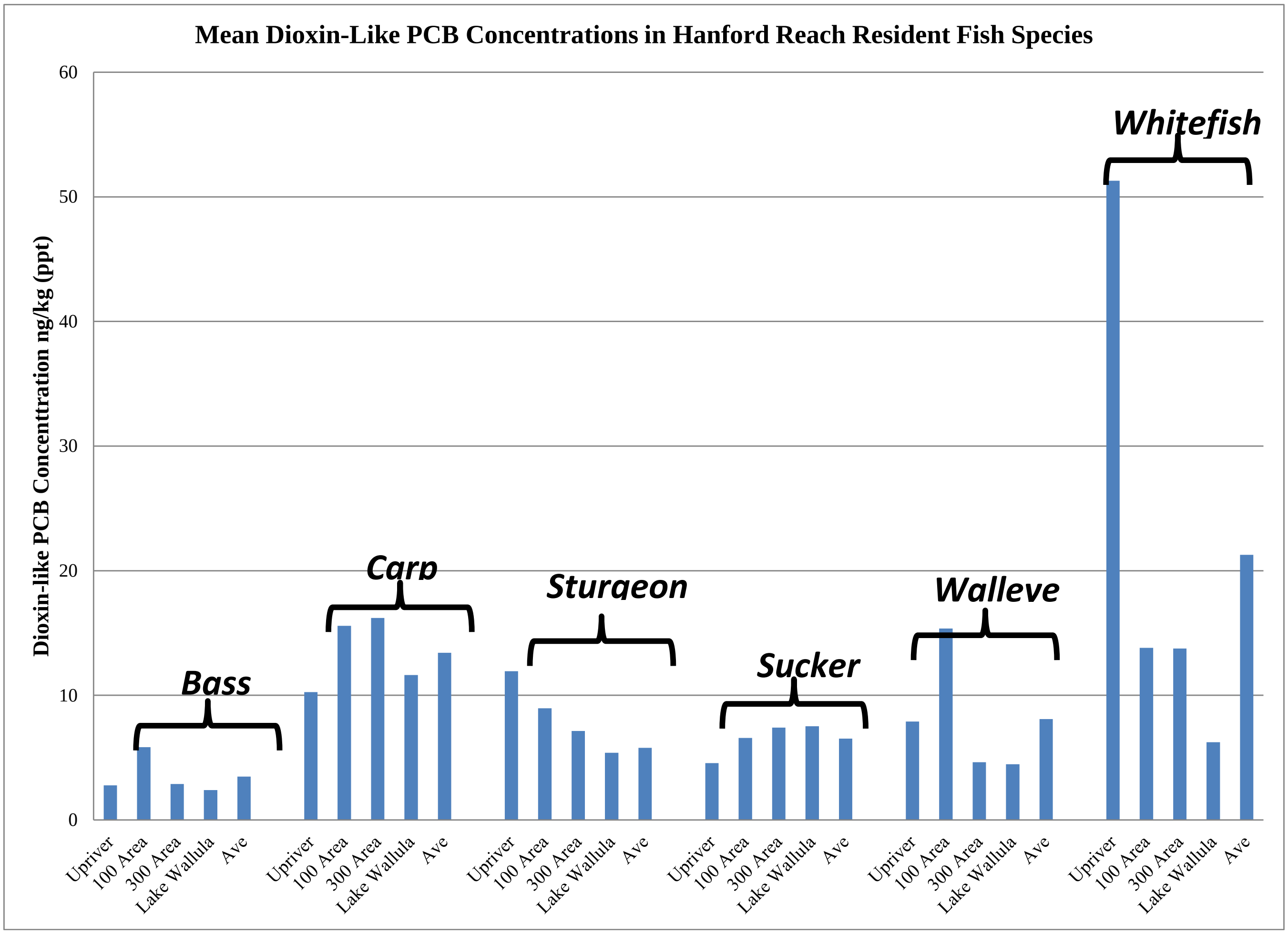
Mean total PCB concentrations for all locations as well as the average concentration across all study locations for all resident fish species exceeded both the general and high consumer screening level. The highest total PCB concentration was about three times higher in the upriver location in whitefish compared to other locations and other fish species (Figure 4).

Figure 4. Mean Total PCB Tissue Concentrations



Total dioxin-like PCBs were similarly elevated to total PCB concentrations across all resident fish species in all locations. The highest dioxin-like PCB concentration seen occurred in whitefish, corresponding to elevated total PCBs seen in the previous figure (Figure 5).

Figure 5. Mean Dioxin-Like PCB Tissue Concentrations



Lead Screening

Estimating Blood Lead Levels in Children

The IEUBK model was used to estimate the percentage of children that could have elevated blood lead levels if they frequently eat lead-contaminated seafood (Table 9). As mentioned above, this evaluation is interested in the impact of seafood consumption on a child's blood lead level. Outdoor soil lead was based on background concentrations in combination with mean lead concentrations observed in Hanford Reach resident fish. Other default parameters (i.e. outdoor air lead concentration of 0.1 µg/m^3, and drinking water lead concentration of 4 µg/kg) were retained. Default bioavailability values were also used to estimate the percentage of lead uptake from the gut or lungs. Dietary exposure is based on a scenario of a child whose meat diet is comprised of 50% of any Hanford Reach resident fish coupled with the mean lead concentration measured in that species.

Table 9. Summary of Children's IEUBK Model Results for Mean Lead Concentrations in Resident Fish Tissue Collected from the Hanford Reach Study Location of the Columbia River

Species	Mean Lead Conc. (ppm)	Detection. Frequency %	General Population Blood Lead Level (% Likelihood of Exceeding BLL of 5 ug/dL)
Bass	0.198	0	0.600
Carp	0.331	36.8	2.096
Sturgeon	0.225	0	0.808
Sucker	0.203	0	0.636
Walleye	0.197	4.5	0.593
Whitefish	0.319	5	1.909
Non-detected values = 1/2 DL			

No lead exposures based on mean lead concentrations measured in any of the Hanford Reach Resident fish species resulted in estimated blood lead levels that exceeded EPA's target level of no more than a 5% probability that an individual in the community exceed 5 μg/dL. The percentage of children with BLLs above 5 μg/dL from consuming 50% of a meat diet comprised of Hanford Reach Resident fish ranged from 0.593 to 2.096%. It should be noted that the exposure scenario chosen likely over estimates actual exposures in the population (i.e., it is unlikely that a child's meat diet would consist of 50% of Hanford Reach Resident fish at the mean concentration throughout ones childhood). Furthermore, only lead measured in common carp were found at a frequency greater than 10%.

Estimating Blood Lead Levels in Adults

The Adult Lead Model (ALM) was used to estimate the probability of a fetus having elevated blood lead levels (BLL) if their mother frequently ate lead-contaminated fish (Table 10). Only the fish portion of the adult lead model was used; the soil ingestion portion was omitted. The adult exposure scenario is based on an adult diet comprised of Hanford Reach resident fish consisting of 59.7 grams per day (equivalent to two-8 oz. meals per week) and the mean lead concentration corresponding to that species.

Table 10. Adult Lead Model Predicted Blood Lead (PbB) Levels

Species	Mean Lead Conc. (ppm)	PbB Adult (µg/dL)	Probability Fetal PbB > 5 µg/dL
Bass	0.198	2.1	1.2
Carp	0.331	2.4	2.1
Sturgeon	0.225	2.1	1.3
Sucker	0.203	2.1	1.2
Walleye	0.197	2.1	1.2
Whitefish	0.319	2.4	2
Non-detected values = 1/2 DL			

Mean lead concentrations resulted in a range of adult blood lead levels ranging from 2.1 to 2.4 µg/dL and a corresponding probability of lead blood levels in the fetus ranging from 1.2 to 2.1 percent. The resulting probability of a pregnant mother who consumes two meals per week of any Hanford Reach resident fish species would not exceed the benchmark (fetal blood lead levels exceeding 5 µg/dL). Based on these results, lead concentrations in Hanford Reach resident fish are not deemed of significant public health concern and no further assessment is necessary.

Dioxin-Like PCB Toxic Equivalence Factor Results

Polychlorinated biphenyls categorized as “dioxin-like” were assessed using the TEF and TEQ methodology, which will be described in this paragraph. Congener results were used to calculate a total “dioxin-like” PCB concentration for each sample. Dioxin-like PCBs are those congeners that exhibit a toxicological mode of action common to chlorinated dibenzo-p-dioxins and dibenzofurans. When calculating a total “dioxin-like” PCB concentration, each congener is assigned a toxicity equivalent to some fraction of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic TCDD. Individual congener concentrations (per sample) are first multiplied by a toxic equivalence factor (TEF) (Table 5) to calculate a weighted congener concentration. Individual TEF-weighted congener concentrations are then summed together to calculate a weighted “total TCDD equivalent” concentration (TEQ). Resulting TEQ concentrations for the six resident fish species in the four study locations as well as an averaged TEQ concentration across all locations for each species were summarized (Table 11). A 50% reduction in TEQ concentrations is also shown and will be referred to in upcoming sections.

Table 11. Dioxin-like Toxic Equivalent Concentrations

Species	Location	TEQ Concentration	
		mg/kg (ppm)	mg/kg (ppm) w/ 50% Reduction
BASS	Upriver	2.77E-06	1.39E-06
BASS	100 Area	5.84E-06	2.92E-06
BASS	300 Area	2.90E-06	1.45E-06
BASS	Lake Wallula	2.40E-06	1.20E-06
BASS	All	3.48E-06	1.74E-06
CARP	Upriver	1.03E-05	5.13E-06
CARP	100 Area	1.56E-05	7.79E-06
CARP	300 Area	1.62E-05	8.10E-06
CARP	Lake Wallula	1.16E-05	5.82E-06
CARP	All	1.34E-05	6.71E-06
STURGEON*	Upriver	1.19E-05	1.19E-05
STURGEON*	100 Area	8.97E-06	8.97E-06
STURGEON*	300 Area	7.14E-06	7.14E-06
STURGEON*	Lake Wallula	5.39E-06	5.39E-06
STURGEON*	All	8.36E-06	8.36E-06
SUCKER	Upriver	4.56E-06	2.28E-06
SUCKER	100 Area	6.58E-06	3.29E-06
SUCKER	300 Area	7.42E-06	3.71E-06
SUCKER	Lake Wallula	7.52E-06	3.76E-06
SUCKER	All	6.52E-06	3.26E-06
WALLEYE	Upriver	7.90E-06	3.95E-06
WALLEYE	100 Area	1.54E-05	7.68E-06
WALLEYE	300 Area	4.64E-06	2.32E-06
WALLEYE	Lake Wallula	4.47E-06	2.24E-06
WALLEYE	All	8.10E-06	4.05E-06
WHITEFISH	Upriver	5.13E-05	2.56E-05
WHITEFISH	100 Area	1.38E-05	6.91E-06
WHITEFISH	300 Area	1.38E-05	6.88E-06
WHITEFISH	Lake Wallula	6.24E-06	3.12E-06
WHITEFISH	All	2.13E-05	1.06E-05

* Skin-off fillets with no adjustment for reduction of organic compounds

Calculated Non-cancer Meal Limits for Individual Contaminants

Calculated meal limits for individual contaminants were derived using the equation above for Hanford Reach Site resident fish tissues for each of the four study locations within the study area using mean contaminant concentrations. Meal restrictions of eight meals per month or less corresponded with tissue levels that exceeded screening levels. For bass fillet tissue concentrations, meal restrictions of fewer than eight meals per month were calculated in all four study locations due to total PCBs and total dioxin-like PCB TEQ concentrations (Table 12a). Calculated meal limits due to PCB concentrations in bass fillet tissue ranged from 1.7 to 3.6 meals per month. Calculated meal limits due to dioxin-like PCB concentrations in bass fillet tissue ranged from 1.1 to 2.7 meals per month. Neither mercury nor total DDT concentrations resulted in calculated meal limit restrictions less than eight meals per month for bass.

Table 12a. Calculated Meal Limits for Bass

Species	Location	Chemical	Mean Concentration (ppm)	Calculated Meal Limits (meals/month)
Bass	Upriver	Mercury	0.078	10.3
Bass	100 Area	Mercury	0.085	9.5
Bass	300 Area	Mercury	0.077	10.4
Bass	Lake Wallula	Mercury	0.058	13.9
Bass	All	Mercury	0.075	10.8
Bass	Upriver	Total DDT	0.041	97.4
Bass	100 Area	Total DDT	0.318	12.7
Bass	300 Area	Total DDT	0.250	16.1
Bass	Lake Wallula	Total DDT	0.028	144.2
Bass	All	Total DDT	0.159	25.3
Bass	Upriver	Total PCBs	0.067	2.8
Bass	100 Area	Total PCBs	0.111	1.7
Bass	300 Area	Total PCBs	0.061	3.1
Bass	Lake Wallula	Total PCBs	0.052	3.6
Bass	All	Total PCBs	0.073	2.6
Bass	Upriver	Dioxin-like PCBs	2.77E-06	2.4
Bass	100 Area	Dioxin-like PCBs	5.84E-06	1.1
Bass	300 Area	Dioxin-like PCBs	2.90E-06	2.3
Bass	Lake Wallula	Dioxin-like PCBs	2.40E-06	2.7
Bass	All	Dioxin-like PCBs	3.48E-06	1.9

Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ
Meal size = 8oz.

For carp, meal restrictions of fewer than eight meals per month were calculated in all four study locations based on mercury, total DDT, total PCBs and total dioxin-like PCB TEQ concentrations (Table 12b). Calculated meal limits due to mercury concentrations in carp fillet tissue ranged from 5.4 to 8.9 meals per month. Calculated meal limits due to total DDT concentrations in carp fillet tissue ranged from 5.4 to 8.4 meals per month. Calculated meal limits due to total PCB concentrations in carp fillet tissue ranged from 0.5 to 0.7 meals per month and calculated meal limits due to dioxin-like PCB concentrations ranged from 0.4 to 0.6 meals per month.

Table 12b. Calculated Meal Limits for Carp

Species	Location	Chemical	Mean Concentration (ppm)	Calculated Meal Limits (meals/month)
Carp	Upriver	Mercury	0.090	8.9
Carp	100 Area	Mercury	0.110	7.3
Carp	300 Area	Mercury	0.130	6.2
Carp	Lake Wallula	Mercury	0.150	5.4
Carp	All	Mercury	0.120	6.7
Carp	Upriver	Total DDT	0.478	8.4
Carp	100 Area	Total DDT	0.567	7.1
Carp	300 Area	Total DDT	0.748	5.4
Carp	Lake Wallula	Total DDT	0.531	7.6
Carp	All	Total DDT	0.581	6.9
Carp	Upriver	Total PCBs	0.252	0.7
Carp	100 Area	Total PCBs	0.328	0.6
Carp	300 Area	Total PCBs	0.351	0.5
Carp	Lake Wallula	Total PCBs	0.254	0.7
Carp	All	Total PCBs	0.296	0.6
Carp	Upriver	Dioxin-like PCBs	1.03E-05	0.6
Carp	100 Area	Dioxin-like PCBs	1.56E-05	0.4
Carp	300 Area	Dioxin-like PCBs	1.62E-05	0.4
Carp	Lake Wallula	Dioxin-like PCBs	1.16E-05	0.6
Carp	All	Dioxin-like PCBs	1.34E-05	0.5
Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ Meal size = 8oz.				

For sturgeon, meal restrictions of fewer than eight meals per month were calculated in all four study locations based on mercury, methylmercury, total PCBs and total dioxin-like PCB TEQ concentrations (Table 12c). Calculated meal limits due to mercury and methylmercury concentrations in sturgeon fillet tissue ranged from 3.7 and 5.4 to 16.1 and 14.7 meals per month, respectively. Calculated meal limits due to total PCBs concentrations in sturgeon fillet tissue ranged from 0.9 to 1.4 meals per month and calculated meal limits due to dioxin-like PCB concentrations ranged from 0.6 to 1.2 meals per month.

Table 12c. Calculated Meal Limits for Sturgeon

Species	Location	Chemical	Mean Concentration (ppm)	Calculated Meal Limits (meals/month)
Sturgeon	Upriver	Mercury	0.050	16.1
Sturgeon	100 Area	Mercury	0.200	4.0
Sturgeon	300 area	Mercury	0.220	3.7
Sturgeon	Lake Wallula	Mercury	0.066	12.2
Sturgeon	All	Mercury	0.134	6.0
Sturgeon	Upriver	Methylmercury	0.055	14.7
Sturgeon	300 area	Methylmercury	0.150	5.4
Sturgeon	Lake Wallula	Methylmercury	0.072	11.2
Sturgeon	All	Methylmercury	0.092	8.7
Sturgeon	Upriver	Total DDT	0.464	8.7
Sturgeon	100 Area	Total DDT	0.209	19.2
Sturgeon	300 Area	Total DDT	0.205	19.6
Sturgeon	Lake Wallula	Total DDT	0.192	21.0
Sturgeon	All	Total DDT	0.267	15.0
Sturgeon	Upriver	Total PCBs	0.206	0.9
Sturgeon	100 Area	Total PCBs	0.180	1.0
Sturgeon	300 Area	Total PCBs	0.155	1.2
Sturgeon	Lake Wallula	Total PCBs	0.137	1.4
Sturgeon	All	Total PCBs	0.170	1.1
Sturgeon	Upriver	Dioxin-like PCBs	1.19E-05	0.6
Sturgeon	100 Area	Dioxin-like PCBs	8.97E-06	0.7
Sturgeon	300 Area	Dioxin-like PCBs	7.14E-06	0.9
Sturgeon	Lake Wallula	Dioxin-like PCBs	5.39E-06	1.2
Sturgeon	All	Dioxin-like PCBs	8.36E-06	0.8
Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ Meal size = 8oz.				

For sucker, meal restrictions of fewer than eight meals per month were calculated in all four study locations based on mercury, total PCBs and total dioxin-like PCB TEQ concentrations (Table 12d). Calculated meal limits due to mercury concentrations in sucker fillet tissue ranged from 6.3 and 7.8 meals per month. Calculated meal limits due to total PCB concentrations in sucker fillet tissue ranged from 1.0 to 2.3 meals per month. Calculated meal limits due to dioxin-like PCB concentrations ranged from 0.9 to 1.4 meals per month.

Table 12d. Calculated Meal Limits for Sucker

Species	Location	Chemical	Mean Concentration (ppm)	Calculated Meal Limits (meals/month)
Sucker	Upriver	Mercury	0.103	7.8
Sucker	100 Area	Mercury	0.111	7.2
Sucker	300 Area	Mercury	0.128	6.3
Sucker	Lake Wallula	Mercury	0.124	6.5
Sucker	All	Mercury	0.117	6.9
Sucker	Upriver	Total DDT	0.295	13.6
Sucker	100 Area	Total DDT	0.194	20.7
Sucker	300 Area	Total DDT	0.272	14.8
Sucker	Lake Wallula	Total DDT	0.235	17.1
Sucker	All	Total DDT	0.249	16.2
Sucker	Upriver	Total PCBs	0.083	2.3
Sucker	100 Area	Total PCBs	0.140	1.3
Sucker	300 Area	Total PCBs	0.182	1.0
Sucker	Lake Wallula	Total PCBs	0.172	1.1
Sucker	All	Total PCBs	0.144	1.3
Sucker	Upriver	Dioxin-like PCBs	4.56E-06	1.4
Sucker	100 Area	Dioxin-like PCBs	6.58E-06	1.0
Sucker	300 Area	Dioxin-like PCBs	7.42E-06	0.9
Sucker	Lake Wallula	Dioxin-like PCBs	7.52E-06	0.9
Sucker	All	Dioxin-like PCBs	6.52E-06	1
Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ Meal size = 8oz.				

For walleye, meal restrictions of fewer than eight meals per month were calculated in all four study locations based on mercury, total PCBs and total dioxin-like PCB TEQ concentrations

(Table 12e). Calculated meal limits due to mercury concentrations in sturgeon fillet tissue ranged from 2.5 and 4.3 meals per month. Calculated meal limits due to total PCB concentrations in walleye fillet tissue ranged from 0.6 to 5.4 meals per month and calculated meal limits due to dioxin-like PCB concentrations ranged from 0.4 to 1.5 meals per month.

Table 12e. Calculated Meal Limits for Walleye

Species	Location	Chemical	Mean Concentration (ppm)	Calculated Meal Limits (meals/month)
Walleye	Upriver	Mercury	0.310	2.6
Walleye	100 Area	Mercury	0.324	2.5
Walleye	300 Area	Mercury	0.210	3.8
Walleye	Lake Wallula	Mercury	0.185	4.3
Walleye	All	Mercury	0.257	3.1
Walleye	Upriver	Total DDT	0.434	9.3
Walleye	100 Area	Total DDT	0.177	22.7
Walleye	300 Area	Total DDT	0.164	24.5
Walleye	Lake Wallula	Total DDT	0.043	93.8
Walleye	All	Total DDT	0.205	19.7
Walleye	Upriver	Total PCBs	0.158	1.2
Walleye	100 Area	Total PCBs	0.327	0.6
Walleye	300 Area	Total PCBs	0.103	1.8
Walleye	Lake Wallula	Total PCBs	0.035	5.4
Walleye	All	Total PCBs	0.156	1.2
Walleye	Upriver	Dioxin-like PCBs	7.90E-06	0.8
Walleye	100 Area	Dioxin-like PCBs	1.54E-05	0.4
Walleye	300 Area	Dioxin-like PCBs	4.64E-06	1.4
Walleye	Lake Wallula	Dioxin-like PCBs	4.47E-06	1.5
Walleye	All	Dioxin-like PCBs	8.10E-06	0.8
Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ Meal size = 8oz.				

Whitefish meal restrictions of fewer than eight meals per month were calculated in all four study locations based on total PCBs and total dioxin-like PCB TEQ concentrations (Table 12f). Calculated meal limits due to total PCBs concentrations in whitefish fillet tissue ranged from 0.2

to 1.6 meals per month and calculated meal limits due to dioxin-like PCB concentrations ranged from 0.1 to 1.1 meals per month.

Table 12f. Calculated Meal Limits for Whitefish

Species	Location	Chemical	Mean Concentration (ppm)	Calculated Meal Limits (meals/month)
Whitefish	Upriver	Mercury	0.027	29.8
Whitefish	100 Area	Mercury	0.070	11.5
Whitefish	300 Area	Mercury	0.055	14.6
Whitefish	Lake Wallula	Mercury	0.060	13.4
Whitefish	All	Mercury	0.053	15.2
Whitefish	Upriver	Total DDT	0.206	19.6
Whitefish	100 Area	Total DDT	0.338	11.9
Whitefish	300 Area	Total DDT	0.318	12.7
Whitefish	Lake Wallula	Total DDT	0.205	19.6
Whitefish	All	Total DDT	0.267	15.1
Whitefish	Upriver	Total PCBs	0.873	0.2
Whitefish	100 Area	Total PCBs	0.330	0.6
Whitefish	300 Area	Total PCBs	0.271	0.7
Whitefish	Lake Wallula	Total PCBs	0.120	1.6
Whitefish	All	Total PCBs	0.398	0.5
Whitefish	Upriver	Dioxin-like PCBs	5.13E-05	0.1
Whitefish	100 Area	Dioxin-like PCBs	1.38E-05	0.5
Whitefish	300 Area	Dioxin-like PCBs	1.38E-05	0.5
Whitefish	Lake Wallula	Dioxin-like PCBs	6.24E-06	1.1
Whitefish	All	Dioxin-like PCBs	2.13E-05	0.3
Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ Meal size = 8oz.				

