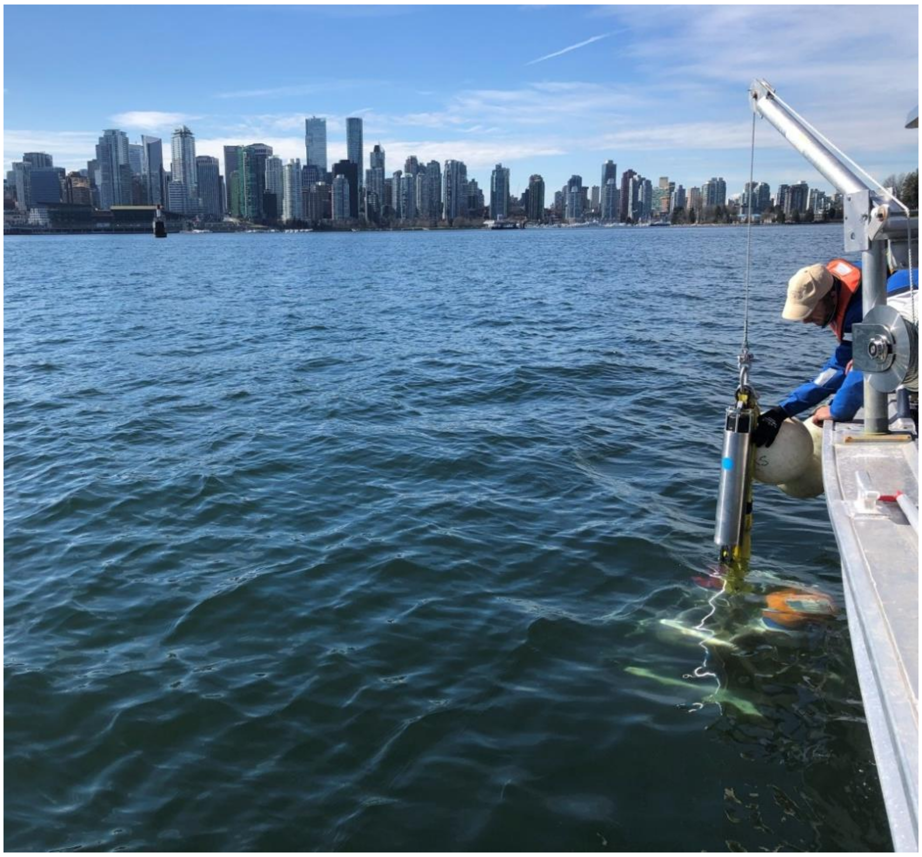
BURRARD INLET WATER QUALITY PROPOSED OBJECTIVES

Tissue Quality Objectives Recommendations for Burrard Inlet



June 2021

Tsleil-Waututh Nation
səlilwətaɬ

BRITISH COLUMBIA

Methodology Report

This Methodology Report supplements a series of water quality parameter reports whose purpose is to inform updates to the 1990 Provincial Water Quality Objectives for Burrard Inlet. The reports in the series assess the current state and impacts of contamination in Burrard Inlet; incorporate new scientific research and monitoring of water quality; and reflect a broader understanding of goals and values, including those of First Nations, to improve the health of the marine waters of Burrard Inlet. Updating the 1990 Provincial Water Quality Objectives is a priority action identified in the Tsleil-Waututh Nation's Burrard Inlet Action Plan which has been an impetus for this work.

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Authors' Affiliations:

Water Protection and Sustainability Branch
BC Ministry of Environment & Climate Change Strategy, Victoria, B.C.

Health Protection Branch
BC Ministry of Health, Victoria, B.C.

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Underwater monitoring equipment is installed from the Tsleil-Waututh Nation boat in Burrard Inlet.

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CHAPTER SUMMARY

Tsleil-Waututh, which means “People of the Inlet”, have used and occupied səlilwət (Burrard Inlet) and its surrounding watersheds since time out of mind. Tsleil-Waututh Nation’s vision for səlilwət includes a productive, resilient, and diverse ecosystem where healthy, wild foods can be harvested safely and sustainably. Based on water quality parameters of concern in Burrard Inlet, tissue screening values for fish and shellfish have been calculated for several contaminants for recommendation as water quality objectives. Tissue screening values for mercury, lead, arsenic, PCBs, chlorophenols, PAHs, copper and zinc are provided in this report as examples. Any information about specific fish ingestion rates in Burrard Inlet could be used to refine these screening values.

CONTENTS

ACRONYMS

AF	Allocation factor
As	Arsenic
B(a)P	Benzo[a]pyrene
BC	British Columbia
BW	Body weight
CCME	Canadian Council of Ministers of the Environment
DCP	Dichlorophenol
ED	Exposure duration
ENV	Ministry of Environment and Climate Change Strategy
ET	Exposure term
Hg	Mercury
ILCR	Incremental lifetime cancer risk
IQ	Intelligence quotient
IR	Ingestion rate
LE	Life expectancy
MeHg	Methyl mercury
OSF	Oral slope factor
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEF	Potency equivalence factor
RAF	Relative absorption factor
RL	Risk level
SV	Screening value
TCP	Trichlorophenol
TDI	Tolerable daily intake
TRV	Toxicological reference value
TTCP	Tetrachlorophenol
TWN	Tsleil-Waututh Nation
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WQO	Water Quality Objective
w/w	Wet weight

1. INTRODUCTION

Tsleil-Waututh, which means “People of the Inlet”, have used and occupied the lands and waters of səlilwət (Burrard Inlet) and its surrounding watersheds since time out of mind. According to Tsleil-Waututh oral history, knowledge and archaeological records, approximately 90% of the Tsleil-Waututh diet was derived from səlilwət marine resources and Fraser River salmon. Today, the Inlet is largely unable to support Tsleil-Waututh’s needs. Over the last 150 years, urban, industrial, and port development, pollution, and resource exploitation around the Inlet have impaired its health and reduced the opportunity for Tsleil-Waututh and other local First Nations to utilize its waters and beaches for cultural practices, including the harvest of traditional foods such as finfish and shellfish that once sustained them. Tsleil-Waututh Nation’s vision for səlilwət includes a productive, resilient, and diverse ecosystem where healthy, wild foods can be harvested safely and sustainably (Rao et al. 2019, TWN 2017). This document was produced in support of this vision.

A risk-based approach was used to develop human health-based fish/shellfish tissue guidelines for human consumption; these guidelines are referred to as screening values (SVs). In this document, SVs are defined as conservative threshold values against which contaminant concentrations in fish (including finfish and shellfish) tissue can be compared and assessed for potential risks to human health. This document follows the recommended method for calculating a human consumption SV for contaminants of concern in fish and shellfish tissue (WLRS 2023).

References to tissue or fish tissue, and the calculated SVs in this report apply to marine country foods, that is, foods produced in an agricultural (not for commercial sale) backyard setting or harvested through hunting, gathering or fishing activities (Health Canada 2010b), and include both finfish and shellfish. SVs were derived using finfish consumption rates, although some shellfish may accumulate contaminants differently than finfish. Due to the conservative approach of this work, this differentiation was not deemed necessary for its scope. Any observed exceedances of these SVs can be explored further by health authorities for calculation of recommended weekly or daily intakes by species.

Screening values provide general guidance to environmental managers and represent a suggested safe level of contaminant in fish tissue based on a conservative estimate of a person’