Calculated meal limits are summarized based on the four primary contaminants of concern (mercury, total DDT, total PCBs, and dioxin-like PCBs) for the six resident fish species for the four study locations as well as averaging meal limits across the entire Hanford Reach site (Table 13). Without exception, dioxin-like PCB TEQ concentrations resulted in the most restrictive calculated meal limits in all resident fish species based on calculated non-cancer meal limits for individual contaminants. Total PCBs resulted in the next most restrictive meal limit calculations.

Table 13. Summary of Calculated Meal Limits for all Resident Fish Species

Chemical	Location	Bass	Carp	Sturgeon	Sucker	Walleye	Whitefish
Mercury	Upriver	10.3	8.9	16.1	7.8	2.6	29.8
Mercury	100 Area	9.5	7.3	4.0	7.2	2.5	11.5
Mercury	300 Area Lake	10.4	6.2	3.7	6.3	3.8	14.6
Mercury	Wallula	13.9	5.4	12.2	6.5	4.3	13.4
Mercury	All	10.8	6.7	6.0	6.9	3.1	15.2
Total DDT	Upriver	97.4	8.4	8.7	13.6	9.3	19.6
Total DDT	100 Area	12.7	7.1	19.2	20.7	22.7	11.9
Total DDT	300 Area Lake	16.1	5.4	19.6	14.8	24.5	12.7
Total DDT	Wallula	144.2	7.6	21.0	17.1	93.8	19.6
Total DDT	All	25.3	6.9	15.0	16.2	19.7	15.1
Total PCBs	Upriver	2.8	0.7	0.9	2.3	1.2	0.2
Total PCBs	100 Area	1.7	0.6	1.0	1.3	0.6	0.6
Total PCBs	300 Area Lake	3.1	0.5	1.2	1.0	1.8	0.7
Total PCBs	Wallula	3.6	0.7	1.4	1.1	5.4	1.6
Total PCBs	All	2.6	0.6	1.1	1.3	1.2	0.5
Dioxin-like PCBs	Upriver	2.4	0.6	0.6	1.4	0.8	0.1
Dioxin-like PCBs	100 Area	1.1	0.4	0.7	1.0	0.4	0.5
Dioxin-like PCBs	300 Area Lake	2.3	0.4	0.9	0.9	1.4	0.5
Dioxin-like PCBs	Wallula	2.7	0.6	1.2	0.9	1.5	1.1
Dioxin-like PCBs	All	1.9	0.5	0.8	1.0	0.8	0.3

Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ
Meal size = 8oz.

Calculated meal limits for organic contaminants are further evaluated based on the known reduction in contaminant concentrations that can be achieved from cleaning and cooking techniques. These techniques can reduce PCB and DDT contaminant loads by 50% or more (Table 14). Thus, contaminant concentrations can be twice as high as the calculated meal limits when considering reductions in concentrations from cleaning and cooking and still remain below a safe dose established by a contaminant's RfD. Sturgeon samples were based on skin-off fillets and no reductions in organic compounds are expected in cleaning techniques. Nonorganic contaminants such as mercury that do not partition into fatty tissue do not see the same type of decrease in concentration when fat is removed by cleaning and cooking techniques. Reductions due to cleaning and cooking techniques were not applied to skin-off sturgeon tissue samples.

Table 14. Summary of Calculated Meal Limits with Reductions in Contaminants from Cleaning and Cooking Techniques for Organic Compounds

Chemical	Location	Bass	Carp	Sturgeon*	Sucker	Walleye	Whitefish
Mercury	Upriver	10.3	8.9	16.1	7.8	2.6	29.8
Mercury	100 Area	9.5	7.3	4.0	7.2	2.5	11.5
Mercury	300 Area	10.4	6.2	3.7	6.3	3.8	14.6
Mercury	Lake Wallula	13.9	5.4	12.2	6.5	4.3	13.4
Mercury	All	10.8	6.7	6.0	6.9	3.1	15.2
Total DDT	Upriver	194.8	16.8	8.7	27.3	18.5	39.1
Total DDT	100 Area	25.4	14.2	19.2	41.5	45.4	23.8
Total DDT	300 Area	32.2	10.8	19.6	29.6	49.0	25.3
Total DDT	Lake Wallula	288.4	15.2	21.0	34.2	187.5	39.2
Total DDT	All	50.6	13.8	15.0	32.3	39.3	30.2
Total PCBs	Upriver	5.6	1.4	0.9	4.5	2.4	0.4
Total PCBs	100 Area	3.4	1.2	1.0	2.7	1.1	1.1
Total PCBs	300 Area	6.2	1	1.2	2.1	3.6	1.4
Total PCBs	Lake Wallula	7.2	1.4	1.4	2.2	10.8	3.1
Total PCBs	All	5.2	1.2	1.1	2.6	2.4	0.9
Dioxin-like PCBs	Upriver	4.8	1.2	0.6	2.8	1.6	0.2
Dioxin-like PCBs	100 Area	2.2	0.8	0.7	2	0.8	1
Dioxin-like PCBs	300 Area	4.6	0.8	0.9	1.8	2.8	1
Dioxin-like PCBs	Lake Wallula	5.4	1.2	1.2	1.8	3	2.2
Dioxin-like PCBs	All	3.8	1	0.8	2	1.6	0.6

Mercury & DDT based on 60 kg BW, dioxin-like PCB concentration based on TEQ

*Skin-off fillets with no adjustment for reduction of organic compounds

Meal size = 8oz.

Calculated Non-Cancer Meal Limits Based on Multiple Chemical Exposures

A summary of meal limits based on individual contaminants and combined neurological health endpoints were developed (Table 15). Individually, mercury, total DDT, and total PCB concentrations result in less restrictive calculated meal limits than when combined effects are taken into consideration. Dioxin-like PCBs meal calculations are also shown for comparison with the individual contaminants as well as the combination of those contaminants that have neurological health endpoints. Total DDT concentrations were the least restrictive of the individual contaminants, followed by mercury, total PCBs and then combined (mercury, DDT, & PCBs) contaminants. Calculated meal limits based on dioxin-like PCBs were the most restrictive.

Table 15. Calculated Combined Contaminant Meal Limits

Species	Location	Individual Calculated Meals per Month				Combined Calculated Meals per Month (mercury, total DDT, & total PCBs)
		Mercury	Total DDT	Total PCBs	Dioxin-like PCBs	
Bass	Upriver	10.3	97.4	2.8	2.4	2.6
	100 Area	9.5	12.7	1.7	1.1	1.7
	300 Area	10.4	16.1	3.1	2.3	2.7
	Lake Wallula	13.9	144.2	3.6	2.7	3.5
	All	10.8	25.3	2.6	1.9	2.5
Carp	Upriver	8.9	8.4	0.7	0.6	0.9
	100 Area	7.3	7.1	0.6	0.4	0.7
	300 Area	6.2	5.4	0.5	0.4	0.6
	Lake Wallula	5.4	7.6	0.7	0.6	0.8
	All	6.7	6.9	0.6	0.5	0.7
Sturgeon	Upriver	16.1	8.7	0.9	0.6	1.3
	100 Area	4.0	19.2	1.0	0.7	1.0
	300 Area	3.7	19.6	1.2	0.9	1.1
	Lake Wallula	12.2	21.0	1.4	1.2	1.5
	All	6.0	15.1	1.1	0.8	1.2
Sucker	Upriver	7.8	13.6	2.3	1.4	2.0
	100 Area	7.2	20.7	1.3	1.0	1.4
	300 Area	6.3	14.8	1.0	0.9	1.1
	Lake Wallula	6.5	17.1	1.1	0.9	1.1
	All	6.9	16.2	1.3	1.0	1.3
Walleye	Upriver	2.6	9.3	1.2	0.8	0.9
	100 Area	2.5	22.7	0.6	0.4	0.6
	300 Area	3.8	24.5	1.8	1.4	1.4
	Lake Wallula	4.3	93.8	5.4	1.5	2.7
	All	3.1	19.7	1.2	0.8	1.0
Whitefish	Upriver	29.8	19.6	0.2	0.1	0.3
	100 Area	11.5	11.9	0.6	0.5	0.7
	300 Area	14.6	12.7	0.7	0.5	0.8
	Lake Wallula	13.4	19.6	1.6	1.1	1.7
	All	15.2	15.1	0.5	0.3	0.6

Similar to the individual contaminant calculated meal limits that are modified to account for reductions in concentrations due to cleaning and cooking techniques, the evaluation of those contaminants that have similar health endpoints (i.e., neurological effects) can also be modified to account for this process as well. Two (total DDT and total PCBs) of the three contaminants are lipophilic and reductions of 50% can be achieved if fish are cleaned and cooked properly (Table 16). The effect of this is that lipophilic contaminant concentrations can be twice as high as the calculated meal limits when considering reductions in concentrations from cleaning and cooking and still remain below a safe dose established for the combination of contaminants. Sturgeon samples were based on skin-off fillets and no reductions in organic compounds are expected in cleaning techniques. Nonorganic contaminants such as mercury that do not partition into fatty tissue do not see the same type of decrease in concentration when fat is removed by cleaning and cooking techniques and no adjustments are made.

Table 16. Calculated Combined Contaminant Meal Limits with Contaminant Reduction

Species	Location	Individual Calculated Meals per Month				Combined Calculated Meals per Month (mercury, total DDT, & total PCBs)
		Mercury	Total DDT	Total PCBs	Dioxin-like PCBs	
Bass	Upriver	10.3	194.8	5.6	4.7	4.2
	100 Area	9.5	25.3	3.4	2.3	2.9
	300 Area	10.4	32.2	6.1	4.5	4.3
	Lake Wallula	13.9	288.4	7.3	5.5	5.6
	All	10.8	50.5	5.2	3.8	4.0
Carp	Upriver	8.9	16.8	1.5	1.3	1.6
	100 Area	7.3	14.2	1.1	0.8	1.2
	300 Area	6.2	10.8	1.1	0.8	1.1
	Lake Wallula	5.4	15.2	1.5	1.1	1.4
	All	6.7	13.8	1.3	1.0	1.3
Sturgeon	Upriver	16.1	17.4	1.8	1.1	1.3
	100 Area	4.0	38.5	2.1	1.5	1.0
	300 Area	3.7	39.2	2.4	1.8	1.1
	Lake Wallula	12.2	41.9	2.7	2.4	1.5
	All	6.0	30.1	2.2	1.6	1.2
Sucker	Upriver	7.8	27.3	4.5	2.9	3.2
	100 Area	7.2	41.5	2.7	2.0	2.3
	300 Area	6.3	29.6	2.1	1.8	1.8
	Lake Wallula	6.5	34.2	2.2	1.7	1.9
	All	6.9	32.3	2.6	2.0	2.2
Walleye	Upriver	2.6	18.5	2.4	1.7	1.4
	100 Area	2.5	45.4	1.1	0.9	0.9
	300 Area	3.8	49.0	3.6	2.8	2.1
	Lake Wallula	4.3	187.5	10.8	2.9	3.3
	All	3.1	39.3	2.4	1.6	1.5
Whitefish	Upriver	29.8	39.1	0.4	0.3	0.5
	100 Area	11.5	23.8	1.1	1.0	1.3
	300 Area	14.6	25.3	1.4	1.0	1.6
	Lake Wallula	13.4	39.2	3.1	2.1	3.0
	All	15.2	30.2	0.9	0.6	1.1

Calculated meal limits for each resident fish species from all Hanford Reach study sites based on either individual or combined COCs were summarized (Table 17). This table reflects a 50% reduction of those lipophilic compounds (total DDT, total PCBs, and total dioxin-like PCBs).

For bass, carp, sturgeon, sucker, and whitefish, total DDT concentrations resulted in the least restrictive calculated meal restrictions followed by mercury, total PCBs, combined neurological effect contaminants, and finally dioxin-like PCBs. Combined contaminants (mercury, total DDT, and total PCBs) walleye resulted in slightly greater restrictions than dioxin-like PCBs.

Table 17. Calculated Meal Limits for COC

Calculated Meal Limits (meals/month)					
Species	**mercury**	**total DDT**	**total PCBs**	**Dioxin-like PCBs**	**Multiple Contaminants (mercury, total DDT, & total PCBs)**
Bass	10.8	50.5	5.2	3.8	4.0
Carp	6.7	13.8	1.3	1.0	1.3
Sturgeon	6.0	30.1	2.2	1.6	1.2
Sucker	6.9	32.3	2.6	2.0	2.2
Walleye	3.1	39.3	2.4	1.6	1.5
Whitefish	15.2	30.2	1.2	0.6	1.1

As part of the fish advisory process, DOH presents meal restrictions in easy to understand categories of zero, one, two, four or eight servings per month. As per EPA fish advisory guidance (EPA 2000b), greater than eight meals per month is considered unrestricted consumption. In order to provide clear, easily understandable advice to the public, calculated meal restrictions are rounded up or down to fit the six categories. The resulting meal recommendations based on mercury, total DDT, total PCBs, dioxin-like PCBs, and the combination of neurological endpoint COCs is presented below (Table 18).

Table 18. DOH Recommended Meal Restrictions for Resident Fish Species

Calculated Meal Limits (meals/month)					
Species	**mercury**	**total DDT**	**total PCBs**	**Dioxin-like PCBs**	**Multiple Contaminants (mercury, total DDT, & total PCBs)**
Bass	Unrestricted	Unrestricted	4	4	4
Carp	8	Unrestricted	1	1	1
Sturgeon	8	Unrestricted	2	2	1
Sucker	8	Unrestricted	2	2	2
Walleye	4	Unrestricted	2	2	2
Whitefish	Unrestricted	Unrestricted	1	1	1

Ultimately the most restrictive meal limits for a given fish species is used to inform the public regarding how much can be safely consumed by the most sensitive population or the general public. Concentrations of either dioxin-like PCBs or the combination of the three COCs having neurological health effects resulted in similar meal restrictions. Setting meal restrictions for either component would then protect against other adverse health endpoints. For this assessment, DOH combined all four locations within the Hanford Reach Study Site to provide species-specific meal recommendations.

Cancer endpoints were also evaluated for contaminants that have been assigned an EPA Integrated Risk Information System (IRIS) cancer slope factor (CSF). Calculated meal limits were conducted across a range of cancer risks from one in one million to one in ten thousand. DOH generally does not base meal limits based on potential cancer endpoints because there are more robust toxicological underpinnings to protect sensitive subpopulations based on non-cancer health effects. Cancer risk assessment has limitations for seafood consumption advisories due to competing, evidence-based benefits, the likely over-estimation of risks, and counter-productive risk perception issues. Use of non-cancer endpoints for setting seafood advisories is in concordance with EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume III (EPA 2000a) that emphasizes flexibility in risk management. Furthermore, the combined neurological health endpoint evaluation also protects resident fish consumers within a range of one and a million to one-in ten thousand cancer risk used by EPA in evaluating contaminated sites (EPA 1989).

Chemical Specific Toxicity

Background information about contaminants of concern, including those contaminants that were significant in this health assessment, is summarized below.

Dichlorodiphenyltrichloroethane (DDT)

DDT is a pesticide that was once used to control insects on agricultural crops. It was also used to control insects that carry diseases like malaria and typhus, but it is now used in only a few countries to control malaria (ATSDR 2002). Technical grade DDT is a mixture of three forms, p,p'-DDT, o,p'-DDT, and o,o'-DDT. All of these are white, crystalline, tasteless, and almost odorless solids. DDT may also contain p,p'-Dichlorodiphenyldichloroethylene (DDE) and p,p'-Dichlorodiphenyldichloroethane (DDD) as contaminants. DDD was used to a lesser extent than DDT to kill pests, and one form of DDD was used medically to treat cancer of the adrenal gland. DDE and DDD are breakdown products of DDT.

DDT does not occur naturally in the environment. The use of DDT was no longer permitted in the United States after 1972 except in the case of a public health emergency. Most DDT in the environment is a result of past use, but current use in other countries is still introducing DDT into the environment. DDE is only found in the environment as a result of contamination or breakdown of DDT. DDD also enters the environment during the breakdown of DDT.

DDT enters the atmosphere when it evaporates from contaminated water and soil and is then deposited on land or surface water. This cycle may be repeated many times, with the result that DDT, DDE, and DDD are carried long distances in the atmosphere, including Arctic and Antarctic regions.

DDT, DDE, and DDD persist in the soil for decades, depending on many factors such as temperature, type of soil, and whether the soil is wet. DDT binds to particles in surface water, settles, and is then deposited in the sediment. It can accumulate to high levels in fish and marine mammals, with the highest levels found in adipose tissue. DDT in soil can also be absorbed by some plants and by animals or people who eat those crops.

Since the ban on DDT in the United States and other parts of the world, environmental concentrations of DDT and metabolites have decreased. Average adult intakes of DDT have fallen over the years, as levels in food items have decreased. However, there are still measurable quantities of DDT, DDE, and DDD in many food groups. Mean concentrations of DDT in fish as measured by FDA between 1991 and 1999 range from 0.2-9.2 ppb (ATSDR 2002)**.** People who eat fish caught in the Great Lakes consume larger amounts of DDT in their diets than average; however, as levels of DDT in the environment decline this exposure route is also expected to decline. At this time, low levels of DDT, DDE, and DDD are expected to be present in food for several more decades (ATSDR 2002).

DDT and its metabolites accumulate in adipose tissue. Indigenous peoples of the arctic are considered at risk to DDT exposure since their diets are particularly high in fatty tissues from marine mammals. Another route of potential exposure of DDT to children is through breast-feeding.

Most information on health effects in humans comes from studies of workers in plants that manufacture DDT or applicators who spray DDT over an extended period (ATSDR 2002). DDT impairs nerve impulse conduction. Observed effects vary from mild altered sensations to tremors and convulsions. DDT is also capable of inducing alterations on reproduction and development in animals, an effect attributed to the alteration of hormones. The o,p’-DDT isomer has the strongest estrogen-like properties. The p,p’-DDE isomer has anti-androgenic properties and can alter development of reproductive organs in rats (ATSDR 2002). An RfD of 5.4 X 10 –4 mg/kg/d was established based on liver effects in rats.

Animal studies have shown that DDT, DDE, and DDD can cause cancer in the liver. There is no conclusive evidence to link DDT to cancer in humans, although possible genotoxic effects have been reported. EPA assigned DDT, DDE, and DDD a weight-of-evidence classification of B2, probable human carcinogens (IRIS). An oral slope factor of 0.34 $(mg/kg\text{-}day)^{-1}$was derived for DDT. The International Agency for Research on Cancer (IARC) assigned a weight-of-evidence classification of B2 to DDT, possibly carcinogenic to humans (IARC 2002).

Mercury

Mercury is widespread in the environment as a result of natural and anthropogenic releases. Everyone is exposed to small amounts of mercury (Clarkson 1993, and Clarkson 1997, in Goldman and Shannon, 2001). Most mercury in the atmosphere is elemental mercury vapor and inorganic mercury, and mercury in water, soil, plants, and animals is in organic or inorganic forms. Organic mercury is primarily in the form of methylmercury.

Mercury is released into surface waters from natural weathering of rocks and soils from volcanic activity. Mercury is also released from human action such as industrial activities, fossil fuel burning, and disposal of consumer products. Global cycling of mercury via air deposition occurs when mercury evaporates from soils and surface waters to the atmosphere. From the atmosphere, mercury is redistributed on land and surface water then absorbed by soil or sediments. Once inorganic mercury is released into the environment, bacteria convert it into organic mercury, the primary form that accumulates in fish and shellfish (ATSDR 1999).

In the aquatic food chain, methylmercury biomagnifies as it is passed from lower to higher trophic levels through consumption of prey organisms. Fish at the top of the food chain can biomagnify methylmercury approximately 1 to 10 million times greater than concentrations found in the surrounding waters. Nearly all of the mercury found in fish is in the methylmercury form. Predatory ocean fish that live for a long time may have increased methylmercury content because of exposure to natural and industrial sources of mercury (Goldman and Shannon 2001). Methylmercury content of fish varies by species and size of the fish as well as harvest location. The top ten commercial fish species represent about 85% of the seafood market and contain a mean mercury level of approximately 0.1 µg/g.

Some states have issued advisories about consumption of fish containing mercury. DOH issued a statewide fish consumption advisory for women of childbearing age and young children based on elevated levels of mercury in various commercially bought fish as well as freshwater bass caught for recreation (DOH 2003).

Most organic mercury compounds are readily absorbed by ingestion and appear in the lipid fraction of blood and brain tissue. Organic mercury readily crosses the blood-brain barrier and also crosses the placenta. Fetal blood mercury levels are equal to or higher than maternal levels (Goldman and Shannon 2001). Methylmercury also appears in human milk. Organic mercury compounds are most toxic in the central nervous system and may also affect the kidneys and immune system (Clarkson 1993, and Clarkson 1997, in Goldman and Shannon, 2001).

Methylmercury is toxic to the cerebral and cerebellar cortex in the developing brain and is a known teratogen. In Minimata Bay, Japan, mothers who were exposed to high amounts of mercury but were asymptomatic gave birth to severely affected infants. The infants often appeared normal at birth but developed psychomotor retardation, blindness, deafness, and seizures over time. Since the fetus is susceptible to neurotoxic effects of methylmercury, several studies have focused on subclinical effects among children whose mothers were exposed to high levels of methylmercury. A study in Iraqi children exposed to high levels of methylmercury in contaminated seeds demonstrated motor retardation in children whose mothers had hair mercury levels ranging from 10-20 ppm. Two prospective epidemiologic studies were conducted in the Seychelles and the Faroe Islands. Results from the Faroe Islands suggest that exposure in utero to mercury at lower levels is associated with subtle adverse effects on the developing brain (maximum level in hair was 39.1 ppm and in blood was 351 ppb). Memory, attention, and language tests were inversely associated with higher methylmercury exposures in children up to 7 years of age (Grandjean et al. 1997, Goldman and Shannon 2001). In the Seychelles study, adverse effects on development or IQ have not been found up to 66 months of age. The Faroe Islands and Seychelles studies are continuing, in order to provide a long-term developmental evaluation of exposed children. Further support for the developmental effects seen in Faroese children is demonstrated in a study of New Zealand children exposed *in utero* to methylmercury consumed in fish by their mothers.

In 1998, the National Academy of Sciences (NAS) was directed by the United States Congress to evaluate methylmercury toxicity and provide recommendations on exposure limits (NRC 2000). The study established a reference dose for mercury of 0.1 µg/kg-day. The EPA has recently re-confirmed 0.1 µg/kg-day as its Reference Dose (RfD) (IRIS). This RfD is based on health effects data specific to the protection of the developing fetus. As the developing fetus represents the population of greatest concern, the RfD is considered protective of all other populations that are less exposed and/or less sensitive. The current action level of FDA for mercury in fish tissue is 1 ppm (1000 ppb).

Polychlorinated Biphenyls (PCBs)

PCBs are persistent environmental contaminants that are ubiquitous in the global environment due to intensive industrial use. PCBs were used as commercial mixtures (Aroclors) that contain up to 209 different chlorinated biphenyl congeners, which are structurally similar compounds that vary in toxicity. Each congener has a biphenyl ring structure but differs in the number and arrangement of chlorine atoms substituted around the biphenyl ring. PCBs are lipid soluble and are stable; their stability depends on the number of chlorine atoms and the position of the chlorine atoms on the biphenyl molecule. Their lipophilic character and resistance to metabolism enhances concentration in the food web and exposure to humans and wildlife.

PCBs were produced commercially in the United States from the 1930's to 1977 and sold primarily as mixtures under the trade name Aroclor. The name Aroclor 1254, for example, means that the molecule contains 12 carbon atoms (the first 2 digits) and approximately 54% chlorine by weight (second 2 digits) (ATSDR 2000). Each mixture (1016, 1242, 1254, and 1260) contained many different PCB congeners. In 1971, the sole producer of PCBs in the United States, Monsanto Chemical Company, voluntarily stopped open-ended uses of PCBs and in 1977 ceased their production. Because PCBs do not burn easily and are good insulators, they were commonly used as lubricants and coolants in capacitors, transformers, and other electrical equipment. Old capacitors and transformers that contain PCBs are still in operation. Over the years, PCBs have been spilled, illegally disposed, and leaked into the environment from transformers and other electrical equipment. PCBs in the environment have decreased since the 1970's but are still detectable in our air, water, soil, food, and in our own bodies.

The breakdown of PCBs in water and soil occurs over many years. The lower chlorinated PCBs are more easily broken down in the environment, while adsorption of PCBs generally increases as chlorination of the compound increases. The highly chlorinated Aroclors (1248, 1254, and 1260) resist both chemical and biological degradation in the environment. Microbial degradation of highly chlorinated Aroclors to lower chlorinated biphenyls has been reported under anaerobic conditions, as has the mineralization of biphenyl and lower chlorinated biphenyls by aerobic microorganisms. Although they are slow processes, volatilization and biodegradation are the major pathways of removal of PCBs from water and soil (ATSDR 2000). In water, photolysis appears to be the only viable chemical degradation process. The chemical composition of the original Aroclor mixtures released to the environment changes over time since the individual congeners degrade and partition at different rates (ATSDR 2000).

Many PCB congeners persist in ambient air, water, marine sediments, and soil at low levels throughout the world. The half-life of PCBs (the time it takes for one-half of the PCBs to breakdown) in the air is 10 days or more, depending on the type of PCB. PCBs in the air can be carried long distances and may be deposited onto land or water. Once in water, most PCBs tend to stick to organic particles and sediments.

In the Columbia River and other waterbodies, PCBs in sediments are taken up in the bodies of aquatic organisms, which are in turn consumed by creatures higher in the food web. Fish, birds, and mammals tend to accumulate certain congeners over time in their fatty tissue. Concentrations of PCBs can reach levels thousands of times higher than the levels in water. Bioconcentration is the uptake of a chemical from water alone, while bioaccumulation is the result of combined uptake via food, sediment, and water. These processes can lead to high levels in the fat of predatory animals (ATSDR 2000). Also, PCBs can biomagnify in fresh and saltwater ecosystems. Humans may be exposed to PCBs when they eat fish, use fish oils in cooking, or consume meat, milk or cheese.

The general population is exposed to PCBs through inhalation and ingestion of contaminated water and food. The dominant source of PCBs to humans is through consumption of seafood, meat, and poultry. Of particular concern is exposure through consumption of fish. Some groups may consume greater amounts of fish than others; for example, Native Americans, Asian immigrant populations and sport anglers are three groups with high rates of seafood ingestion in Washington State (Landolt et al. 1985, Landolt et al. 1987, CRITFC 1994, Toy et al. 1996, EPA 1999, Suquamish 2000).

Toxic responses to PCBs include dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development, and endocrine functions. Some epidemiological studies indicate that consumption of fish containing PCBs may cause slight but measurable impairments in physical growth and learning behavior in children. Some PCB congeners have a structure and biological activity that is similar to dioxin. EPA has determined that PCBs are probable human carcinogens and assigned them the cancer weight-of evidence classification B2 based on animal studies. Human studies are being updated; current available evidence is inadequate, but suggestive regarding cancer to humans. The upper-bound cancer slope factor for PCBs is 2.0 per (mg/kg)/day.

Part of the uncertainty in assessing PCB effects from consuming fish is that PCB congeners selectively bioaccumulate in fish in different patterns than found in commercial mixtures of PCBs (Schwartz et al 1987). The congener mix that a fetus would encounter during pregnancy and via nursing may be quite different than congener patterns initially released into the environment. Since PCB congeners differ in their potency and in the specific ways they interact with biological systems, health criteria based on data from Aroclor mixtures fed to animals (e.g., the EPA RfD) may not account for the effects of biodegradation that result in differing initial and final congener patterns.

DOH recently conducted a thorough review of recent scientific literature in an attempt to set a state standard for exposure to PCBs through consumption of fish and shellfish. DOH concluded that ATSDR’s minimal risk level (MRL) of 0.03 µg/kg-day for chronic-duration oral exposure to

PCBs would be protective of the most sensitive population (fetus) for the most sensitive endpoints reviewed (immune and developmental). The chronic oral MRL is based on a lowest-observed adverse effect level (LOAEL) of 0.005 mg/kg-day for immunological effects seen in adult monkeys exposed to Aroclor 1254 (ATSDR 2000). EPA verified an oral reference dose (RfD) of 0.02 µg/kg-day for Aroclor 1254 (IRIS), based on dermal/ocular and immunological effects in monkeys. For comparison, FDA set residue levels in fish and edible shellfish as 2 mg/kg.

Cancer Risk Evaluation

DOH generally does not base meal limits based on potential cancer endpoints because there are more robust toxicological underpinnings to protect sensitive subpopulations based on non-cancer health effects (Stone and Hope, 2010). Cancer risk assessment has limitations for seafood consumption advisories due to competing, evidence-based benefits, the likely over-estimation of risks, and counter-productive risk perception issues. Use of non-cancer endpoints for setting seafood advisories is in concordance with EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume III (EPA 2000a) that emphasizes flexibility in risk management. Furthermore, the combined neurological health endpoint evaluation also protects resident fish consumers within a range of one and a million to one-in ten thousand cancer risk used by EPA in evaluating contaminated sites (EPA 1989).

Cancer endpoints were evaluated for contaminants that have been assigned an EPA Integrated Risk Information System (IRIS) cancer slope factor (CSF). Calculated meal limits were determined across a range of cancer risks from one in one million to one in ten thousand. With few exceptions, DOH generally does not base meal limits on potential cancer risks. Some contaminants may have both cancer and non-cancer health criteria as reported in EPA's IRIS database (i.e. an RfD and a CSF). For contaminants such as PCBs that have an RfD and CSF, DOH relies on the more robust toxicological findings coming from the non-cancer studies to protect sensitive subpopulations. Using the non-cancer health endpoint and associated dose (RfD), cancer risks may also be calculated to determine whether risks fall within an acceptable range. The following equation illustrates the cancer risk:

$$Cancer\ Risk = dose\ \times CSF$$

Where:

$$dose = \frac{mg}{kg - day}$$

$$CSF = \left(\frac{mg}{kg - day}\right)^{-1}$$

In the case of PCBs, the calculate cancer risk at a dose equivalent to the RfD is four in one hundred thousand (4.0 x 10-5), which is still within EPA's acceptable risk level.

$$Cancer\ Risk = 2.0\ \times 10^{-5} \times 2.0$$

Where:

$$dose\ (RfD\ for\ PCBs =\ 2x10^{-5}\frac{mg}{kg - day}$$

$$CSF\ for\ PCBs =\ 2\left(\frac{mg}{kg - day}\right)^{-1}$$

The exceptions are for those contaminants for which there is only a CSF or the calculated cancer risk based on a contaminant specific RfD is greater than that deemed acceptable by EPA (i.e. cancer risk greater than one in ten thousand. In those cases, meal limits may be based on cancer endpoints.

Further, cancer risk assessment has limitations for seafood consumption advisories due to competing, evidence-based benefits, the likely over-estimation of risks, and counter-productive risk perception issues (Stone and Hope, 2010). Use of non-cancer endpoints for setting seafood advisories is in concordance with EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume III (2000), which emphasizes flexibility in risk management. Nonetheless, the combined neurological health endpoint evaluation indicates that consumers of resident fish species from the Hanford Reach of the Columbia River are protected within the one and a million to one-in-ten thousand cancer risk range used by EPA to evaluate contaminated sites.

Uncertainty

Methodology used in this report involves many uncertainties. Uncertainty with regard to the risk assessment process refers to the lack of knowledge about factors such as chemical toxicity, human variability, human behavior patterns, and chemical concentrations in the environment. Uncertainty can only be reduced through further study.

The majority of uncertainty comes from our knowledge of chemical toxicity. For most chemicals, there is little knowledge of the actual health impacts that can occur in humans from environmental exposures. In the absence of epidemiological or clinical evidence, risk assessors must rely on toxicological experiments performed on animals. These animals are exposed to chemicals at much higher levels than are found in the environment. The critical doses in animal studies are often extrapolated to "real world" exposures for use in human health risk assessments. In order to be protective of human health, uncertainty factors are used to lower that dose in consideration of variability in sensitivity between animals and humans, and the variability within humans. These uncertainty factors can account for a difference of two to three orders of magnitude in the calculation of risk. For this reason, it is important to note that the risk assessment methodology is only a partial guide as to how Health establishes seafood consumption guidance or advisories in the state.

Discussion

Calculated meal limits

Contaminant concentrations, as measured in fillet tissue of resident fish from the Hanford Reach Study Site, were screened by calculating potential meal limits based on concentrations observed in samples from various locations in the river. Concentrations were also averaged across the study site. Contaminants whose concentrations resulted in meal limits more restrictive than eight meals per month were evaluated further for potential human health impacts and for more specific meal recommendations.

DOH's meal recommendations for the Hanford Reach Study Site portion of the Columbia River are summarized (Table 19). Meal recommendations are based on the contaminant concentration of either dioxin-like PCBs or the combination of mercury, total DDT, and total PCBs, analyses for resident fish fillet tissue.

Table 19. Summary of Meal Recommendations for Resident Fish Species from the Hanford Reach Study Site, Columbia River

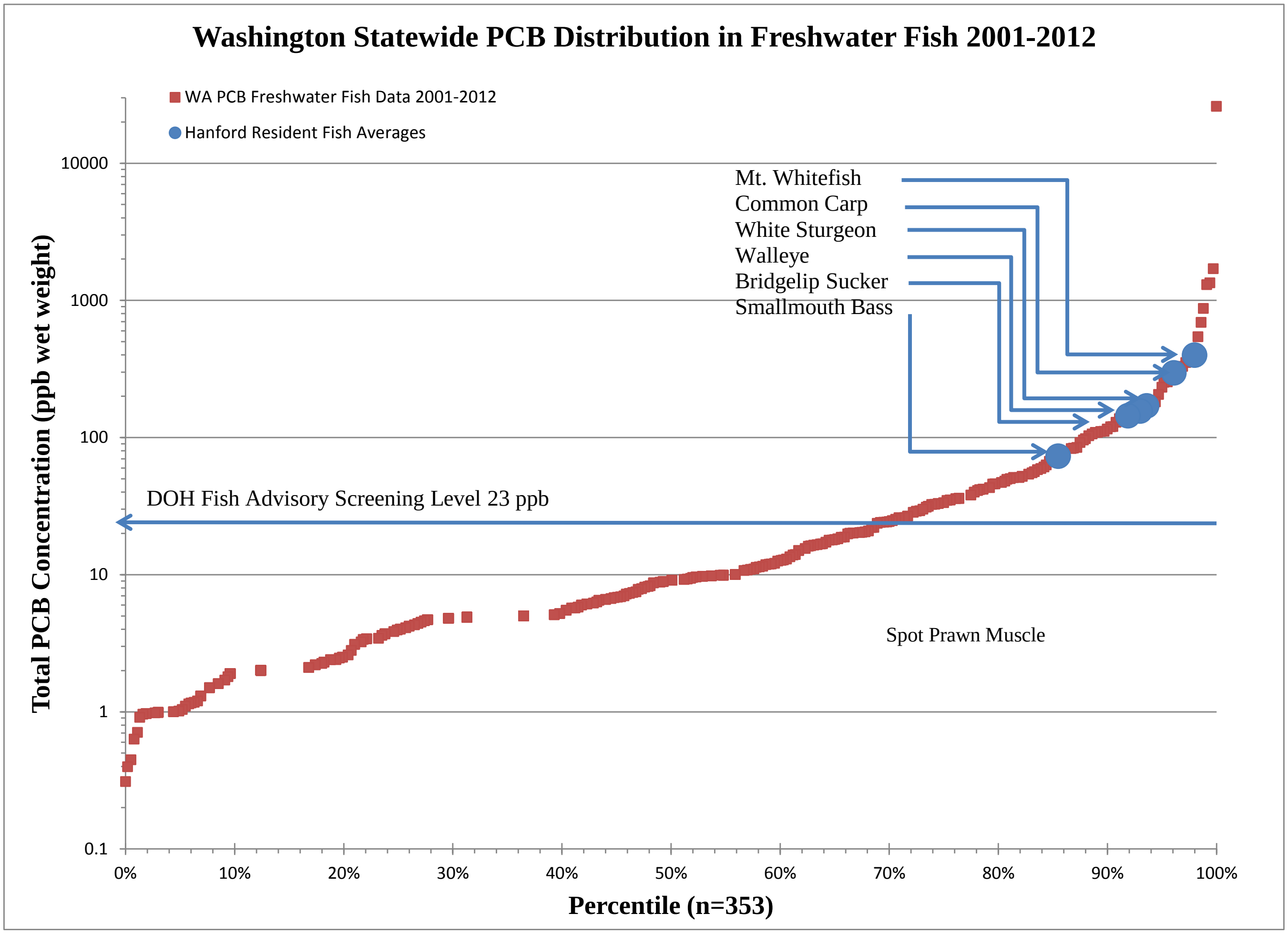
Species	Recommended Meal Restrictions (Meals per Month)
Smallmouth Bass	4
Common Carp	1
White Sturgeon	1
Bridgelip Sucker	2
Walleye	2
Mountain Whitefish	1
meal size = 8 oz.	

Comparison of PCBs in Hanford Reach Resident Fish with PCBs in Freshwater Fish Species from other Areas of Washington State

PCBs can be highly concentrated in the fish of waters contaminated with even low levels of PCBs. The Ecology routinely conducts fish tissue monitoring as part of its Washington State Toxics Monitoring Program (WSTMP) and thousands of fish have been sampled from hundreds of sites across Washington State.

The distribution of total PCB tissue concentrations from fish collected across Washington State from several sources is present (Figure 6). Results of fillet tissue PCB concentrations from resident fish species collected from the Hanford Reach Study Site are also depicted. All resident fish species within the Hanford Reach Study Site are above the 70th percentile distribution concentration. Total PCB concentrations in whitefish are greater than the 97th percentile distribution concentrations with many of the other fish species assessed in this report around the 90th percentile.

Figure 6. Statewide PCB Distribution in Freshwater Fish Species



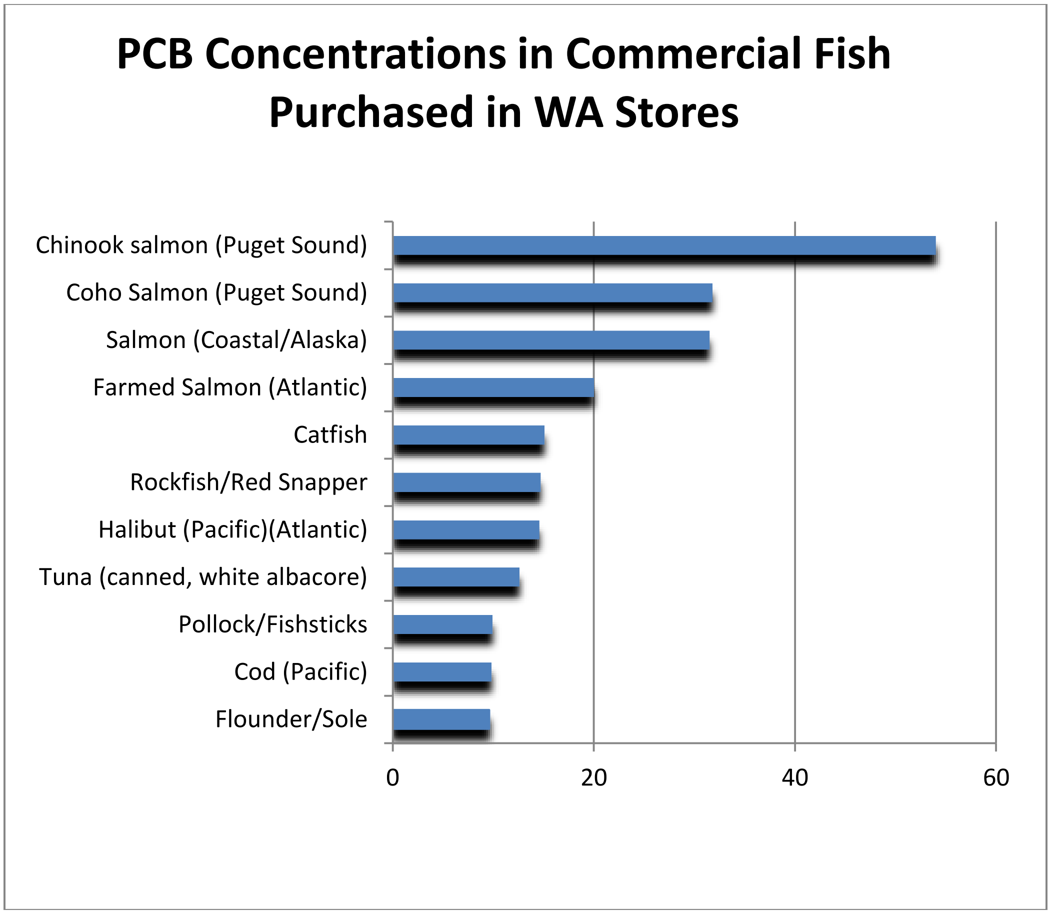
Washington Statewide PCB Distribution in Freshwater Fish Fillets 2001-2012. Data sources: 2001-2010 total PCB fish tissue concentrations extracted from Ecology's EIM database (Ecology 2012), EPA's Upper Columbia River site investigation as reported by DOH (DOH 2012), U.S Department of Energy's 2012 assessment of contaminant data in the Mid-Columbia River, and fish tissue data provided to DOH by the U.S. Army Corps of Engineers near Bradford Island and the Bonneville Dam on the Columbia River (unpublished data).

The data set displayed above includes 353 total PCB values that range from non-detects to greater than 26,000 ppb, with a median of 8.7 ppb. The maximum detection is from a single bass collected near the Bonneville Dam in the Columbia River. Fish from the Hanford Reach Site of the Columbia River appear to contain relatively high concentrations compared to fish from other areas of the state.

PCBs in Commercially Available Fish in Washington State

Limited data on PCBs in commercially available fish are also available for Washington State. The primary source of this data is a DOH study (2005) of contaminants in canned tuna and other frequently consumed store bought fish purchased in Washington state grocery stores (McBride *et al*. 2005). In this study, PCBs (based on Aroclors concentrations) were detected in store-bought halibut, red snapper, and salmon in at least 10% of the samples collected. Salmon had the highest average PCB concentrations (31.5 ppb PCBs, total Aroclors). Additional data from the Washington State Department of Fish and Wildlife on PCB levels in Puget Sound Chinook and Coho salmon were also included for this assessment (WDOH 2006). PCB concentrations in store bought and Puget Sound commercially available fish were compared (Figure 7). Of all fish species, PCB concentrations were highest in Chinook salmon collected in Puget Sound. PCB levels in Chinook salmon returning to Puget Sound waters typically have higher concentrations than coastal salmon or Alaskan Chinook. The higher concentration in Puget Sound Chinook and resident blackmouth are believed to be due to length of residence time in areas of Puget Sound that result in greater fish tissue PCB loads. DOH recommends that women of childbearing age and young children should eat no more than one meal per week of Puget Sound Chinook salmon. Most fish species collected from grocery stores were below DOH's general screening level of 23 ppb, compared to higher levels in the fish species from the Hanford Reach Site of the Columbia.

Figure 7. Mean PCB concentrations (total Aroclors) in Fish Collected from Markets and Grocery Stores in Washington State and from Puget Sound. Data Source: McBride et al. 2005.



Comparison of PCBs in Mid-Columbia River Fish with Other Foods

PCBs in food and in particular seafood is the most significant source of exposure for most people. Recent studies on fish indicate concentrations of PCBs can be in the 10 to 100 parts per million in fish (especially freshwater fish). High levels are typically found in top predator fish, in bottom-feeding fish such as carp and largescale suckers, and in fish living near known sources of PCB contamination. Meat and dairy products are generally much lower in PCBs with concentrations in the low parts per billion (see Table 20). A recent analysis of 2001-2004 NHANES data looked at food consumption patterns in a general U.S. population relative to 30 PCB congeners measured in their serum (Xue *et al.* 2014). The study found a strong correlation between serum PCB and reported fish consumption but no measurable correlation with consumption of meat or milk.

Other Dietary Sources of PCBs

Humans may be exposed to small but detectable quantities of PCBs in meat, dairy products, and other foods. PCB concentrations in these products vary widely depending on where they are grown and how they are processed or cooked. Sampling for PCB concentrations in FDA's Market Basket studies between 1991 and 2003 showed PCB levels are far below FDA limits in a variety of prepared dishes.

The Total Diet Study (TDS), sometimes called the market basket study, is an ongoing FDA program that determines levels of various contaminants and nutrients in foods. http://www.fda.gov/downloads/Food/FoodScienceResearch/TotalDietStudy/UCM184304.pdf. A unique aspect of the TDS is that foods are prepared as they would be consumed (table-ready) prior to analysis, so analytical results provide the basis for realistic estimates of the dietary intake of these analytes. TDS Market Basket surveys are generally conducted four times each year, once in each of four geographic regions of the country. Food samples are purchased from supermarkets, grocery stores, and fast food restaurants in three cities in the region and are shipped to a central laboratory. Foods are then prepared table-ready and the three samples are combined to form a single analytical composite for each food. For each survey, samples of food are collected over a 5-week period and are based on average sample sizes of 40. The state of origin of sampled food is not reported. Data on PCBs in 26 separate food items collected from 1991 through 2004 are summarized (Table 20). Total PCB concentrations are expressed as Aroclor equivalents, rather than as the sum of congener-specific measurements. Mean PCB concentrations ranged from 0.09 ppb for chicken potpie to 24.4 ppb for salmon.

PCB concentrations in foods from the market basket survey are much lower than previously reported by the Puget Sound Action Team in 2007 and cited by Ecology's Toxics Cleanup Program (Ecology 2012). PCB levels in foods reported by the Puget Sound Action Team were based on very small sample sizes of one or two. FDA data presented in Table 20 are based on average samples sizes of 40 resulting in more robust, representative PCB levels.

Table 20. PCB Analytical Results of Food from the FDA's Total Diet Study

Food Description	Sample Size	Results		
		Concentration (ppb)		Detection Frequency %
		Mean	Maximum	
Chicken potpie, frozen, heated	44	0.09	4	2.3
Candy, caramels	40	0.15	6	2.5
Beef roast, chuck, oven-roasted	44	0.23	10	2.3
Pork roast, loin, oven-roasted	44	0.23	10	2.3
Lamb chop, pan-cooked w/ oil	44	0.23	10	2.3
Chicken, drumsticks and breasts, breaded and fried, homemade	40	0.23	9	2.5
Corn/hominy grits, enriched, cooked	44	0.23	10	2.3
Cornbread, homemade	44	0.23	10	2.3
Biscuits, refrigerated-type, baked	44	0.23	10	2.3
Raisins	44	0.23	10	2.3
English muffin, plain, toasted	44	0.23	10	2.3
Veal cutlet, pan-cooked	40	0.25	10	2.5
Crackers, butter-type	44	0.25	11	2.3
Pork chop, pan-cooked w/ oil	44	0.45	20	2.3
Meatloaf, beef, homemade	44	0.45	20	2.3
Beef (loin/sirloin) steak, pan cooked with added fat	40	0.5	20	2.5
Pancakes made from mix with addition of egg, milk, and oil	40	0.5	20	2.5
Baby food, vegetables and chicken	44	0.68	30	2.3
Brown gravy, homemade	40	0.75	30	2.5
Tuna, canned in oil, drained	40	1.0	40	2.5
Eggs, fried with added fat	40	1.23	39	5.0
Chicken breast, oven-roasted (skin removed)	44	1.36	30	4.5
Popcorn, popped in oil	40	1.7	30	10.0
Butter, regular (salted)	44	3.18	120	4.5
Catfish, pan-cooked w/ oil	4	4.25	17	25.0
Salmon, steaks/fillets, baked	24	24.38	55	91.7

Data available on the internet at: http://www.cfsan.fda.gov/~comm/tds-res.html.

Benefits of Fish Consumption

The primary health benefits of eating fish are well documented for children and adults. Dietary fish is associated with reduction of cardiovascular disease (Yuan *et al*. 2001, Rodriguez *et al*. 1996, Hu *et al*. 2002, Marckmann and Gronbaek 1999, Mozaffarian *et al*. 2003, Simon *et al*. 1995, Burr *et al*. 1989, 1994, Singh *et al*.1997, and Harrison and Abhyankar 2005) and a positive pregnancy outcome (Jorgensen *et al*. 2001, Olsen *et al*. 1992, Olsen *et al*. 1995, Olsen and Secher 2002, Carlson *et al*. 1993, 1996, Fadella *et al*. 1996, San Giovanni *et al*. 2000, and Helland *et al*. 2003). Limited data also show a link between fish consumption and a decrease in development of some cancers (SACN 2004, IOM 2007). Additionally, eating fish has been associated with impacts on brain function, including protection against cognitive decline (SACN 2004, IOM 2007).

At present, we know that fish is an excellent protein source that is low in saturated fats, rich in vitamin D, omega-3 fatty acids, and other vitamins and minerals. The health benefits of eating fish are associated with low levels of saturated versus unsaturated fats. Saturated fats are linked with increased cholesterol levels and risk of heart disease while unsaturated fats (e.g., omega-3 polyunsaturated fatty acid) are an essential nutrient. Replacing fish in the diet with other sources of protein may reduce exposure to contaminants but could also result in increased risk for certain diseases (Pan *et al*. 2012). For example, replacing fish with red meat could increase the risk of cardiovascular disease due to the fact that red meat has higher levels of saturated fat and cholesterol (Law 2000).

DOH fish advisories are intended to be protective of human health while acknowledging the benefits of eating fish. This is done by recommending decreased consumption of fish known to have high concentrations of contaminants in favor of fish that are lower in contaminants. DOH supports the American Heart Association (AHA 2015) and the U.S. Food and Drug Administration recommendation of consuming at least two servings (12 oz.) of fish per week as part of a healthy diet.

DOH benefits of eating fish deserve particular consideration when dealing with groups that consume fish for subsistence. Removal of fish from the diet of subsistence consumers may have serious health, social, cultural, and economic consequences. In order to decrease potential risks of fish consumption, these populations are encouraged to consume a variety of fish species, to fish from locations with low contamination, and to follow recommended preparation and cooking methods.

Conclusions

Resident fish species within the Hanford Reach study area of the Columbia River have accumulated toxic contaminants that are reflective of the contaminants present in their surrounding environment. Resident fish species are able to accumulate metals and contaminants through their food or by absorbing them directly from their surrounding environment. While certain fish species accumulate these contaminants to greater extent than others, all resident fish species are affected.

In particular, mercury and PCB concentrations are elevated in resident fish species from the Hanford Reach study area and warrant public health intervention. Elevated mercury levels are seen in common carp, white sturgeon, bridgelip suckers, and walleye. However, mercury concentrations in smallmouth bass were lower than smallmouth bass statewide (DOH Statewide Mercury Advisory). Elevated PCBs (total PCBs or dioxin-like PCBs) are seen in all resident fish species with highest concentrations seen in white sturgeon and mountain whitefish.

Risk communication outreach efforts will focus on consumption advice for all resident fish species in the Hanford Reach study site to the general public due to PCBs. The second focus will be on guidance for women of childbearing age and young children to reduce how much resident fish species they eat. This is due to the combination of contaminants in the fish that may adversely impact fetal, neonatal, and childhood development.

Summary

- Contaminant concentrations in resident fish species muscle tissue from the Hanford Reach study site were screened, and then meal limits were calculated based on sample concentrations. Contaminants with concentrations resulting in meal limits more restrictive than eight meals per month were evaluated further for potential human health impacts and for consumption advice.

- Based on mercury and PCB analyses in resident fish species in the entire Hanford Reach study location of the Columbia River, DOH advises the following consumption restrictions:
    - Smallmouth bass no more than four meals per month
    - Common carp no more than one meal per month
    - White sturgeon no more than one meals per month
    - Bridgelip sucker no more than two meals per month
    - Walleye no more than two meals per month
    - Mountain whitefish on more than one meal per month

- DOH encourages the public and in particular women of childbearing to consume fish to gain the known health benefits of seafood consumption. However, fish consumed should be species low in contaminants.

Appendix A

Appendix A, Table 1. DOH Screening Values for the Hanford Reach of the Columbia River							
ANALYTE	**CASRN**	**RfD (mg/kg-day)**	**CSF $(mg/kg\text{-}day)^{-1}$**	**Screening Level based on 59.7 g/day (ppm)**	**Screening Level based on 175 g/day (ppm)**	**Reference**	**Critical Effect**
Metal/oids							
Antimony	7440-36-0	0.0004		0.469	0.160	IRIS 1991	Longevity, blood glucose, cholesterol
Arsenic (inorganic)	7440-38-2	0.0003		0.352	0.120	IRIS 1993	Hyperpigmentation, keratosis, vascular complications
Arsenic (inorganic)	7440-38-2	-	5.7	0.0002	0.00007	IRIS 1998	Cancer $1x10^{-6}$ note: CSF under review
Barium	7440-39-3	0.2		234.5	80.0	IRIS 2005	Nephropathy
Beryllium	7440-41-7	0.002		2.35	0.800	IRIS 1998	Small intestine lesions
Boron	7440-42-8	0.2		234.5	80.0	IRIS 2004	Decrease fetal weight (developmental)
Cadmium	7440-43-9	0.001		1.173	0.400	IRIS 1994	Proteinuria - RfD for food, Water RfD 0.0005
Chromium (VI)	7440-47-3	0.003		3.52	1.20	IRIS 1998	none reported
Chromium (III)	7440-47-3	1.5		1758.8	600.0	IRIS 1998	none reported
Lead*	7439-92-1	<10 ug/dl		<10 ug/dl	<10 ug/dl	CDC 1991	neurotoxicity
Manganese	7439-96-5	0.14		164.2	56.00	IRIS 1996	CNS effects
Mercury	7439-97-6	0.0001		0.101	0.034	IRIS 2001	Developmental neuropsychological impairment
Molybdenum	7439-98-7	0.005		5.86	2.0	IRIS 1993/98	Increase uric acid levels
Nickel	7440-02-0	0.02		23.5	8.0	IRIS 1996	Decreased body weights
Selenium	7782-49-2	0.005		5.86	2.0	IRIS 1991	Clinical selenosis
Silver	7440-22-4	0.005		5.86	2.0	IRIS 1996	Argyria
Strontium	7440-24-6	0.6		703.5	240.0	IRIS 1996	Rachitic bone
Zinc	7440-66-6	0.3		351.8	120.0	IRIS 2005	Decrease in erthyrocyte Cu, Zn-superoxide dismutase activity
PAHs							
1,1'-Biphenyl	92-52-4	0.05		58.6	20.0	IRIS 1989	Kidney damage
2-Methylnaphthalene	91-57-6	0.004		4.69	1.6	IRIS 2003	Pulmonary alveolar proteinosis
Acenaphthene	83-32-9	0.06		70.4	24.0	IRIS 1994	Hepatotoxicity
Anthracene	120-12-7	0.3		351.8	120.0	IRIS 1993	Cellular necrosis
Benzo[a]anthracene	56-55-3	NA	0.73	0.0016	0.0005	IRIS 1994	Cancer $1x10^{-6}$
Benzo[b]fluoranthene	205-99-2	NA	0.73	0.0016	0.0005	IRIS 1994	Cancer $1x10^{-6}$
Benzo[k]fluoranthene	207-08-9	NA	0.073	0.0161	0.0055	IRIS 1994	Cancer $1x10^{-6}$
Benzo[a]pyrene	50-32-8	NA	7.3	0.0002	0.0001	IRIS 1994	Cancer $1x10^{-6}$
Chrysene	21-80-19	NA	0.0073	0.1606	0.0548	IRIS 1994	Cancer $1x10^{-6}$
Dibenzo[a,h]anthene	53-70-3	NA	7.3	0.0002	0.0001	IRIS 1994	Cancer $1x10^{-6}$
Fluoranthene	206-44-0	0.04		46.9	16.0	IRIS 1993	Nephroppathy, increase liver weights, hematological alterations
Fluorene	86-73-7	0.04		46.9	16.0	IRIS 1990	Decreased RBC, packed cell volume and hemoglobin
Indeno[1,2,3-cd]pyrene	193-39-5	NA	0.73	0.00161	0.00055	IRIS 1994	Cancer $1x10^{-6}$
Naphthalene	91-20-3	0.02		23.5	8.0	IRIS 1998	Decreased body weight
Pentachlorophenol	87-86-5	0.005		5.86	2.0	IRIS 2010	Hepatotoxicity
Pyrene	129-00-0	0.03		35.2	12.0	IRIS 1993	Renal tubular pathology, decrease kidney weight
Pest-Herb							
Aldrin	309-00-2	0.00003		0.035	0.012	IRIS 1988	Liver toxicity
Aldrin	309-00-2	-	17	0.00007	0.000024	IRIS 1988	Cancer $1x10^{-6}$
Chlordane (Total)	57-74-9	0.0005		0.586	0.200	IRIS 1998	Hepatic Necrosis
Chlordane (Total)	57-74-9	-	0.35	0.0034	0.0011	IRIS 1998	Cancer $1x10^{-6}$
DDT (Total)	50-29-3	0.0005		0.503	0.171	IRIS 1996	Liver lesions
DDT (Total)	50-29-4	0.002		2.010	0.686	ATSDR MRL 2004	Neurological effects
DDT (Total)	50-29-3		0.34	0.0034	0.0012	IRIS 1996	Cancer $1x10^{-6}$
Dieldrin	60-57-1	0.00005		0.059	0.020	IRIS 1990	Liver lesions
Dieldrin	60-57-1		16	0.00007	0.00003	IRIS 1990	Cancer $1x10^{-6}$
Endrin	72-20-8	0.0003		0.352	0.120	IRIS 1991/93	Liver lesions
Heptachlor	76-44-8	0.0005		0.586	0.200	IRIS 1991	Increased liver weight
Heptachlor	76-44-8		4.5	0.0003	0.0001	IRIS 1991	Cancer $1x10^{-6}$
Heptachor Epoxide	1024-57-3	0.000013		0.015	0.005	IRIS 1991	Increased liver weight
Heptachor Epoxide	1024-57-3		9.1	0.00013	0.00004	IRIS 1991	Cancer $1x10^{-6}$
Methoxychlor	72-43-5	0.005		5.86	2.00	IRIS 1991	Excessive loss of litters
SVOC							
1,2,4-TriChlorobenzene	120-82-1	0.01		11.7	4.00	IRIS 1996	Increase adrenal weights
1,2,4-TriChlorobenzene	120-82-1		0.0036	0.3	0.1	IRIS 1996	Cancer $1x10^{-6}$
Bis (2-ethylhexyl) Phthalate	117-81-7	0.02		23.5	8.00	IRIS 1991	Increased liver weight
Bis (2-ethylhexyl) Phthalate	117-81-7		0.014	0.1	0.03	IRIS 1991	Cancer $1x10^{-6}$
Butyl benzyl phthalate	85-68-7	0.2		234.5	80.0	IRIS 1993	Increased liver weight
Dibutyl phthalate	84-74-2	0.1		117.3	40.0	IRIS 1990	Increased mortality
Hexachloroethane	67-72-1	0.001		1.17	0.400	IRIS 1991	Atrophy and degeneration of renal tubules
Hexachlorobenzene	118-74-1	0.0008		0.938	0.320	IRIS 1991	Liver effects
Hexachlorobenzene	118-74-1	-	1.6	0.00073	0.00025	IRIS 1996	Cancer $1x10^{-6}$
Hexachloro-1,3-butadiene	87-68-3	0.001		1.17	0.40	IRIS 1993	IRIS withdrawn (PPRTV)
Hexachloro-1,3-butadiene	87-68-3		0.078	0.015	0.005	IRIS 1993	Cancer $1x10^{-6}$
Hexachlorocyclopentadiene	77-47-4	0.006		7.04	2.40	IRIS 2001	Chronic irritation
PCBs/Dioxins							
PCBs (Total)	1336-36-3	0.00002		0.023	0.008	IRIS 1994	Immune effects
PCBs (Total)	1336-36-3	0.00003		0.030	0.010	ATSDR MRL 2005	Developmental effects
PCBs (Total)	1336-36-3	-	2	0.00059	0.00020	IRIS 1994	Cancer $1x10^{-6}$
Total Dioxins	-	7E-10		8.21E-07	2.80E-07	EPA 2012	Decreased sperm count and mobility
Total Dioxins	-	-	1.56E+05	7.52E-09	2.56E-09	ATSDR MRL 2005	Cancer $1x10^{-6}$ currently no EPA CSF

Reference:

*http://www.epa.gov/iris/index.html

ATSDR - http://www.atsdr.cdc.gov/interactionprofiles/ip01.html table 35

General Population consumption rate = 59.7 g/d = 2 meals per week

High Consumers consumption rate = 175 g/d

Cancer Risk $1x10^{-6}$

Mercury, total DDT, and PBDEs were assessed using 60 kg body weight

†IEUBK – EPA's Integrated Exposure Uptake Biokinetic Model for Lead in children is used to predict blood lead levels in children.

‡Zinc is an essential nutrient found in almost every cell. The Recommended Daily Allowance (RDA), one of the Dietary Reference Intakes (DRIs), is the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals. For infants 0 to 6 months, the DRI is in the form of an Adequate Intake (AI), which is the mean intake of zinc in healthy, breastfed infants. The AI for zinc for infants 0 to 6 months is 2.0 milligrams (mg) per day. The 2001 RDAs for zinc for infants 7 through 12 months, children and adults in mg per day are: 7 months through 3 years, the AI is 3.0 mg per day; 4 to 8 years 5 mg per day; 9 to 13 years is 8 mg per day; 14 and up is 13 mg per day. (Results of two national surveys, the National Health and Nutrition Examination Survey (NHANES III 1988-91) and the Continuing Survey of Food Intakes of Individuals (1194 CSFII) indicate that most infants, children, and adults consume recommended amounts of zinc).

Appendix B

Appendix B, Table 1. Bass Miniumum, Maximum, Mean, & Detection Frequency

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)			Detection Frequency %
				Min	Max	Mean	
Bass	Upriver	Metal	Barium	0.263	0.623	0.374	100
Bass	100 Area	Metal	Barium	0.373	1.030	0.634	100
Bass	300 Area	Metal	Barium	0.194	0.529	0.324	100
Bass	Lake Wallula	Metal	Barium	0.199	1.390	0.585	100
Bass	Upriver	Metal	Chromium	0.234	0.803	0.548	100
Bass	100 Area	Metal	Chromium	0.275	1.44	0.787	100
Bass	300 Area	Metal	Chromium	0.505	0.87	0.697	100
Bass	Lake Wallula	Metal	Chromium	0.567	2.01	1.188	100
Bass	Upriver	Metal	Cobalt	1.32*	1.92*	0.8	0
Bass	100 Area	Metal	Cobalt	0.829	1.83	1.05	60
Bass	300 Area	Metal	Cobalt	0.793	1.52*	0.9	80
Bass	Lake Wallula	Metal	Cobalt	0.943	1.64*	1.1	40
Bass	Upriver	Metal	Iron	3.92	5.79	4.83	100
Bass	100 Area	Metal	Iron	4.6	6.78	5.56	100
Bass	300 Area	Metal	Iron	3.51	8.67	5.3	100
Bass	Lake Wallula	Metal	Iron	6.54	15.2	10.51	100
Bass	Upriver	Metal	Manganese	0.586	1.77	0.95	100
Bass	100 Area	Metal	Manganese	1.02	1.95	1.15	60
Bass	300 Area	Metal	Manganese	0.552	1.9	1	100
Bass	Lake Wallula	Metal	Manganese	0.857	5.85	2.5	100
Bass	Upriver	Metal	Mercury	0.038	0.122	0.078	100
Bass	100 Area	Metal	Mercury	0.073	0.101	0.085	100
Bass	300 Area	Metal	Mercury	0.066	0.087	0.077	100
Bass	Lake Wallula	Metal	Mercury	0.035	0.102	0.058	100
Bass	Upriver	Metal	Selenium	0.804	1.14	1.0	100
Bass	100 Area	Metal	Selenium	0.85	1.03	0.95	100
Bass	300 Area	Metal	Selenium	0.776	0.98	0.87	100
Bass	Lake Wallula	Metal	Selenium	0.76	1.13	0.99	100
Bass	Upriver	Metal	Strontium	3.38	11.5	6.1	100
Bass	100 Area	Metal	Strontium	4.33	18.8	9.8	100
Bass	300 Area	Metal	Strontium	3.51	7.1	5.2	100
Bass	Lake Wallula	Metal	Strontium	1.99	22.8	9.3	100
Bass	Upriver	Metal	Tin	4.84*	11.1	7.3	80
Bass	100 Area	Metal	Tin	3.97*	16.9	6.3	60
Bass	300 Area	Metal	Tin	3.76	11.8	7.8	100
Bass	Lake Wallula	Metal	Tin	9.91	14.7	12.6	100
Bass	Upriver	Metal	Vanadium	0.175	2.12	0.51	60
Bass	100 Area	Metal	Vanadium	0.346	0.52	0.44	100
Bass	300 Area	Metal	Vanadium	0.326	0.443	0.38	100
Bass	Lake Wallula	Metal	Vanadium	0.166	0.475	0.32	100
Bass	Upriver	Metal	Zinc	7.95	15.2	11	100
Bass	100 Area	Metal	Zinc	10.8	16.2	12.9	100
Bass	300 Area	Metal	Zinc	6.97	9.91	8.77	100
Bass	Lake Wallula	Metal	Zinc	9.09	30.1	14.5	100
Bass	Upriver	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.004	0.019	0.008	40
Bass	Lake Wallula	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.003	0.005	0.004	0
Bass	Upriver	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.006*	0.009	0.007	60
Bass	100 Area	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.219	0.239	0.226	100
Bass	300 Area	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.165	0.251	0.21	100
Bass	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.006*	0.013	0.006	20
Bass	Upriver	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.015	0.061	0.035	100
Bass	100 Area	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.018	0.239	0.092	100
Bass	300 Area	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.021	0.060	0.040	100
Bass	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.012	0.032	0.022	100
Bass	Upriver	PCBs	Total PCBs	0.032	0.115	0.067	
Bass	100 Area	PCBs	Total PCBs	0.023	0.234	0.111	
Bass	300 Area	PCBs	Total PCBs	0.039	0.095	0.061	
Bass	Lake Wallula	PCBs	Total PCBs	0.089	0.031	0.052	
Bass	Upriver	PCBs	Total Dioxin-Like PCBs	1.51E-06	3.64E-06	2.66E-06	
Bass	100 Area	PCBs	Total Dioxin-Like PCBs	2.84958E-06	1.02139E-05	4.84E-06	
Bass	300 Area	PCBs	Total Dioxin-Like PCBs	1.30408E-06	2.8823E-06	2.18E-06	
Bass	Lake Wallula	PCBs	Total Dioxin-Like PCBs	1.47256E-06	2.17391E-06	2.23E-06	

* = non-detected

Appendix B, Table 2. Carp Miniumum, Maximum, Mean, & Detection Frequency

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)			Detection Frequency %
				Min	Max	Mean	
Carp	Upriver	Metal	Barium	0.147	0.529	0.3	100%
Carp	100 Area	Metal	Barium	0.269	0.664	0.467	100%
Carp	300 Area	Metal	Barium	0.158	0.782	0.42	100%
Carp	Lake Wallula	Metal	Barium	0.163	0.538	0.388	100%
Carp	Upriver	Metal	Cadmium	0.046	0.156*	0.069	50
Carp	100 Area	Metal	Cadmium	0.033	0.159	0.065	40
Carp	300 Area	Metal	Cadmium	0.04	0.169*	0.06	80
Carp	Lake Wallula	Metal	Cadmium	0.038	0.161	0.065	20
Carp	Upriver	Metal	Chromium	0.161	0.572	0.401	0
Carp	100 Area	Metal	Chromium	0.243	0.488	0.327	60
Carp	300 Area	Metal	Chromium	0.182	0.456	0.269	80
Carp	Lake Wallula	Metal	Chromium	0.206	1.34	0.517	40
Carp	Upriver	Metal	Copper	0.601	0.792	0.78	100
Carp	100 Area	Metal	Copper	0.59	1.02	0.779	100
Carp	300 Area	Metal	Copper	0.547	0.926	0.68	100
Carp	Lake Wallula	Metal	Copper	0.627	0.853	0.739	100
Carp	Upriver	Metal	Iron	16.3	23.1	19.1	100
Carp	100 Area	Metal	Iron	9.86	16.6	14.1	100
Carp	300 Area	Metal	Iron	12.1	19.5	14.3	100
Carp	Lake Wallula	Metal	Iron	13.3	17.6	15.3	100
Carp	Upriver	Metal	Lead	0.237	0.391*	0.219	50
Carp	100 Area	Metal	Lead	0.262	0.865	0.418	80
Carp	300 Area	Metal	Lead	0.28	0.424*	0.256	60
Carp	Lake Wallula	Metal	Lead	0.333*	0.635	0.407	60
Carp	Upriver	Metal	Lithium	0.673	1.95*	0.856	50
Carp	100 Area	Metal	Lithium	0.374	1.98*	0.583	80
Carp	300 Area	Metal	Lithium	0.58	1.58*	0.73	60
Carp	Lake Wallula	Metal	Lithium	0.398	1.69*	0.67	80
Carp	Upriver	Metal	Manganese	0.312	0.757	0.59	100
Carp	100 Area	Metal	Manganese	0.543	0.929	0.749	100
Carp	300 Area	Metal	Manganese	0.298	1.29	0.76	100
Carp	Lake Wallula	Metal	Manganese	0.469	1.6	0.89	100
Carp	Upriver	Metal	Mercury	0.070	0.130	0.09	100
Carp	100 Area	Metal	Mercury	0.060	0.160	0.11	100
Carp	300 Area	Metal	Mercury	0.100	0.173	0.13	100
Carp	Lake Wallula	Metal	Mercury	0.109	0.180	0.15	100
Carp	Upriver	Metal	Selenium	0.725	1.26	0.88	100
Carp	100 Area	Metal	Selenium	0.707	0.987	0.849	100
Carp	300 Area	Metal	Selenium	0.499	1.43	0.94	100
Carp	Lake Wallula	Metal	Selenium	0.704	0.758	0.74	100
Carp	Upriver	Metal	Strontium	1.03	5.38	3.42	100
Carp	100 Area	Metal	Strontium	2.29	5.39	3.93	100
Carp	300 Area	Metal	Strontium	1.58	6.46	3.54	100
Carp	Lake Wallula	Metal	Strontium	2.03	7.96	3.8	100
Carp	Upriver	Metal	Tin	5.34*	18.6	11.42	75
Carp	100 Area	Metal	Tin	5.45*	64.7	28.7	80
Carp	300 Area	Metal	Tin	6.82	37.4	18.7	100
Carp	Lake Wallula	Metal	Tin	13.2	49.7	29.8	100
Carp	Upriver	Metal	Total inorganic Arsenic	0.003*	0.00545	0.02	25
Carp	100 Area	Metal	Total inorganic Arsenic	0.003*	0.005358	0.003	60
Carp	300 Area	Metal	Total inorganic Arsenic	0.003*	0.0037	0.002	20
Carp	Lake Wallula	Metal	Total inorganic Arsenic	0.003*	0.00385	0.003	60
Carp	Upriver	Metal	Vanadium	0.268	1.95*	0.61	50
Carp	100 Area	Metal	Vanadium	0.302	1.98*	0.46	80
Carp	300 Area	Metal	Vanadium	0.274	1.58*	0.56	60
Carp	Lake Wallula	Metal	Vanadium	0.261	0.33	0.3	100
Carp	Upriver	Metal	Zinc	21.8	33.9	27.0	100
Carp	100 Area	Metal	Zinc	19.2	34.7	27.7	100
Carp	300 Area	Metal	Zinc	18.6	32.8	24.9	100
Carp	Lake Wallula	Metal	Zinc	18.2	38.2	26.1	100
Carp	Upriver	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.00033*	0.0112*	0.0034	0
Carp	100 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0079*	0.106	0.025	20
Carp	300 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0152*	0.224	0.100	60
Carp	Lake Wallula	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.00811*	0.318	0.146	80
Carp	Upriver	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.002	0.148	0.06145	100
Carp	100 Area	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.021	0.106	0.05394	100
Carp	300 Area	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0149	0.355	0.14934	100
Carp	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.00959	0.286	0.123	100
Carp	Upriver	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.009	1.19	0.41625	100
Carp	100 Area	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.192	0.998	0.5134	100
Carp	300 Area	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.112	0.995	0.5986	100
Carp	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.144	0.68	0.4082	100
Carp	Upriver	PCB	Total PCBs	0.162	0.454	0.252	
Carp	100 Area	PCB	Total PCBs	0.168	0.531	0.328	
Carp	300 Area	PCB	Total PCBs	0.101	0.559	0.351	
Carp	Lake Wallula	PCB	Total PCBs	0.118	0.429	0.254	
Carp	Upriver	PCB	Total Dioxin-Like PCBs	4.84E-06	1.56E-05	9.85E-06	
Carp	100 Area	PCB	Total Dioxin-Like PCBs	7.44E-06	2.54E-05	1.56E-05	
Carp	300 Area	PCB	Total Dioxin-Like PCBs	3.53E-06	2.45E-05	1.56E-05	
Carp	Lake Wallula	PCB	Total Dioxin-Like PCBs	5.63E-06	1.46E-05	1.01E-05	

* = non-detected

Appendix B, Table 3. Sturgeon Miniumum, Maximum, Mean, & Detection Frequency

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm) Min	Max	Mean	Detection Frequency (%)
Sturgeon	Upriver	Metal	Arsenic	0.625*	0.82*	0.37	0
Sturgeon	100 Area	Metal	Arsenic	0.35	1.02	0.53	11
Sturgeon	300 area	Metal	Arsenic	0.327	1.13	0.61	100
Sturgeon	Lake Wallula	Metal	Arsenic	0.552	0.994	0.496	33
Sturgeon	Upriver	Metal	Barium	0.312*	0.41*	0.19	0
Sturgeon	100 Area	Metal	Barium	0.159	0.472	0.25	89
Sturgeon	300 area	Metal	Barium	0.099	0.397	0.212	60
Sturgeon	Lake Wallula	Metal	Barium	0.078	0.124	0.1	100
Sturgeon	Upriver	Metal	Chromium	0.125	0.235	0.16	80
Sturgeon	100 Area	Metal	Chromium	0.139*	0.877*	0.25	33
Sturgeon	300 area	Metal	Chromium	0.154*	1.47	0.32	70
Sturgeon	Lake Wallula	Metal	Chromium	0.143*	0.189	0.108	33
Sturgeon	Upriver	Metal	Iron	3.56	16.4*	5.8	40
Sturgeon	100 Area	Metal	Iron	3.72	17.5*	5.26	78
Sturgeon	300 area	Metal	Iron	3.02	15.9*	4.49	90
Sturgeon	Lake Wallula	Metal	Iron	3.11	17.5*	5.7	50
Sturgeon	Upriver	Metal	Lithium	0.371	1.98*	0.75	40
Sturgeon	100 Area	Metal	Lithium	1.25*	2.27*	0.87	0
Sturgeon	300 area	Metal	Lithium	1.71*	2.45*	0.97	0
Sturgeon	Lake Wallula	Metal	Lithium	0.472	2.02*	0.7	50
Sturgeon	Upriver	Metal	Manganese	0.167	0.233	0.199	100
Sturgeon	100 Area	Metal	Manganese	0.204	0.439	0.3	100
Sturgeon	300 area	Metal	Manganese	0.152	4.24*	0.271	90
Sturgeon	Lake Wallula	Metal	Manganese	0.193	0.304	0.245	100
Sturgeon	Upriver	Metal	Mercury	0.013	0.103	0.05	86
Sturgeon	100 Area	Metal	Mercury	0.038	0.246	0.2	100
Sturgeon	300 area	Metal	Mercury	0.091	0.612	0.22	100
Sturgeon	Lake Wallula	Metal	Mercury	0.052	0.095	0.066	100
Sturgeon	Upriver	Metal	Methylmercury	0.014	0.096	0.054848	100
Sturgeon	300 area	Metal	Methylmercury	0.104	0.239	0.14956	100
Sturgeon	Lake Wallula	Metal	Methylmercury	0.072	0.072	0.072091	100
Sturgeon	Upriver	Metal	Selenium	0.825	1.6	1.2	100
Sturgeon	100 Area	Metal	Selenium	0.755	1.59	1.12	100
Sturgeon	300 area	Metal	Selenium	0.792	2.67	1.3	100
Sturgeon	Lake Wallula	Metal	Selenium	1.23	2.92	1.9	100
Sturgeon	Upriver	Metal	Strontium	0.625*	0.82*	0.37	0
Sturgeon	100 Area	Metal	Strontium	0.312*	0.909*	0.281	0
Sturgeon	300 area	Metal	Strontium	0.091	0.794*	0.30	30
Sturgeon	Lake Wallula	Metal	Strontium	0.1	0.877*	0.3	33
Sturgeon	Upriver	Metal	Vanadium	1.56*	2.05*	0.93	0
Sturgeon	100 Area	Metal	Vanadium	0.185	0.943*	0.298	67
Sturgeon	300 area	Metal	Vanadium	0.263	2.45*	0.84	20
Sturgeon	Lake Wallula	Metal	Vanadium	1.6*	2.19*	0.9	0
Sturgeon	Upriver	Metal	Zinc	3.62	4.62	3.78	80
Sturgeon	100 Area	Metal	Zinc	3.04	4.18	3.58	100
Sturgeon	300 area	Metal	Zinc	2.82	4.83	3.75	100
Sturgeon	Lake Wallula	Metal	Zinc	2.92*	4.27	2.56	33
Sturgeon	Upriver	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.00757*	0.0104*	0.0047	0
Sturgeon	100 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.00549*	0.00763*	0.032	0
Sturgeon	300 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.00546*	0.05	0.01	30
Sturgeon	Lake Wallula	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.00581*	0.115	0.044	83
Sturgeon	Upriver	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0479	0.144	0.079	100
Sturgeon	100 Area	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0211	0.136	0.056	100
Sturgeon	300 Area	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.00653	0.125	0.03	70
Sturgeon	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0182	0.0351	0.025	100
Sturgeon	Upriver	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.159	0.833	0.380	100
Sturgeon	100 Area	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.0407	0.227	0.15	100
Sturgeon	300 Area	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.0612	0.376	0.17	100
Sturgeon	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.0818	0.224	0.159	100
Sturgeon	Upriver	Pesticide	Dichlorodiphenyltrichloroethane (DDT)	0.00757*	0.0104*	0.0047	0
Sturgeon	100 Area	Pesticide	Dichlorodiphenyltrichloroethane (DDT)	0.00549*	0.00763*	0.0032	0
Sturgeon	300 Area	Pesticide	Dichlorodiphenyltrichloroethane (DDT)	0.00546*	0.0147	0.005	30
Sturgeon	Lake Wallula	Pesticide	Dichlorodiphenyltrichloroethane (DDT)	0.00581	0.0149	0.0080	67
Sturgeon	Upriver	PCB	Total PCBs	0.104	0.386	0.206	
Sturgeon	100 Area	PCB	Total PCBs	0.104	0.289	0.180	
Sturgeon	300 Area	PCB	Total PCBs	0.081	0.325	0.155	
Sturgeon	Lake Wallula	PCB	Total PCBs	0.083	0.188	0.137	
Sturgeon	Upriver	PCB	Total Dioxin-Like PCBs	4.42E-07	1.41E-05	5.02E-06	
Sturgeon	100 Area	PCB	Total Dioxin-Like PCBs	3.72E-06	1.64E-05	8.63E-06	
Sturgeon	300 Area	PCB	Total Dioxin-Like PCBs	3.44E-07	1.44E-05	6.72E-06	
Sturgeon	Lake Wallula	PCB	Total Dioxin-Like PCBs	1.11E-06	6.43E-06	4.12E-06	

* = non-detected

Appendix B, Table 4. Sucker Miniumum, Maximum, Mean, & Detection Frequency

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm) Min	Max	Mean	Detection Frequency (%)
Sucker	Upriver	Metal	Barium	0.513	1.05	0.71	100
Sucker	100 Area	Metal	Barium	0.272	1.13	0.63	100
Sucker	300 Area	Metal	Barium	0.296	0.756	0.520	100
Sucker	Lake Wallula	Metal	Barium	0.267	0.715	0.524	100
Sucker	Upriver	Metal	Chromium	0.192	0.585	0.31	100
Sucker	100 Area	Metal	Chromium	0.176	0.562	0.351	100
Sucker	300 Area	Metal	Chromium	0.153	0.674	0.2	60
Sucker	Lake Wallula	Metal	Chromium	0.148	0.235	0.182	80
Sucker	Upriver	Metal	Copper	0.381	0.877*	0.400	40
Sucker	100 Area	Metal	Copper	0.469	1.0*	0.5	80
Sucker	300 Area	Metal	Copper	0.45	1.0*	0.6	40
Sucker	Lake Wallula	Metal	Copper	0.45	0.746*	0.43	60
Sucker	Upriver	Metal	Iron	4.52	26.5	9.2	100
Sucker	100 Area	Metal	Iron	5.38	10.3	7.3	100
Sucker	300 Area	Metal	Iron	4.24	6.54	5.35	100
Sucker	Lake Wallula	Metal	Iron	5.16	7.19	6.05	100
Sucker	Upriver	Metal	Manganese	1.7	3.58	2.8	100
Sucker	100 Area	Metal	Manganese	0.937	3.99	2.23	100
Sucker	300 Area	Metal	Manganese	0.985	2.1	1.7	100
Sucker	Lake Wallula	Metal	Manganese	0.971	1.86	1.55	100
Sucker	Upriver	Metal	Mercury	0.076	0.144	0.103	100
Sucker	100 Area	Metal	Mercury	0.073	0.151	0.111	100
Sucker	300 Area	Metal	Mercury	0.092	0.153	0.128	100
Sucker	Lake Wallula	Metal	Mercury	0.106	0.172	0.124	100
Sucker	Upriver	Metal	Seleium	0.554	0.948	0.703	100
Sucker	100 Area	Metal	Seleium	0.918	1.06	0.98	100
Sucker	300 Area	Metal	Seleium	0.646	0.967	0.808	100
Sucker	Lake Wallula	Metal	Seleium	0.803	0.994	0.9	100
Sucker	Upriver	Metal	Strontium	1.73	4.49	2.9	100
Sucker	100 Area	Metal	Strontium	0.923	4.31	2.41	100
Sucker	300 Area	Metal	Strontium	1.56	3.68	2.5	100
Sucker	Lake Wallula	Metal	Strontium	1.65	3.8	2.5	100
Sucker	Upriver	Metal	Tin	2.81*	7.15	2.7	20
Sucker	100 Area	Metal	Tin	3.44*	9.04	5.15	60
Sucker	300 Area	Metal	Tin	1.65*	2.05*	0.93	0
Sucker	Lake Wallula	Metal	Tin	1.51*	5.03	2.00	20
Sucker	Upriver	Metal	Inorganic Arsenic	0.003*	0.00312	0.0018	20
Sucker	100 Area	Metal	Inorganic Arsenic	0.003*	0.003*	0.0015	0
Sucker	300 Area	Metal	Inorganic Arsenic	0.003*	0.00356	0.0019	20
Sucker	Lake Wallula	Metal	Inorganic Arsenic	0.003*	0.00313	0.0025	60
Sucker	Upriver	Metal	Vanadium	0.283	2.12*	0.57	60
Sucker	100 Area	Metal	Vanadium	1.67*	2.5*	1.03	0
Sucker	300 Area	Metal	Vanadium	1.89*	2.5*	1.12	0
Sucker	Lake Wallula	Metal	Vanadium	1.69*	2.31*	0.96	0
Sucker	Upriver	Metal	Zinc	11.2	19.6	16.4	100
Sucker	100 Area	Metal	Zinc	9.76	18.5	14.0	100
Sucker	300 Area	Metal	Zinc	10.2	14.2	11.8	100
Sucker	Lake Wallula	Metal	Zinc	9.21	14.8	11.90	100
Sucker	Upriver	Pesticide	Delta-BHC	0.0153*	0.019*	0.0083	0
Sucker	100 Area	Pesticide	Delta-BHC	0.0127*	0.016*	0.007	0
Sucker	300 Area	Pesticide	Delta-BHC	0.0208	0.0757	0.0362	80
Sucker	Lake Wallula	Pesticide	Delta-BHC	0.012*	0.0172*	0.008	0
Sucker	Upriver	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0313	0.243	0.144	100
Sucker	100 Area	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0255	0.0481	0.035	100
Sucker	300 Area	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0212*	0.0584	0.0419	80
Sucker	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethane (DDD)	0.0166	0.0534	0.0353	100
Sucker	Upriver	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.125	0.182	0.151	100
Sucker	100 Area	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.106	0.241	0.159	100
Sucker	300 Area	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.0849	0.329	0.23	100
Sucker	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethylene (DDE)	0.0998	0.274	0.2	100
Sucker	Upriver	PCB	Total PCBs	0.059	0.123	0.083	
Sucker	100 Area	PCB	Total PCBs	0.105	0.170	0.140	
Sucker	300 Area	PCB	Total PCBs	0.105	0.247	0.182	
Sucker	Lake Wallula	PCB	Total PCBs	0.106	0.240	0.172	
Sucker	Upriver	PCB	Total Dioxin-Like PCBs	2.13E-06	4.85E-06	3.07E-06	
Sucker	100 Area	PCB	Total Dioxin-Like PCBs	4.18E-06	6.84E-06	5.40E-06	
Sucker	300 Area	PCB	Total Dioxin-Like PCBs	3.33E-06	8.54E-06	5.95E-06	
Sucker	Lake Wallula	PCB	Total Dioxin-Like PCBs	3.72E-06	1.06E-05	6.93E-06	

* = non-detected

Appendix B, Table 5. Walleye Miniumum, Maximum, Mean, & Detection Frequency

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm) Min	Max	Mean	Detection Frequency (%)
Walleye	Upriver	Metal	Barium	0.208	0.628	0.415	100
Walleye	100 Area	Metal	Barium	0.17	1.08	0.38	100
Walleye	300 Area	Metal	Barium	0.131	0.372	0.30	100
Walleye	Lake Wallula	Metal	Barium	0.09	0.592	0.28	80
Walleye	Upriver	Metal	Chromium	0.193	0.928	0.53	100
Walleye	100 Area	Metal	Chromium	0.182	0.814	0.400	100
Walleye	300 Area	Metal	Chromium	0.163	0.313	0.23	100
Walleye	Lake Wallula	Metal	Chromium	0.141	0.824	0.34	100
Walleye	Upriver	Metal	Cobalt	0.705*	1.3	0.9	33
Walleye	100 Area	Metal	Cobalt	0.65*	0.86*	0.73	0
Walleye	300 Area	Metal	Cobalt	0.65*	1.0*	0.8	0
Walleye	Lake Wallula	Metal	Cobalt	0.665*	0.895*	0.76	20
Walleye	Upriver	Metal	Iron	3.71	13.4	6.3	100
Walleye	100 Area	Metal	Iron	2.91	5.4	4.1	100
Walleye	300 Area	Metal	Iron	4.1	10.0*	7.5	20
Walleye	Lake Wallula	Metal	Iron	2.76	9.21	6.3	60
Walleye	Upriver	Metal	Lithium	0.399	1.2*	0.9	33
Walleye	100 Area	Metal	Lithium	0.51	1.11	0.67	100
Walleye	300 Area	Metal	Lithium	0.206*	1.25*	0.62	0
Walleye	Lake Wallula	Metal	Lithium	0.835*	1.115*	0.94	0
Walleye	Upriver	Metal	Manganese	0.289	0.929	0.57	100
Walleye	100 Area	Metal	Manganese	0.217	1.04	0.37	100
Walleye	300 Area	Metal	Manganese	0.237	0.443	0.341	100
Walleye	Lake Wallula	Metal	Manganese	0.258	0.473	0.349	100
Walleye	Upriver	Metal	Mercury	0.197	0.721	0.31	100
Walleye	100 Area	Metal	Mercury	0.177	0.606	0.324	100
Walleye	300 Area	Metal	Mercury	0.135	0.314	0.21	100
Walleye	Lake Wallula	Metal	Mercury	0.098	0.401	0.185	100
Walleye	Upriver	Metal	Selenium	0.633	0.754	0.7	100
Walleye	100 Area	Metal	Selenium	0.51	0.625	0.59	100
Walleye	300 Area	Metal	Selenium	0.57	0.723	0.65	100
Walleye	Lake Wallula	Metal	Selenium	0.549	0.729	0.64	100
Walleye	Upriver	Metal	Strontium	0.372	8.42	6.10	100
Walleye	100 Area	Metal	Strontium	1.85	15.3	4.92	100
Walleye	300 Area	Metal	Strontium	2.13	6.59	4.30	100
Walleye	Lake Wallula	Metal	Strontium	0.798	5.78	2.8	100
Walleye	Upriver	Metal	Tin	2.7*	7.18	3.3	33
Walleye	100 Area	Metal	Tin	8.15	22.9	15.9	100
Walleye	300 Area	Metal	Tin	3.39	10	6.0	80
Walleye	Lake Wallula	Metal	Tin	1.41	4.2	1.8	20
Walleye	Upriver	Metal	Inoranic Arsenic	0.002*	0.003*	0.001	0
Walleye	100 Area	Metal	Inoranic Arsenic	0.003*	0.0042	0.0020	50
Walleye	300 Area	Metal	Inoranic Arsenic	0.003*	0.0036	0.002	20
Walleye	Lake Wallula	Metal	Inoranic Arsenic	0.002*	0.00515	0.003	80
Walleye	Upriver	Metal	Vanadium	0.281	0.399	0.339	100
Walleye	100 Area	Metal	Vanadium	0.152	0.339	0.241	100
Walleye	300 Area	Metal	Vanadium	0.284	0.393	0.339	100
Walleye	Lake Wallula	Metal	Vanadium	0.238	0.319	0.29	100
Walleye	Upriver	Metal	Zinc	6.97	15.7	10.6	100
Walleye	100 Area	Metal	Zinc	6.17	11.1	7.9	100
Walleye	300 Area	Metal	Zinc	6.79	10.5	8.2	100
Walleye	Lake Wallula	Metal	Zinc	5.02	8.26	6.03	100
Walleye	Upriver	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0398	1.87	0.45	100
Walleye	100 Area	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0051	0.0361	0.0166	50
Walleye	300 Area	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.006*	0.173	0.042	60
Walleye	Lake Wallula	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0131*	0.156	0.069	80
Walleye	Upriver	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.0706	0.197	0.126	100
Walleye	100 Area	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.0051*	0.0266	0.0164	17
Walleye	300 Area	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.0056*	0.009	0.0148	40
Walleye	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.010*	0.0133	0.0071	20
Walleye	Upriver	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.174	0.655	0.3	100
Walleye	100 Area	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.0218	0.339	0.157	100
Walleye	300 Area	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.0135	0.416	0.145	100
Walleye	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.0192	0.08	0.03	100
Walleye	Upriver	Pesticides	Dichlorodiphenyltrichloroethane (DDT)	0.0107*	0.0182*	0.0081	17
Walleye	100 Area	Pesticides	Dichlorodiphenyltrichloroethane (DDT)	0.0051*	0.0075	0.00373	17
Walleye	300 Area	Pesticides	Dichlorodiphenyltrichloroethane (DDT)	0.0056*	0.0077	0.00456	40
Walleye	Lake Wallula	Pesticides	Dichlorodiphenyltrichloroethane (DDT)	0.010*	0.0133*	0.0058	0
Walleye	Upriver	Pesticides	Gamma-BHC (Lindane)	0.0115	0.0753	0.0322	67
Walleye	100 Area	Pesticides	Gamma-BHC (Lindane)	0.0051*	0.0083*	0.0030	0
Walleye	300 Area	Pesticides	Gamma-BHC (Lindane)	0.0056*	0.0070*	0.0032	0
Walleye	Lake Wallula	Pesticides	Gamma-BHC (Lindane)	0.0096	0.0267	0.0108	40
Walleye	Upriver	Pesticides	Heptachlor	0.011*	0.0182	0.0071	0
Walleye	100 Area	Pesticides	Heptachlor	0.0053*	0.0249	0.0079	33
Walleye	300 Area	Pesticides	Heptachlor	0.0056*	0.0115	0.0048	20
Walleye	Lake Wallula	Pesticides	Heptachlor	0.0096*	0.0133*	0.0058	0
Walleye	Upriver	PCB	Total PCBs	0.055	0.324	0.158	
Walleye	100 Area	PCB	Total PCBs	0.138	0.600	0.327	
Walleye	300 Area	PCB	Total PCBs	0.058	0.162	0.103	
Walleye	Lake Wallula	PCB	Total PCBs	0.018	0.088	0.035	
Walleye	Upriver	PCB	Total Dioxin-Like PCBs	1.92E-06	1.44E-05	6.73E-06	
Walleye	100 Area	PCB	Total Dioxin-Like PCBs	0.00000599	0.00002605	1.48699E-05	
Walleye	300 Area	PCB	Total Dioxin-Like PCBs	2.42888E-06	5.17342E-06	3.74723E-06	
Walleye	Lake Wallula	PCB	Total Dioxin-Like PCBs	3.07109E-08	3.6E-06	9.77131E-07	

* = non-detected

Appendix B, Table 6. Whitefish Miniumum, Maximum, Mean, & Detection Frequency

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)			Detection Frequency (%)
				Min	Max	Mean	
Whitefish	Upriver	Metal	Aluminum	2.99	5.1	2.9	40
Whitefish	100 Area	Metal	Aluminum	3.38*	4.55*	2.29	20
Whitefish	300 Area	Metal	Aluminum	3.47	4.9*	2.3	20
Whitefish	Lake Wallula	Metal	Aluminum	3.38*	4.63*	1.89	0
Whitefish	Upriver	Metal	Arsenic	0.224	0.926*	0.387	20
Whitefish	100 Area	Metal	Arsenic	0.211	0.847*	0.325	60
Whitefish	300 Area	Metal	Arsenic	0.255	0.794*	0.315	80
Whitefish	Lake Wallula	Metal	Arsenic	0.269	0.359	0.309	100
Whitefish	Upriver	Metal	Barium	0.144	0.698	0.335	80
Whitefish	100 Area	Metal	Barium	0.149	0.316	0.218	100
Whitefish	300 Area	Metal	Barium	0.13	0.877	0.45	100
Whitefish	Lake Wallula	Metal	Barium	0.082	0.653	0.38	100
Whitefish	Upriver	Metal	Boron	0.447	3.86	1.30	100
Whitefish	100 Area	Metal	Boron	1.32*	1.82*	0.77	0
Whitefish	300 Area	Metal	Boron	1.39*	1.96*	0.83	0
Whitefish	Lake Wallula	Metal	Boron	1.35*	1.85*	0.75	0
Whitefish	Upriver	Metal	Cadmium	0.141*	0.185*	0.083	0
Whitefish	100 Area	Metal	Cadmium	0.132*	0.182*	0.077	0
Whitefish	300 Area	Metal	Cadmium	0.139*	0.196*	0.083	0
Whitefish	Lake Wallula	Metal	Cadmium	0.038	0.185*	0.059	60
Whitefish	Upriver	Metal	Chromium	0.144	2.03	0.60	100
Whitefish	100 Area	Metal	Chromium	0.334	0.988	0.54	100
Whitefish	300 Area	Metal	Chromium	0.297	0.649	0.455	100
Whitefish	Lake Wallula	Metal	Chromium	0.273	0.797	0.469	100
Whitefish	Upriver	Metal	Copper	0.578	0.926*	0.661	80
Whitefish	100 Area	Metal	Copper	0.439	0.622	0.559	100
Whitefish	300 Area	Metal	Copper	0.514	0.905	0.692	100
Whitefish	Lake Wallula	Metal	Copper	0.522	0.932	0.684	100
Whitefish	Upriver	Metal	Iron	7.09	18.5	8.4	80
Whitefish	100 Area	Metal	Iron	5.93	11.5	8.0	100
Whitefish	300 Area	Metal	Iron	6.3	10.6	7.9	100
Whitefish	Lake Wallula	Metal	Iron	7.75	11.9	8.9	100
Whitefish	Upriver	Metal	Manganese	0.479*	0.923*	0.309	0
Whitefish	100 Area	Metal	Manganese	0.275	0.884*	0.499	80
Whitefish	300 Area	Metal	Manganese	0.321	1.25	0.74	100
Whitefish	Lake Wallula	Metal	Manganese	0.258	2.3	0.8	100
Whitefish	Upriver	Metal	Mercury	0.015	0.054	0.027	100
Whitefish	100 Area	Metal	Mercury	0.040	0.093	0.07	100
Whitefish	300 Area	Metal	Mercury	0.026	0.099	0.055	100
Whitefish	Lake Wallula	Metal	Mercury	0.040	0.062	0.06	100
Whitefish	Upriver	Metal	Selenium	0.718	0.86	0.76	100
Whitefish	100 Area	Metal	Selenium	0.808	0.978	0.92	100
Whitefish	300 Area	Metal	Selenium	0.964	1.25	1.09	100
Whitefish	Lake Wallula	Metal	Selenium	0.935	1.28	1.09	100
Whitefish	Upriver	Metal	Strontium	0.692	4.19	2.18	100
Whitefish	100 Area	Metal	Strontium	1.13	3.37	1.90	100
Whitefish	300 Area	Metal	Strontium	1.33	8.91	4.67	100
Whitefish	Lake Wallula	Metal	Strontium	0.353	4.24	3.0	100
Whitefish	Upriver	Metal	Tin	5.14	27.4	15.40	100
Whitefish	100 Area	Metal	Tin	9.44	33.9	24.6	100
Whitefish	300 Area	Metal	Tin	15.4	161.0	64.5	100
Whitefish	Lake Wallula	Metal	Tin	21.4	79.8	51.8	100
Whitefish	Upriver	Metal	Vanadium	1.76*	2.31*	1.04	0
Whitefish	100 Area	Metal	Vanadium	1.64*	2.27*	0.96	0
Whitefish	300 Area	Metal	Vanadium	0.18	2.05*	0.66	40
Whitefish	Lake Wallula	Metal	Vanadium	0.155	2.31*	0.52	60
Whitefish	Upriver	Metal	Zinc	10.3	14.5	11.800	100
Whitefish	100 Area	Metal	Zinc	7.32	16.4	9.8	100
Whitefish	300 Area	Metal	Zinc	11.2	17.7	13.7	100
Whitefish	Lake Wallula	Metal	Zinc	6.44	12.7	10.8	100
Whitefish	Upriver	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.0097	0.0542	0.0256	100
Whitefish	100 Area	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.0803	0.108	0.079	100
Whitefish	300 Area	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.072	0.124	0.098	100
Whitefish	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethane (DDD)	0.028	0.0788	0.055	100
Whitefish	Upriver	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.0736	0.382	0.18	100
Whitefish	100 Area	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.121	0.592	0.259	100
Whitefish	300 Area	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.12	0.317	0.22	100
Whitefish	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethylene (DDE)	0.0885	0.188	0.15	100
Whitefish	Upriver	Pesticides	Dieldrin	0.0083	0.0264	0.0143	80
Whitefish	100 Area	Pesticides	Dieldrin	0.0115	0.0255	0.0209	100
Whitefish	300 Area	Pesticides	Dieldrin	0.0193	0.033	0.028	100
Whitefish	Lake Wallula	Pesticides	Dieldrin	0.0165	0.0386	0.0289	100
Whitefish	Upriver	PCB	Total PCBs	0.067	3.755	0.873	
Whitefish	100 Area	PCB	Total_PCB	0.163	0.505	0.330	
Whitefish	300 Area	PCB	Total PCBs	0.095	0.769	0.271	
Whitefish	Lake Wallula	PCB	Total PCBs	0.111	0.141	0.120	
Whitefish	Upriver	PCB	Total Dioxin-Like PCBs	1.57E-07	2.14E-04	4.69E-05	
Whitefish	100 Area	PCB	Total Dioxin-Like PCBs	1.72E-06	2.27E-05	1.23E-05	
Whitefish	300 Area	PCB	Total Dioxin-Like PCBs	2.09E-06	2.84E-05	1.08E-05	
Whitefish	Lake Wallula	PCB	Total Dioxin-Like PCBs	1.38E-06	7.87E-06	4.81E-06	

* = non-detected

Appendix C

Appendix C, Table 1. Bass Screening Level Exceedance

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)	Detection Frequency %	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Bass	Upriver	Metal	Barium	0.374	100%	NO	NO	NA	NA
Bass	100 Area	Metal	Barium	0.634	100%	NO	NO	NA	NA
Bass	300 Area	Metal	Barium	0.324	100%	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Barium	0.585	100%	NO	NO	NA	NA
Bass	All	Metal	Barium	0.479		NO	NO	NA	NA
Bass	Upriver	Metal	Chromium	0.548	100	NO	NO	NA	NA
Bass	100 Area	Metal	Chromium	0.787	100	NO	NO	NA	NA
Bass	300 Area	Metal	Chromium	0.697	100	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Chromium	1.188	100	NO	NO	NA	NA
Bass	All	Metal	Chromium	0.805		NO	NO	NA	NA
Bass	Upriver	Metal	Cobalt	0.8	0	NA	NA	NA	NA
Bass	100 Area	Metal	Cobalt	1.05	60	NA	NA	NA	NA
Bass	300 Area	Metal	Cobalt	0.9	80	NA	NA	NA	NA
Bass	Lake Wallula	Metal	Cobalt	1.1	40	NA	NA	NA	NA
Bass	All	Metal	Cobalt	1.0		NA	NA	NA	NA
Bass	Upriver	Metal	Iron	4.83	100	NA	NA	NA	NA
Bass	100 Area	Metal	Iron	5.56	100	NA	NA	NA	NA
Bass	300 Area	Metal	Iron	5.3	100	NA	NA	NA	NA
Bass	Lake Wallula	Metal	Iron	10.51	100	NA	NA	NA	NA
Bass	All	Metal	Iron	6.6		NA	NA	NA	NA
Bass	Upriver	Metal	Manganese	0.95	100	NO	NO	NA	NA
Bass	100 Area	Metal	Manganese	1.15	60	NO	NO	NA	NA
Bass	300 Area	Metal	Manganese	1	100	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Manganese	2.5	100	NO	NO	NA	NA
Bass	All	Metal	Manganese	1.4		NO	NO	NA	NA
Bass	Upriver	Metal	Mercury	0.078	100	NO	**YES**	NA	NA
Bass	100 Area	Metal	Mercury	0.085	100	NO	**YES**	NA	NA
Bass	300 Area	Metal	Mercury	0.077	100	NO	**YES**	NA	NA
Bass	Lake Wallula	Metal	Mercury	0.058	100	NO	**YES**	NA	NA
Bass	All	Metal	Mercury	0.075		NO	**YES**	NA	NA
Bass	Upriver	Metal	Selenium	1	100	NO	NO	NA	NA
Bass	100 Area	Metal	Selenium	0.95	100	NO	NO	NA	NA
Bass	300 Area	Metal	Selenium	0.87	100	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Selenium	0.99	100	NO	NO	NA	NA
Bass	All	Metal	Selenium	1.0		NO	NO	NA	NA
Bass	Upriver	Metal	Strontium	6.1	100	NO	NO	NA	NA
Bass	100 Area	Metal	Strontium	9.8	100	NO	NO	NA	NA
Bass	300 Area	Metal	Strontium	5.2	100	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Strontium	9.3	100	NO	NO	NA	NA
Bass	All	Metal	Strontium	7.6	100	NO	NO	NA	NA
Bass	Upriver	Metal	Tin	7.3	80	NA	NA	NA	NA
Bass	100 Area	Metal	Tin	6.3	60	NA	NA	NA	NA
Bass	300 Area	Metal	Tin	7.8	100	NA	NA	NA	NA
Bass	Lake Wallula	Metal	Tin	12.6	100	NA	NA	NA	NA
Bass	All	Metal	Tin	8.5		NA	NA	NA	NA
Bass	Upriver	Metal	Vanadium	0.51	60	NO	NO	NA	NA
Bass	100 Area	Metal	Vanadium	0.44	100	NO	NO	NA	NA
Bass	300 Area	Metal	Vanadium	0.38	100	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Vanadium	0.32	100	NO	NO	NA	NA
Bass	All	Metal	Vanadium	0.41		NO	NO	NA	NA
Bass	Upriver	Metal	Zinc	11	100	NO	NO	NA	NA
Bass	100 Area	Metal	Zinc	12.9	100	NO	NO	NA	NA
Bass	300 Area	Metal	Zinc	8.77	100	NO	NO	NA	NA
Bass	Lake Wallula	Metal	Zinc	14.5	100	NO	NO	NA	NA
Bass	All	Metal	Zinc	11.8		NO	NO	NA	NA
Bass	Upriver	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0078	50	NA	NA	NA	NA
Bass	Lake Wallula	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0036	0	NA	NA	NA	NA
Bass	All	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0057		NA	NA	NA	NA
Bass	Upriver	Pesticides	Dichlorodiphenyldichloroethane	0.0066	60	NA	NA	NA	NA
Bass	100 Area	Pesticides	Dichlorodiphenyldichloroethane	0.226	100	NA	NA	NA	NA
Bass	300 Area	Pesticides	Dichlorodiphenyldichloroethane	0.21	100	NA	NA	NA	NA
Bass	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethane	0.0056	20	NA	NA	NA	NA
Bass	All	Pesticides	Dichlorodiphenyldichloroethane	0.11		NA	NA	NA	NA
Bass	Upriver	Pesticides	Dichlorodiphenyldichloroethylene	0.0347	100	NA	NA	NA	NA
Bass	100 Area	Pesticides	Dichlorodiphenyldichloroethylene	0.092	100	NA	NA	NA	NA
Bass	300 Area	Pesticides	Dichlorodiphenyldichloroethylene	0.04	100	NA	NA	NA	NA
Bass	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethylene	0.0223	100	NA	NA	NA	NA
Bass	All	Pesticides	Dichlorodiphenyldichloroethylene	0.05		NA	NA	NA	NA
Bass	Upriver	Pesticides	Total DDT	0.0413		NO	NO	**YES**	**YES**
Bass	100 Area	Pesticides	Total DDT	0.318		NO	**YES**	**YES**	**YES**
Bass	300 Area	Pesticides	Total DDT	0.25		NO	**YES**	**YES**	**YES**
Bass	Lake Wallula	Pesticides	Total DDT	0.0279		NO	NO	**YES**	**YES**
Bass	All	Pesticides	Total DDT	0.16		NO	NO	**YES**	**YES**
Bass	Upriver	PCBs	Total PCBs	0.067		**YES**	**YES**	**YES**	**YES**
Bass	100 Area	PCBs	Total PCBs	0.111		**YES**	**YES**	**YES**	**YES**
Bass	300 Area	PCBs	Total PCBs	0.061		**YES**	**YES**	**YES**	**YES**
Bass	Lake Wallula	PCBs	Total PCBs	0.052		**YES**	**YES**	**YES**	**YES**
Bass	All	PCBs	Total PCBs	0.073		**YES**	**YES**	**YES**	**YES**
Bass	Upriver	PCBs	Total Dioxin-Like PCBs	2.66E-06		NA	NA	NA	NA
Bass	100 Area	PCBs	Total Dioxin-Like PCBs	4.84E-06		NA	NA	NA	NA
Bass	300 Area	PCBs	Total Dioxin-Like PCBs	2.18E-06		NA	NA	NA	NA
Bass	Lake Wallula	PCBs	Total Dioxin-Like PCBs	2.23E-06		NA	NA	NA	NA
Bass	All	PCBs	Total Dioxin-Like PCBs	2.98E-06		NA	NA	NA	NA

NA = not assessed

Highlighted values indicate exceedance of screening level

Appendix C, Table 2. Carp Screening Level Exceedance

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)	Detection Frequency %	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Carp	Upriver	Metal	Arsenic (inorganic)	0.02	25	NO	NO	**YES**	**YES**
Carp	100 Area	Metal	Arsenic (inorganic)	0.003	60	NO	NO	**YES**	**YES**
Carp	300 Area	Metal	Arsenic (inorganic)	0.002	20	NO	NO	**YES**	**YES**
Carp	Lake Wallula	Metal	Arsenic (inorganic)	0.003	60	NO	NO	**YES**	**YES**
Carp	All	Metal	Arsenic (inorganic)	0.01		NO	NO	**YES**	**YES**
Carp	Upriver	Metal	Barium	0.3	100%	NO	NO	NA	NA
Carp	100 Area	Metal	Barium	0.467	100%	NO	NO	NA	NA
Carp	300 Area	Metal	Barium	0.42	100%	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Barium	0.388	100%	NO	NO	NA	NA
Carp	All	Metal	Barium	0.4		NO	NO	NA	NA
Carp	Upriver	Metal	Cadmium	0.069	50	NO	NO	NA	NA
Carp	100 Area	Metal	Cadmium	0.065	40	NO	NO	NA	NA
Carp	300 Area	Metal	Cadmium	0.06	80	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Cadmium	0.065	20	NO	NO	NA	NA
Carp	All	Metal	Cadmium	0.06		NO	NO	NA	NA
Carp	Upriver	Metal	Chromium	0.401	0	NO	NO	NA	NA
Carp	100 Area	Metal	Chromium	0.327	60	NO	NO	NA	NA
Carp	300 Area	Metal	Chromium	0.269	80	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Chromium	0.517	40	NO	NO	NA	NA
Carp	All	Metal	Chromium	0.379		NO	NO	NA	NA
Carp	Upriver	Metal	Copper	0.78	100	NA	NA	NA	NA
Carp	100 Area	Metal	Copper	0.779	100	NA	NA	NA	NA
Carp	300 Area	Metal	Copper	0.68	100	NA	NA	NA	NA
Carp	Lake Wallula	Metal	Copper	0.739	100	NA	NA	NA	NA
Carp	All	Metal	Copper	0.74		NA	NA	NA	NA
Carp	Upriver	Metal	Iron	19.1	100	NA	NA	NA	NA
Carp	100 Area	Metal	Iron	14.1	100	NA	NA	NA	NA
Carp	300 Area	Metal	Iron	14.3	100	NA	NA	NA	NA
Carp	Lake Wallula	Metal	Iron	15.3	100	NA	NA	NA	NA
Carp	All	Metal	Iron	15.7		NA	NA	NA	NA
Carp	Upriver	Metal	Lead	0.219	50	NA	NA	NA	NA
Carp	100 Area	Metal	Lead	0.418	80	NA	NA	NA	NA
Carp	300 Area	Metal	Lead	0.256	60	NA	NA	NA	NA
Carp	Lake Wallula	Metal	Lead	0.407	60	NA	NA	NA	NA
Carp	All	Metal	Lead	0.325		NA	NA	NA	NA
Carp	Upriver	Metal	Lithium	0.856	50	NA	NA	NA	NA
Carp	100 Area	Metal	Lithium	0.583	80	NA	NA	NA	NA
Carp	300 Area	Metal	Lithium	0.73	60	NA	NA	NA	NA
Carp	Lake Wallula	Metal	Lithium	0.67	80	NA	NA	NA	NA
Carp	All	Metal	Lithium	0.71		NA	NA	NA	NA
Carp	Upriver	Metal	Manganese	0.59	100	NO	NO	NA	NA
Carp	100 Area	Metal	Manganese	0.749	100	NO	NO	NA	NA
Carp	300 Area	Metal	Manganese	0.76	100	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Manganese	0.89	100	NO	NO	NA	NA
Carp	All	Metal	Manganese	0.75		NO	NO	NA	NA
Carp	Upriver	Metal	Mercury	0.09	100	NO	**YES**	NA	NA
Carp	100 Area	Metal	Mercury	0.11	100	**YES**	**YES**	NA	NA
Carp	300 Area	Metal	Mercury	0.13	100	**YES**	**YES**	NA	NA
Carp	Lake Wallula	Metal	Mercury	0.15	100	**YES**	**YES**	NA	NA
Carp	All	Metal	Mercury	0.12		**YES**	**YES**	NA	NA
Carp	Upriver	Metal	Selenium	0.88	100	NO	NO	NA	NA
Carp	100 Area	Metal	Selenium	0.849	100	NO	NO	NA	NA
Carp	300 Area	Metal	Selenium	0.94	100	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Selenium	0.74	100	NO	NO	NA	NA
Carp	All	Metal	Selenium	0.85		NO	NO	NA	NA
Carp	Upriver	Metal	Strontium	3.42	100	NO	NO	NA	NA
Carp	100 Area	Metal	Strontium	3.93	100	NO	NO	NA	NA
Carp	300 Area	Metal	Strontium	3.54	100	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Strontium	3.8	100	NO	NO	NA	NA
Carp	All	Metal	Strontium	3.7		NO	NO	NA	NA
Carp	Upriver	Metal	Tin	11.42	75	NA	NA	NA	NA
Carp	100 Area	Metal	Tin	28.7	80	NA	NA	NA	NA
Carp	300 Area	Metal	Tin	18.7	100	NA	NA	NA	NA
Carp	Lake Wallula	Metal	Tin	29.8	100	NA	NA	NA	NA
Carp	All	Metal	Tin	22.2		NA	NA	NA	NA
Carp	Upriver	Metal	Vanadium	0.61	50	NO	NO	NA	NA
Carp	100 Area	Metal	Vanadium	0.46	80	NO	NO	NA	NA
Carp	300 Area	Metal	Vanadium	0.56	60	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Vanadium	0.3	100	NO	NO	NA	NA
Carp	All	Metal	Vanadium	0.5		NO	NO	NA	NA
Carp	Upriver	Metal	Zinc	27.0	100	NO	NO	NA	NA
Carp	100 Area	Metal	Zinc	27.7	100	NO	NO	NA	NA
Carp	300 Area	Metal	Zinc	24.9	100	NO	NO	NA	NA
Carp	Lake Wallula	Metal	Zinc	26.1	100	NO	NO	NA	NA
Carp	All	Metal	Zinc	26.4		NO	NO	NA	NA
Carp	Upriver	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0034	0	NA	NA	NA	NA
Carp	100 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.025	20	NA	NA	NA	NA
Carp	300 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.100	60	NA	NA	NA	NA
Carp	Lake Wallula	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.146	80	NA	NA	NA	NA
Carp	All	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.069		NA	NA	NA	NA
Carp	Upriver	Pesticide	Dichlorodiphenyldichloroethane	0.06145	100	NA	NA	NA	NA
Carp	100 Area	Pesticide	Dichlorodiphenyldichloroethane	0.05394	100	NA	NA	NA	NA
Carp	300 Area	Pesticide	Dichlorodiphenyldichloroethane	0.14934	100	NA	NA	NA	NA
Carp	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethane	0.123	100	NA	NA	NA	NA
Carp	All	Pesticide	Dichlorodiphenyldichloroethane	0.0969		NA	NA	NA	NA
Carp	Upriver	Pesticide	Dichlorodiphenyldichloroethylene	0.41625	100	NA	NA	NA	NA
Carp	100 Area	Pesticide	Dichlorodiphenyldichloroethylene	0.5134	100	NA	NA	NA	NA
Carp	300 Area	Pesticide	Dichlorodiphenyldichloroethylene	0.5986	100	NA	NA	NA	NA
Carp	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethylene	0.4082	100	NA	NA	NA	NA
Carp	All	Pesticide	Dichlorodiphenyldichloroethylene	0.484		NA	NA	NA	NA
Carp	Upriver	Pesticide	Total DDT	0.4777		NO	**YES**	**YES**	**YES**
Carp	100 Area	Pesticide	Total DDT	0.56734		NO	**YES**	**YES**	**YES**
Carp	300 Area	Pesticide	Total DDT	0.74794		**YES**	**YES**	**YES**	**YES**
Carp	Lake Wallula	Pesticide	Total DDT	0.531		NO	**YES**	**YES**	**YES**
Carp	All	Pesticide	Total DDT	0.581		NO	**YES**	**YES**	**YES**
Carp	Upriver	PCB	Total PCBs	0.252		**YES**	**YES**	**YES**	**YES**
Carp	100 Area	PCB	Total PCBs	0.328		**YES**	**YES**	**YES**	**YES**
Carp	300 Area	PCB	Total PCBs	0.351		**YES**	**YES**	**YES**	**YES**
Carp	Lake Wallula	PCB	Total PCBs	0.254		**YES**	**YES**	**YES**	**YES**
Carp	All	PCB	Total PCBs	0.296		**YES**	**YES**	**YES**	**YES**
Carp	Upriver	PCB	Total Dioxin-Like PCBs	9.85E-06		NA	NA	NA	NA
Carp	100 Area	PCB	Total Dioxin-Like PCBs	1.56E-05		NA	NA	NA	NA
Carp	300 Area	PCB	Total Dioxin-Like PCBs	1.56E-05		NA	NA	NA	NA
Carp	Lake Wallula	PCB	Total Dioxin-Like PCBs	1.01E-05		NA	NA	NA	NA
Carp	All	PCB	Total Dioxin-Like PCBs	1.28E-05		NA	NA	NA	NA

NA = not assessed

Highlighted values indicate exceedance of screening level

Appendix C, Table 3. Sturgeon Screening Level Exceedance

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)	Detection Frequency %	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Sturgeon	Upriver	Metal	Arsenic	0.53	11	NA	NA	NA	NA
Sturgeon	100 Area	Metal	Arsenic	0.61	100	NA	NA	NA	NA
Sturgeon	300 area	Metal	Arsenic	0.0496	33	NA	NA	NA	NA
Sturgeon	Lake Wallula	Metal	Arsenic	0.37	0	NA	NA	NA	NA
Sturgeon	All	Metal	Arsenic	0.39		NA	NA	NA	NA
Sturgeon	Upriver	Metal	Barium	0.19	0	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Barium	0.25	10	NO	NO	NA	NA
Sturgeon	300 area	Metal	Barium	0.212	60	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Barium	0.1	100	NO	NO	NA	NA
Sturgeon	All	Metal	Barium	0.2		NO	NO	NA	NA
Sturgeon	Upriver	Metal	Chromium	0.16	80	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Chromium	0.25	33	NO	NO	NA	NA
Sturgeon	300 area	Metal	Chromium	0.35	70	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Chromium	0.108	33	NO	NO	NA	NA
Sturgeon	All	Metal	Chromium	0.22		NO	NO	NA	NA
Sturgeon	Upriver	Metal	Iron	5.8	78	NA	NA	NA	NA
Sturgeon	100 Area	Metal	Iron	5.26	90	NA	NA	NA	NA
Sturgeon	300 area	Metal	Iron	4.49	50	NA	NA	NA	NA
Sturgeon	Lake Wallula	Metal	Iron	5.7	40	NA	NA	NA	NA
Sturgeon	All	Metal	Iron	5.3		NA	NA	NA	NA
Sturgeon	Upriver	Metal	Lithium	0.75	40	NA	NA	NA	NA
Sturgeon	100 Area	Metal	Lithium	0.87	0	NA	NA	NA	NA
Sturgeon	300 area	Metal	Lithium	0.97	0	NA	NA	NA	NA
Sturgeon	Lake Wallula	Metal	Lithium	0.7	50	NA	NA	NA	NA
Sturgeon	All	Metal	Lithium	0.8		NA	NA	NA	NA
Sturgeon	Upriver	Metal	Manganese	0.199	100	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Manganese	0.3	100	NO	NO	NA	NA
Sturgeon	300 area	Metal	Manganese	0.271	100	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Manganese	0.245	100	NO	NO	NA	NA
Sturgeon	All	Metal	Manganese	0.3		NO	NO	NA	NA
Sturgeon	Upriver	Metal	Mercury	0.05	85	NO	**YES**	NA	NA
Sturgeon	100 Area	Metal	Mercury	0.2	100	**YES**	**YES**	NA	NA
Sturgeon	300 area	Metal	Mercury	0.22	100	**YES**	**YES**	NA	NA
Sturgeon	Lake Wallula	Metal	Mercury	0.066	100	NO	**YES**	NA	NA
Sturgeon	All	Metal	Mercury	0.1		**YES**	**YES**	NA	NA
Sturgeon	Upriver	Metal	Methylmercury	0.054848	100	NO	**YES**	NA	NA
Sturgeon	300 area	Metal	Methylmercury	0.14956	100	**YES**	**YES**	NA	NA
Sturgeon	Lake Wallula	Metal	Methylmercury	0.072091	100	NO	**YES**	NA	NA
Sturgeon	All	Metal	Methylmercury	0.09217		NO	**YES**	NA	NA
Sturgeon	Upriver	Metal	Selenium	1.2	100	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Selenium	1.12	100	NO	NO	NA	NA
Sturgeon	300 area	Metal	Selenium	1.3	100	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Selenium	1.9	100	NO	NO	NA	NA
Sturgeon	All	Metal	Selenium	1.4		NO	NO	NA	NA
Sturgeon	Upriver	Metal	Strontium	0.37	0	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Strontium	0.281	0	NO	NO	NA	NA
Sturgeon	300 area	Metal	Strontium	0.30	30	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Strontium	0.3	33	NO	NO	NA	NA
Sturgeon	All	Metal	Strontium	0.3		NO	NO	NA	NA
Sturgeon	Upriver	Metal	Vanadium	0.93	0	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Vanadium	0.298	67	NO	NO	NA	NA
Sturgeon	300 area	Metal	Vanadium	0.84	20	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Vanadium	0.9	0	NO	NO	NA	NA
Sturgeon	All	Metal	Vanadium	0.7		NO	NO	NA	NA
Sturgeon	Upriver	Metal	Zinc	3.78	80	NO	NO	NA	NA
Sturgeon	100 Area	Metal	Zinc	3.58	100	NO	NO	NA	NA
Sturgeon	300 area	Metal	Zinc	3.75	100	NO	NO	NA	NA
Sturgeon	Lake Wallula	Metal	Zinc	2.56	33	NO	NO	NA	NA
Sturgeon	All	Metal	Zinc	3.42		NO	NO	NA	NA
Sturgeon	Upriver	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0047	0	NA	NA	NA	NA
Sturgeon	100 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.032	0	NA	NA	NA	NA
Sturgeon	300 Area	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.01	30	NA	NA	NA	NA
Sturgeon	Lake Wallula	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.044	83	NA	NA	NA	NA
Sturgeon	All	Pesticide	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.02		NA	NA	NA	NA
Sturgeon	Upriver	Pesticide	Dichlorodiphenyldichloroethane	0.079	100	NA	NA	NA	NA
Sturgeon	100 Area	Pesticide	Dichlorodiphenyldichloroethane	0.056	100	NA	NA	NA	NA
Sturgeon	300 Area	Pesticide	Dichlorodiphenyldichloroethane	0.03	70	NA	NA	NA	NA
Sturgeon	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethane	0.025	100	NA	NA	NA	NA
Sturgeon	All	Pesticide	Dichlorodiphenyldichloroethane	0.05		NA	NA	NA	NA
Sturgeon	Upriver	Pesticide	Dichlorodiphenyldichloroethylene	0.380	100	NA	NA	NA	NA
Sturgeon	100 Area	Pesticide	Dichlorodiphenyldichloroethylene	0.15	100	NA	NA	NA	NA
Sturgeon	300 Area	Pesticide	Dichlorodiphenyldichloroethylene	0.17	100	NA	NA	NA	NA
Sturgeon	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethylene	0.159	100	NA	NA	NA	NA
Sturgeon	All	Pesticide	Dichlorodiphenyldichloroethylene	0.21		NA	NA	NA	NA
Sturgeon	Upriver	Pesticide	Dichlorodiphenyltrichloroethane	0.0047	0	NA	NA	NA	NA
Sturgeon	100 Area	Pesticide	Dichlorodiphenyltrichloroethane	0.0032	0	NA	NA	NA	NA
Sturgeon	300 Area	Pesticide	Dichlorodiphenyltrichloroethane	0.005	30	NA	NA	NA	NA
Sturgeon	Lake Wallula	Pesticide	Dichlorodiphenyltrichloroethane	0.0080	67	NA	NA	NA	NA
Sturgeon	All	Pesticide	Dichlorodiphenyltrichloroethane	0.0052		NA	NA	NA	NA
Sturgeon	Upriver	Pesticide	Total DDT	0.464		NO	**YES**	**YES**	**YES**
Sturgeon	100 Area	Pesticide	Total DDT	0.209		NO	**YES**	**YES**	**YES**
Sturgeon	300 Area	Pesticide	Total DDT	0.205		NO	**YES**	**YES**	**YES**
Sturgeon	Lake Wallula	Pesticide	Total DDT	0.192		NO	NO	**YES**	**YES**
Sturgeon	All	Pesticide	Total DDT	0.267		NO	**YES**	**YES**	**YES**
Sturgeon	Upriver	PCB	Total PCBs	0.206		**YES**	**YES**	**YES**	**YES**
Sturgeon	100 Area	PCB	Total PCBs	0.180		**YES**	**YES**	**YES**	**YES**
Sturgeon	300 Area	PCB	Total PCBs	0.155		**YES**	**YES**	**YES**	**YES**
Sturgeon	Lake Wallula	PCB	Total PCBs	0.137		**YES**	**YES**	**YES**	**YES**
Sturgeon	All	PCB	Total PCBs	0.170		**YES**	**YES**	**YES**	**YES**
Sturgeon	Upriver	PCB	Total Dioxin-Like PCBs	5.02E-06		NA	NA	NA	NA
Sturgeon	100 Area	PCB	Total Dioxin-Like PCBs	8.63E-06		NA	NA	NA	NA
Sturgeon	300 Area	PCB	Total Dioxin-Like PCBs	6.72E-06		NA	NA	NA	NA
Sturgeon	Lake Wallula	PCB	Total Dioxin-Like PCBs	4.12E-06		NA	NA	NA	NA
Sturgeon	All	PCB	Total Dioxin-Like PCBs	6.12E-06		NA	NA	NA	NA

NA = not assessed

Highlighted values indicate exceedance of screening level

Appendix C, Table 4. Sucker Screening Level Exceedance

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)	Detection Frequency %	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Sucker	Upriver	Metal	Arsenic (inorganic)	0.0018	20	NO	NO	**YES**	**YES**
Sucker	100 Area	Metal	Arsenic (inorganic)	0.0015	0	NO	NO	**YES**	**YES**
Sucker	300 Area	Metal	Arsenic (inorganic)	0.0019	20	NO	NO	**YES**	**YES**
Sucker	Lake Wallula	Metal	Arsenic (inorganic)	0.0025	60	NO	NO	**YES**	**YES**
Sucker	All	Metal	Arsenic (inorganic)	0.0019		NO	NO	**YES**	**YES**
Sucker	Upriver	Metal	Barium	0.71	100	NO	NO	NA	NA
Sucker	100 Area	Metal	Barium	0.63	100	NO	NO	NA	NA
Sucker	300 Area	Metal	Barium	0.520	100	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Barium	0.524	100	NO	NO	NA	NA
Sucker	All	Metal	Barium	0.60		NO	NO	NA	NA
Sucker	Upriver	Metal	Chromium	0.31	100	NO	NO	NA	NA
Sucker	100 Area	Metal	Chromium	0.351	100	NO	NO	NA	NA
Sucker	300 Area	Metal	Chromium	0.2	60	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Chromium	0.182	80	NO	NO	NA	NA
Sucker	All	Metal	Chromium	0.3		NO	NO	NA	NA
Sucker	Upriver	Metal	Copper	0.400	40	NA	NA	NA	NA
Sucker	100 Area	Metal	Copper	0.5	80	NA	NA	NA	NA
Sucker	300 Area	Metal	Copper	0.6	40	NA	NA	NA	NA
Sucker	Lake Wallula	Metal	Copper	0.43	60	NA	NA	NA	NA
Sucker	All	Metal	Copper	0.5		NA	NA	NA	NA
Sucker	Upriver	Metal	Iron	9.2	100	NA	NA	NA	NA
Sucker	100 Area	Metal	Iron	7.3	100	NA	NA	NA	NA
Sucker	300 Area	Metal	Iron	5.35	100	NA	NA	NA	NA
Sucker	Lake Wallula	Metal	Iron	6.05	100	NA	NA	NA	NA
Sucker	All	Metal	Iron	7.0		NA	NA	NA	NA
Sucker	Upriver	Metal	Manganese	2.8	100	NO	NO	NA	NA
Sucker	100 Area	Metal	Manganese	2.23	100	NO	NO	NA	NA
Sucker	300 Area	Metal	Manganese	1.7	100	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Manganese	1.55	100	NO	NO	NA	NA
Sucker	All	Metal	Manganese	2.1		NO	NO	NA	NA
Sucker	Upriver	Metal	Mercury	0.103	100	**YES**	**YES**	NA	NA
Sucker	100 Area	Metal	Mercury	0.111	100	**YES**	**YES**	NA	NA
Sucker	300 Area	Metal	Mercury	0.128	100	**YES**	**YES**	NA	NA
Sucker	Lake Wallula	Metal	Mercury	0.124	100	**YES**	**YES**	NA	NA
Sucker	All	Metal	Mercury	0.117		**YES**	**YES**	NA	NA
Sucker	Upriver	Metal	Selenium	0.703	100	NO	NO	NA	NA
Sucker	100 Area	Metal	Selenium	0.98	100	NO	NO	NA	NA
Sucker	300 Area	Metal	Selenium	0.808	100	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Selenium	0.9	100	NO	NO	NA	NA
Sucker	All	Metal	Selenium	0.8		NO	NO	NA	NA
Sucker	Upriver	Metal	Strontium	2.9	100	NO	NO	NA	NA
Sucker	100 Area	Metal	Strontium	2.41	100	NO	NO	NA	NA
Sucker	300 Area	Metal	Strontium	2.5	100	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Strontium	2.5	100	NO	NO	NA	NA
Sucker	All	Metal	Strontium	2.6		NO	NO	NA	NA
Sucker	Upriver	Metal	Tin	2.7	20	NA	NA	NA	NA
Sucker	100 Area	Metal	Tin	5.15	60	NA	NA	NA	NA
Sucker	300 Area	Metal	Tin	0.93	0	NA	NA	NA	NA
Sucker	Lake Wallula	Metal	Tin	2.00	20	NA	NA	NA	NA
Sucker	All	Metal	Tin	2.7		NA	NA	NA	NA
Sucker	Upriver	Metal	Vanadium	0.57	60	NO	NO	NA	NA
Sucker	100 Area	Metal	Vanadium	1.03	0	NO	NO	NA	NA
Sucker	300 Area	Metal	Vanadium	1.12	0	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Vanadium	0.96	0	NO	NO	NA	NA
Sucker	All	Metal	Vanadium	0.92		NO	NO	NA	NA
Sucker	Upriver	Metal	Zinc	16.4	100	NO	NO	NA	NA
Sucker	100 Area	Metal	Zinc	14.0	100	NO	NO	NA	NA
Sucker	300 Area	Metal	Zinc	11.8	100	NO	NO	NA	NA
Sucker	Lake Wallula	Metal	Zinc	11.90	100	NO	NO	NA	NA
Sucker	All	Metal	Zinc	13.5		NO	NO	NA	NA
Sucker	Upriver	Pesticide	Delta-BHC	0.0083	0	NA	NA	NA	NA
Sucker	100 Area	Pesticide	Delta-BHC	0.007	0	NA	NA	NA	NA
Sucker	300 Area	Pesticide	Delta-BHC	0.0362	20	NA	NA	NA	NA
Sucker	Lake Wallula	Pesticide	Delta-BHC	0.008	0	NA	NA	NA	NA
Sucker	All	Pesticide	Delta-BHC	0.015		NA	NA	NA	NA
Sucker	Upriver	Pesticide	Dichlorodiphenyldichloroethane	0.144	100	NA	NA	NA	NA
Sucker	100 Area	Pesticide	Dichlorodiphenyldichloroethane	0.035	100	NA	NA	NA	NA
Sucker	300 Area	Pesticide	Dichlorodiphenyldichloroethane	0.0419	80	NA	NA	NA	NA
Sucker	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethane	0.0353	100	NA	NA	NA	NA
Sucker	All	Pesticide	Dichlorodiphenyldichloroethane	0.064		NA	NA	NA	NA
Sucker	Upriver	Pesticide	Dichlorodiphenyldichloroethylene	0.151	100	NA	NA	NA	NA
Sucker	100 Area	Pesticide	Dichlorodiphenyldichloroethylene	0.159	100	NA	NA	NA	NA
Sucker	300 Area	Pesticide	Dichlorodiphenyldichloroethylene	0.23	100	NA	NA	NA	NA
Sucker	Lake Wallula	Pesticide	Dichlorodiphenyldichloroethylene	0.2	100	NA	NA	NA	NA
Sucker	All	Pesticide	Dichlorodiphenyldichloroethylene	0.2		NA	NA	NA	NA
Sucker	Upriver	Pesticide	Total DDT	0.295	100	NO	**YES**	**YES**	**YES**
Sucker	100 Area	Pesticide	Total DDT	0.194	100	NO	NO	**YES**	**YES**
Sucker	300 Area	Pesticide	Total DDT	0.27	100	NO	**YES**	**YES**	**YES**
Sucker	Lake Wallula	Pesticide	Total DDT	0.2	100	NO	**YES**	**YES**	**YES**
Sucker	All	Pesticide	Total DDT	0.2		NO	**YES**	**YES**	**YES**
Sucker	Upriver	PCB	Total PCBs	0.083		**YES**	**YES**	**YES**	**YES**
Sucker	100 Area	PCB	Total PCBs	0.140		**YES**	**YES**	**YES**	**YES**
Sucker	300 Area	PCB	Total PCBs	0.182		**YES**	**YES**	**YES**	**YES**
Sucker	Lake Wallula	PCB	Total PCBs	0.172		**YES**	**YES**	**YES**	**YES**
Sucker	All	PCB	Total PCBs	0.144		**YES**	**YES**	**YES**	**YES**
Sucker	Upriver	PCB	Total Dioxin-Like PCBs	3.07E-06		NA	NA	NA	NA
Sucker	100 Area	PCB	Total Dioxin-Like PCBs	5.40E-06		NA	NA	NA	NA
Sucker	300 Area	PCB	Total Dioxin-Like PCBs	5.95E-06		NA	NA	NA	NA
Sucker	Lake Wallula	PCB	Total Dioxin-Like PCBs	6.93E-06		NA	NA	NA	NA
Sucker	All	PCB	Total Dioxin-Like PCBs	5.34E-06		NA	NA	NA	NA

NA = not assessed
Highlighted values indicate exceedance of screening level

Appendix C, Table 5. Walleye Screening Level Exceedance

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)	Detection Frequency %	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Walleye	Upriver	Metal	Arsenic (inorganic)	0.001	0	NO	NO	YES	YES
Walleye	100 Area	Metal	Arsenic (inorganic)	0.0020	50	NO	NO	YES	YES
Walleye	300 Area	Metal	Arsenic (inorganic)	0.002	20	NO	NO	YES	YES
Walleye	Lake Wallula	Metal	Arsenic (inorganic)	0.003	80	NO	NO	YES	YES
Walleye	All	Metal	Arsenic (inorganic)	0.002		NO	NO	YES	YES
Walleye	Upriver	Metal	Barium	0.415	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Barium	0.38	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Barium	0.30	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Barium	0.28	80	NO	NO	NA	NA
Walleye	All	Metal	Barium	0.34		NO	NO	NA	NA
Walleye	Upriver	Metal	Chromium	0.53	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Chromium	0.400	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Chromium	0.23	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Chromium	0.34	100	NO	NO	NA	NA
Walleye	All	Metal	Chromium	0.38		NO	NO	NA	NA
Walleye	Upriver	Metal	Cobalt	0.9	33	NA	NA	NA	NA
Walleye	100 Area	Metal	Cobalt	0.73	0	NA	NA	NA	NA
Walleye	300 Area	Metal	Cobalt	0.8	0	NA	NA	NA	NA
Walleye	Lake Wallula	Metal	Cobalt	0.76	20	NA	NA	NA	NA
Walleye	All	Metal	Cobalt	0.8		NA	NA	NA	NA
Walleye	Upriver	Metal	Iron	6.3	100	NA	NA	NA	NA
Walleye	100 Area	Metal	Iron	4.1	100	NA	NA	NA	NA
Walleye	300 Area	Metal	Iron	7.5	20	NA	NA	NA	NA
Walleye	Lake Wallula	Metal	Iron	6.3	60	NA	NA	NA	NA
Walleye	All	Metal	Iron	6.1		NA	NA	NA	NA
Walleye	Upriver	Metal	Lithium	0.9	33	NA	NA	NA	NA
Walleye	100 Area	Metal	Lithium	0.67	100	NA	NA	NA	NA
Walleye	300 Area	Metal	Lithium	0.62	0	NA	NA	NA	NA
Walleye	Lake Wallula	Metal	Lithium	0.94	0	NA	NA	NA	NA
Walleye	All	Metal	Lithium	0.8		NA	NA	NA	NA
Walleye	Upriver	Metal	Manganese	0.57	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Manganese	0.37	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Manganese	0.341	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Manganese	0.349	100	NO	NO	NA	NA
Walleye	All	Metal	Manganese	0.41		NO	NO	NA	NA
Walleye	Upriver	Metal	Mercury	0.31	100	YES	YES	NA	NA
Walleye	100 Area	Metal	Mercury	0.324	100	YES	YES	NA	NA
Walleye	300 Area	Metal	Mercury	0.21	100	YES	YES	NA	NA
Walleye	Lake Wallula	Metal	Mercury	0.185	100	YES	YES	NA	NA
Walleye	All	Metal	Mercury	0.26		YES	YES	NA	NA
Walleye	Upriver	Metal	Selenium	0.7	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Selenium	0.59	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Selenium	0.65	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Selenium	0.64	100	NO	NO	NA	NA
Walleye	All	Metal	Selenium	0.6		NO	NO	NA	NA
Walleye	Upriver	Metal	Strontium	6.10	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Strontium	4.92	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Strontium	4.30	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Strontium	2.8	100	NO	NO	NA	NA
Walleye	All	Metal	Strontium	4.5		NO	NO	NA	NA
Walleye	Upriver	Metal	Tin	3.3	33	NA	NA	NA	NA
Walleye	100 Area	Metal	Tin	15.9	100	NA	NA	NA	NA
Walleye	300 Area	Metal	Tin	6.0	80	NA	NA	NA	NA
Walleye	Lake Wallula	Metal	Tin	1.8	20	NA	NA	NA	NA
Walleye	All	Metal	Tin	6.8		NA	NA	NA	NA
Walleye	Upriver	Metal	Vanadium	0.339	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Vanadium	0.241	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Vanadium	0.339	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Vanadium	0.29	100	NO	NO	NA	NA
Walleye	All	Metal	Vanadium	0.30		NO	NO	NA	NA
Walleye	Upriver	Metal	Zinc	10.6	100	NO	NO	NA	NA
Walleye	100 Area	Metal	Zinc	7.9	100	NO	NO	NA	NA
Walleye	300 Area	Metal	Zinc	8.2	100	NO	NO	NA	NA
Walleye	Lake Wallula	Metal	Zinc	6.03	100	NO	NO	NA	NA
Walleye	All	Metal	Zinc	8.2		NO	NO	NA	NA
Walleye	Upriver	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.45	100	NA	NA	NA	NA
Walleye	100 Area	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.0166	50	NA	NA	NA	NA
Walleye	300 Area	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.042	60	NA	NA	NA	NA
Walleye	Lake Wallula	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.069	80	NA	NA	NA	NA
Walleye	All	Pesticides	beta-1,2,3,4,5,6-Hexachlorocyclohexane	0.14		NA	NA	NA	NA
Walleye	Upriver	Pesticides	Gamma-BHC (Lindane)	0.0322	67	NO	NO	NA	NA
Walleye	100 Area	Pesticides	Gamma-BHC (Lindane)	0.0030	0	NO	NO	NA	NA
Walleye	300 Area	Pesticides	Gamma-BHC (Lindane)	0.0032	0	NO	NO	NA	NA
Walleye	Lake Wallula	Pesticides	Gamma-BHC (Lindane)	0.0108	40	NO	NO	NA	NA
Walleye	All	Pesticides	Gamma-BHC (Lindane)	0.0123		NO	NO	NA	NA
Walleye	Upriver	Pesticides	Total BHC (Lindane)	0.48	67	NA	NA	NA	NA
Walleye	100 Area	Pesticides	Total BHC (Lindane)	0.0196	0	NA	NA	NA	NA
Walleye	300 Area	Pesticides	Total BHC (Lindane)	0.045	0	NA	NA	NA	NA
Walleye	Lake Wallula	Pesticides	Total BHC (Lindane)	0.080	40	NA	NA	NA	NA
Walleye	All	Pesticides	Total BHC (Lindane)	0.16		NA	NA	NA	NA
Walleye	Upriver	Pesticides	Dichlorodiphenyldichloroethane	0.126	100	NA	NA	NA	NA
Walleye	100 Area	Pesticides	Dichlorodiphenyldichloroethane	0.0164	17	NA	NA	NA	NA
Walleye	300 Area	Pesticides	Dichlorodiphenyldichloroethane	0.0148	40	NA	NA	NA	NA
Walleye	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethane	0.0071	20	NA	NA	NA	NA
Walleye	All	Pesticides	Dichlorodiphenyldichloroethane	0.041		NA	NA	NA	NA
Walleye	Upriver	Pesticides	Dichlorodiphenyldichloroethylene	0.3	100	NA	NA	NA	NA
Walleye	100 Area	Pesticides	Dichlorodiphenyldichloroethylene	0.157	100	NA	NA	NA	NA
Walleye	300 Area	Pesticides	Dichlorodiphenyldichloroethylene	0.145	100	NA	NA	NA	NA
Walleye	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethylene	0.03	100	NA	NA	NA	NA
Walleye	All	Pesticides	Dichlorodiphenyldichloroethylene	0.2		NA	NA	NA	NA
Walleye	Upriver	Pesticides	Dichlorodiphenyltrichloroethane	0.0081	17	NA	NA	NA	NA
Walleye	100 Area	Pesticides	Dichlorodiphenyltrichloroethane	0.00373	17	NA	NA	NA	NA
Walleye	300 Area	Pesticides	Dichlorodiphenyltrichloroethane	0.00456	40	NA	NA	NA	NA
Walleye	Lake Wallula	Pesticides	Dichlorodiphenyltrichloroethane	0.0058	0	NA	NA	NA	NA
Walleye	All	Pesticides	Dichlorodiphenyltrichloroethane	0.0055		NA	NA	NA	NA
Walleye	Upriver	Pesticides	Total DDT	0.434		NO	YES	YES	YES
Walleye	100 Area	Pesticides	Total DDT	0.177		NO	NO	YES	YES
Walleye	300 Area	Pesticides	Total DDT	0.164		NO	NO	YES	YES
Walleye	Lake Wallula	Pesticides	Total DDT	0.04		NO	NO	YES	YES
Walleye	All	Pesticides	Total DDT	0.2		NO	YES	YES	YES
Walleye	Upriver	Pesticides	Heptachlor	0.0071	0	NO	NO	YES	YES
Walleye	100 Area	Pesticides	Heptachlor	0.0079	33	NO	NO	YES	YES
Walleye	300 Area	Pesticides	Heptachlor	0.0048	20	NO	NO	YES	YES
Walleye	Lake Wallula	Pesticides	Heptachlor	0.0058	0	NO	NO	YES	YES
Walleye	All	Pesticides	Heptachlor	0.0064		NO	NO	YES	YES
Walleye	Upriver	PCB	Total PCBs	0.158		YES	YES	YES	YES
Walleye	100 Area	PCB	Total PCBs	0.327		YES	YES	YES	YES
Walleye	300 Area	PCB	Total PCBs	0.103		YES	YES	YES	YES
Walleye	Lake Wallula	PCB	Total PCBs	0.035		YES	YES	YES	YES
Walleye	All	PCB	Total PCBs	0.156		YES	YES	YES	YES
Walleye	Upriver	PCB	Total Dioxin-Like PCBs	6.73E-06		NA	NA	NA	NA
Walleye	100 Area	PCB	Total Dioxin-Like PCBs	1.49E-05		NA	NA	NA	NA
Walleye	300 Area	PCB	Total Dioxin-Like PCBs	3.75E-06		NA	NA	NA	NA
Walleye	Lake Wallula	PCB	Total Dioxin-Like PCBs	9.77E-07		NA	NA	NA	NA
Walleye	All	PCB	Total Dioxin-Like PCBs	6.58E-06		NA	NA	NA	NA

NA = not assessed
Highlighted values indicate exceedance of screening level

Appendix C, Table 6. Whitefish Screening Level Exceedance

Species	Location	Chemical Category	Chemical	Concentration mg/kg (ppm)	Detection Frequency %	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Whitefish	Upriver	Metal	Aluminum	2.9	40	NA	NA	NA	NA
Whitefish	100 Area	Metal	Aluminum	2.29	20	NA	NA	NA	NA
Whitefish	300 Area	Metal	Aluminum	2.3	20	NA	NA	NA	NA
Whitefish	Lake Wallula	Metal	Aluminum	1.89	0	NA	NA	NA	NA
Whitefish	All	Metal	Aluminum	2.3		NA	NA	NA	NA
Whitefish	Upriver	Metal	Arsenic	0.387	20	NA	NA	NA	NA
Whitefish	100 Area	Metal	Arsenic	0.325	60	NA	NA	NA	NA
Whitefish	300 Area	Metal	Arsenic	0.315	80	NA	NA	NA	NA
Whitefish	Lake Wallula	Metal	Arsenic	0.309	100	NA	NA	NA	NA
Whitefish	All	Metal	Arsenic	0.334		NA	NA	NA	NA
Whitefish	Upriver	Metal	Barium	0.335	80	NO	NO	NA	NA
Whitefish	100 Area	Metal	Barium	0.218	100	NO	NO	NA	NA
Whitefish	300 Area	Metal	Barium	0.45	100	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Barium	0.38	100	NO	NO	NA	NA
Whitefish	All	Metal	Barium	0.35		NO	NO	NA	NA
Whitefish	Upriver	Metal	Boron	1.30	100	NO	NO	NA	NA
Whitefish	100 Area	Metal	Boron	0.77	0	NO	NO	NA	NA
Whitefish	300 Area	Metal	Boron	0.83	0	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Boron	0.75	0	NO	NO	NA	NA
Whitefish	All	Metal	Boron	0.91		NO	NO	NA	NA
Whitefish	Upriver	Metal	Cadmium	0.083	0	NO	NO	NA	NA
Whitefish	100 Area	Metal	Cadmium	0.077	0	NO	NO	NA	NA
Whitefish	300 Area	Metal	Cadmium	0.083	0	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Cadmium	0.059	60	NO	NO	NA	NA
Whitefish	All	Metal	Cadmium	0.076		NO	NO	NA	NA
Whitefish	Upriver	Metal	Chromium	0.60	100	NO	NO	NA	NA
Whitefish	100 Area	Metal	Chromium	0.54	100	NO	NO	NA	NA
Whitefish	300 Area	Metal	Chromium	0.455	100	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Chromium	0.469	100	NO	NO	NA	NA
Whitefish	All	Metal	Chromium	0.52		NO	NO	NA	NA
Whitefish	Upriver	Metal	Copper	0.661	80	NA	NA	NA	NA
Whitefish	100 Area	Metal	Copper	0.559	100	NA	NA	NA	NA
Whitefish	300 Area	Metal	Copper	0.692	100	NA	NA	NA	NA
Whitefish	Lake Wallula	Metal	Copper	0.684	100	NA	NA	NA	NA
Whitefish	All	Metal	Copper	0.649		NA	NA	NA	NA
Whitefish	Upriver	Metal	Iron	8.4	80	NA	NA	NA	NA
Whitefish	100 Area	Metal	Iron	8.0	100	NA	NA	NA	NA
Whitefish	300 Area	Metal	Iron	7.9	100	NA	NA	NA	NA
Whitefish	Lake Wallula	Metal	Iron	8.9	100	NA	NA	NA	NA
Whitefish	All	Metal	Iron	8.3		NA	NA	NA	NA
Whitefish	Upriver	Metal	Manganese	0.309	0	NO	NO	NA	NA
Whitefish	100 Area	Metal	Manganese	0.499	80	NO	NO	NA	NA
Whitefish	300 Area	Metal	Manganese	0.74	100	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Manganese	0.8	100	NO	NO	NA	NA
Whitefish	All	Metal	Manganese	0.6		NO	NO	NA	NA
Whitefish	Upriver	Metal	Mercury	0.027	100	NO	NO	NA	NA
Whitefish	100 Area	Metal	Mercury	0.07	100	NO	**YES**	NA	NA
Whitefish	300 Area	Metal	Mercury	0.055	100	NO	**YES**	NA	NA
Whitefish	Lake Wallula	Metal	Mercury	0.06	100	NO	**YES**	NA	NA
Whitefish	All	Metal	Mercury	0.05		NO	**YES**	NA	NA
Whitefish	Upriver	Metal	Selenium	0.76	100	NO	NO	NA	NA
Whitefish	100 Area	Metal	Selenium	0.92	100	NO	NO	NA	NA
Whitefish	300 Area	Metal	Selenium	1.09	100	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Selenium	1.09	100	NO	NO	NA	NA
Whitefish	All	Metal	Selenium	0.97		NO	NO	NA	NA
Whitefish	Upriver	Metal	Strontium	2.18	100	NO	NO	NA	NA
Whitefish	100 Area	Metal	Strontium	1.90	100	NO	NO	NA	NA
Whitefish	300 Area	Metal	Strontium	4.67	100	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Strontium	3.0	100	NO	NO	NA	NA
Whitefish	All	Metal	Strontium	2.9		NO	NO	NA	NA
Whitefish	Upriver	Metal	Tin	15.4	100	NA	NA	NA	NA
Whitefish	100 Area	Metal	Tin	24.6	100	NA	NA	NA	NA
Whitefish	300 Area	Metal	Tin	64.5	100	NA	NA	NA	NA
Whitefish	Lake Wallula	Metal	Tin	51.8	100	NA	NA	NA	NA
Whitefish	All	Metal	Tin	39.1		NA	NA	NA	NA
Whitefish	Upriver	Metal	Vanadium	1.04	0	NO	NO	NA	NA
Whitefish	100 Area	Metal	Vanadium	0.96	0	NO	NO	NA	NA
Whitefish	300 Area	Metal	Vanadium	0.66	40	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Vanadium	0.52	60	NO	NO	NA	NA
Whitefish	All	Metal	Vanadium	0.80		NO	NO	NA	NA
Whitefish	Upriver	Metal	Zinc	11.8	100	NO	NO	NA	NA
Whitefish	100 Area	Metal	Zinc	9.8	100	NO	NO	NA	NA
Whitefish	300 Area	Metal	Zinc	13.7	100	NO	NO	NA	NA
Whitefish	Lake Wallula	Metal	Zinc	10.8	100	NO	NO	NA	NA
Whitefish	All	Metal	Zinc	11.5		NO	NO	NA	NA
Whitefish	Upriver	Pesticides	Dichlorodiphenyldichloroethane	0.0256	100	NA	NA	NA	NA
Whitefish	100 Area	Pesticides	Dichlorodiphenyldichloroethane	0.079	100	NA	NA	NA	NA
Whitefish	300 Area	Pesticides	Dichlorodiphenyldichloroethane	0.098	100	NA	NA	NA	NA
Whitefish	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethane	0.055	100	NA	NA	NA	NA
Whitefish	All	Pesticides	Dichlorodiphenyldichloroethane	0.064		NA	NA	NA	NA
Whitefish	Upriver	Pesticides	Dichlorodiphenyldichloroethylene	0.18	100	NA	NA	NA	NA
Whitefish	100 Area	Pesticides	Dichlorodiphenyldichloroethylene	0.259	100	NA	NA	NA	NA
Whitefish	300 Area	Pesticides	Dichlorodiphenyldichloroethylene	0.22	100	NA	NA	NA	NA
Whitefish	Lake Wallula	Pesticides	Dichlorodiphenyldichloroethylene	0.15	100	NA	NA	NA	NA
Whitefish	All	Pesticides	Dichlorodiphenyldichloroethylene	0.20		NA	NA	NA	NA
Whitefish	Upriver	Pesticides	Total DDT	0.21		NO	**YES**	**YES**	**YES**
Whitefish	100 Area	Pesticides	Total DDT	0.338		NO	**YES**	**YES**	**YES**
Whitefish	300 Area	Pesticides	Total DDT	0.32		NO	**YES**	**YES**	**YES**
Whitefish	Lake Wallula	Pesticides	Total DDT	0.21		NO	**YES**	**YES**	**YES**
Whitefish	All	Pesticides	Total DDT	0.27		NO	**YES**	**YES**	**YES**
Whitefish	Upriver	Pesticides	Dieldrin	0.0143	80	NO	NO	**YES**	**YES**
Whitefish	100 Area	Pesticides	Dieldrin	0.0209	100	NO	**YES**	**YES**	**YES**
Whitefish	300 Area	Pesticides	Dieldrin	0.028	100	NO	**YES**	**YES**	**YES**
Whitefish	Lake Wallula	Pesticides	Dieldrin	0.0289	100	NO	**YES**	**YES**	**YES**
Whitefish	All	Pesticides	Dieldrin	0.023		NO	**YES**	**YES**	**YES**
Whitefish	Upriver	PCB	Total PCBs	0.873		**YES**	**YES**	**YES**	**YES**
Whitefish	100 Area	PCB	Total PCBs	0.330		**YES**	**YES**	**YES**	**YES**
Whitefish	300 Area	PCB	Total PCBs	0.271		**YES**	**YES**	**YES**	**YES**
Whitefish	Lake Wallula	PCB	Total PCBs	0.120		**YES**	**YES**	**YES**	**YES**
Whitefish	All	PCB	Total PCBs	0.398		**YES**	**YES**	**YES**	**YES**
Whitefish	Upriver	PCB	Total Dioxin-Like PCBs	4.69E-05		NA	NA	NA	NA
Whitefish	100 Area	PCB	Total Dioxin-Like PCBs	1.23E-05		NA	NA	NA	NA
Whitefish	300 Area	PCB	Total Dioxin-Like PCBs	1.08E-05		NA	NA	NA	NA
Whitefish	Lake Wallula	PCB	Total Dioxin-Like PCBs	4.81E-06		NA	NA	NA	NA
Whitefish	All	PCB	Total Dioxin-Like PCBs	1.87E-05		NA	NA	NA	NA

NA = not assessed

Highlighted values indicate exceedance of screening level

Appendix C, Table 7. Summary - Screening Level Exceedance

Species	Location	Chemical	Concentration mg/kg (ppm)	Exceed General Population Non-Cancer SL	Exceed High Consumer Non-Cancer SL	Exceed General Population Cancer SL	Exceed High Consumer Cancer SL
Bass	Upriver	Mercury	0.078	NO	YES	NA	NA
Bass	100 Area	Mercury	0.085	NO	YES	NA	NA
Bass	300 Area	Mercury	0.077	NO	YES	NA	NA
Bass	Lake Wallula	Mercury	0.058	NO	YES	NA	NA
Bass	All	Mercury	0.075	NO	YES	NA	NA
Bass	Upriver	Total DDT	0.041	NO	NO	YES	YES
Bass	100 Area	Total DDT	0.318	NO	YES	YES	YES
Bass	300 Area	Total DDT	0.250	NO	YES	YES	YES
Bass	Lake Wallula	Total DDT	0.028	NO	NO	YES	YES
Bass	All	Total DDT	0.159	NO	NO	YES	YES
Bass	Upriver	Total PCBs	0.067	YES	YES	YES	YES
Bass	100 Area	Total PCBs	0.111	YES	YES	YES	YES
Bass	300 Area	Total PCBs	0.061	YES	YES	YES	YES
Bass	Lake Wallula	Total PCBs	0.052	YES	YES	YES	YES
Bass	All	Total PCBs	0.073	YES	YES	YES	YES
Carp	Upriver	Arsenic (inorganic)	0.020	NO	NO	YES	YES
Carp	100 Area	Arsenic (inorganic)	0.003	NO	NO	YES	YES
Carp	300 Area	Arsenic (inorganic)	0.002	NO	NO	YES	YES
Carp	Lake Wallula	Arsenic (inorganic)	0.003	NO	NO	YES	YES
Carp	All	Arsenic (inorganic)	0.007	NO	NO	YES	YES
Carp	Upriver	Mercury	0.090	NO	YES	NA	NA
Carp	100 Area	Mercury	0.110	YES	YES	NA	NA
Carp	300 Area	Mercury	0.130	YES	YES	NA	NA
Carp	Lake Wallula	Mercury	0.150	YES	YES	NA	NA
Carp	All	Mercury	0.120	YES	YES	NA	NA
Carp	Upriver	Total DDT	0.110	NO	YES	YES	YES
Carp	100 Area	Total DDT	0.113	NO	YES	YES	YES
Carp	300 Area	Total DDT	0.132	YES	YES	YES	YES
Carp	Lake Wallula	Total DDT	0.153	NO	YES	YES	YES
Carp	All	Total DDT	0.127	NO	YES	YES	YES
Carp	Upriver	Total PCBs	0.252	YES	YES	YES	YES
Carp	100 Area	Total PCBs	0.328	YES	YES	YES	YES
Carp	300 Area	Total PCBs	0.351	YES	YES	YES	YES
Carp	Lake Wallula	Total PCBs	0.254	YES	YES	YES	YES
Carp	All	Total PCBs	0.296	YES	YES	YES	YES
Sturgeon	Upriver	Mercury	0.050	NO	YES	NA	NA
Sturgeon	100 Area	Mercury	0.200	YES	YES	NA	NA
Sturgeon	300 area	Mercury	0.220	YES	YES	NA	NA
Sturgeon	Lake Wallula	Mercury	0.066	NO	YES	NA	NA
Sturgeon	All	Mercury	0.134	YES	YES	NA	NA
Sturgeon	Upriver	Methylmercury	0.055	NO	YES	NA	NA
Sturgeon	300 area	Methylmercury	0.150	YES	YES	NA	NA
Sturgeon	Lake Wallula	Methylmercury	0.072	NO	YES	NA	NA
Sturgeon	All	Methylmercury	0.092	NO	YES	NA	NA
Sturgeon	Upriver	Total DDT	0.000	NO	YES	YES	YES
Sturgeon	100 Area	Total DDT	0.357	NO	YES	YES	YES
Sturgeon	300 Area	Total DDT	0.678	NO	YES	YES	YES
Sturgeon	Lake Wallula	Total DDT	0.643	NO	NO	YES	YES
Sturgeon	All	Total DDT	0.412	NO	YES	YES	YES
Sturgeon	Upriver	Total PCBs	0.206	YES	YES	YES	YES
Sturgeon	100 Area	Total PCBs	0.180	YES	YES	YES	YES
Sturgeon	300 Area	Total PCBs	0.155	YES	YES	YES	YES
Sturgeon	Lake Wallula	Total PCBs	0.137	YES	YES	YES	YES
Sturgeon	All	Total PCBs	0.170	YES	YES	YES	YES
Sucker	Upriver	Arsenic (inorganic)	0.0018	NO	NO	YES	YES
Sucker	100 Area	Arsenic (inorganic)	0.0015	NO	NO	YES	YES
Sucker	300 Area	Arsenic (inorganic)	0.0019	NO	NO	YES	YES
Sucker	Lake Wallula	Arsenic (inorganic)	0.0025	NO	NO	YES	YES
Sucker	All	Arsenic (inorganic)	0.0019	NO	NO	YES	YES
Sucker	Upriver	Mercury	0.103	YES	YES	NA	NA
Sucker	100 Area	Mercury	0.111	YES	YES	NA	NA
Sucker	300 Area	Mercury	0.128	YES	YES	NA	NA
Sucker	Lake Wallula	Mercury	0.124	YES	YES	NA	NA
Sucker	All	Mercury	0.117	YES	YES	NA	NA
Sucker	Upriver	Total DDT	0.105	NO	YES	YES	YES
Sucker	100 Area	Total DDT	0.113	NO	NO	YES	YES
Sucker	300 Area	Total DDT	0.130	NO	YES	YES	YES
Sucker	Lake Wallula	Total DDT	0.127	NO	YES	YES	YES
Sucker	All	Total DDT	0.118	NO	YES	YES	YES
Sucker	Upriver	Total PCBs	0.083	YES	YES	YES	YES
Sucker	100 Area	Total PCBs	0.140	YES	YES	YES	YES
Sucker	300 Area	Total PCBs	0.182	YES	YES	YES	YES
Sucker	Lake Wallula	Total PCBs	0.172	YES	YES	YES	YES
Sucker	All	Total PCBs	0.144	YES	YES	YES	YES
Walleye	Upriver	Arsenic (inorganic)	0.001	NO	NO	YES	YES
Walleye	100 Area	Arsenic (inorganic)	0.002	NO	NO	YES	YES
Walleye	300 Area	Arsenic (inorganic)	0.002	NO	NO	YES	YES
Walleye	Lake Wallula	Arsenic (inorganic)	0.003	NO	NO	YES	YES
Walleye	All	Arsenic (inorganic)	0.002	NO	NO	YES	YES
Walleye	Upriver	Mercury	0.310	YES	YES	NA	NA
Walleye	100 Area	Mercury	0.324	YES	YES	NA	NA
Walleye	300 Area	Mercury	0.210	YES	YES	NA	NA
Walleye	Lake Wallula	Mercury	0.185	YES	YES	NA	NA
Walleye	All	Mercury	0.257	YES	YES	NA	NA
Walleye	Upriver	Total DDT	0.394	NO	YES	YES	YES
Walleye	100 Area	Total DDT	0.466	NO	NO	YES	YES
Walleye	300 Area	Total DDT	0.394	NO	NO	YES	YES
Walleye	Lake Wallula	Total DDT	0.360	NO	NO	YES	YES
Walleye	All	Total DDT	0.403	NO	YES	YES	YES
Walleye	Upriver	Heptachlor	0.007	NO	NO	YES	YES
Walleye	100 Area	Heptachlor	0.008	NO	NO	YES	YES
Walleye	300 Area	Heptachlor	0.005	NO	NO	YES	YES
Walleye	Lake Wallula	Heptachlor	0.006	NO	NO	YES	YES
Walleye	All	Heptachlor	0.006	NO	NO	YES	YES
Walleye	Upriver	Total PCBs	0.158	YES	YES	YES	YES
Walleye	100 Area	Total PCBs	0.327	YES	YES	YES	YES
Walleye	300 Area	Total PCBs	0.103	YES	YES	YES	YES
Walleye	Lake Wallula	Total PCBs	0.035	YES	YES	YES	YES
Walleye	All	Total PCBs	0.156	YES	YES	YES	YES
Whitefish	Upriver	Mercury	0.027	NO	NO	NA	NA
Whitefish	100 Area	Mercury	0.070	NO	YES	NA	NA
Whitefish	300 Area	Mercury	0.055	NO	YES	NA	NA
Whitefish	Lake Wallula	Mercury	0.060	NO	YES	NA	NA
Whitefish	All	Mercury	0.053	NO	YES	NA	NA
Whitefish	Upriver	Total DDT	0.185	NO	YES	YES	YES
Whitefish	100 Area	Total DDT	0.397	NO	YES	YES	YES
Whitefish	300 Area	Total DDT	0.158	NO	YES	YES	YES
Whitefish	Lake Wallula	Total DDT	0.095	NO	YES	YES	YES
Whitefish	All	Total DDT	0.209	NO	YES	YES	YES
Whitefish	Upriver	Dieldrin	0.014	NO	NO	YES	YES
Whitefish	100 Area	Dieldrin	0.021	NO	YES	YES	YES
Whitefish	300 Area	Dieldrin	0.028	NO	YES	YES	YES
Whitefish	Lake Wallula	Dieldrin	0.029	NO	YES	YES	YES
Whitefish	All	Dieldrin	0.023	NO	YES	YES	YES
Whitefish	Upriver	Total PCBs	0.873	YES	YES	YES	YES
Whitefish	100 Area	Total PCBs	0.330	YES	YES	YES	YES
Whitefish	300 Area	Total PCBs	0.271	YES	YES	YES	YES
Whitefish	Lake Wallula	Total PCBs	0.120	YES	YES	YES	YES
Whitefish	All	Total PCBs	0.398	YES	YES	YES	YES

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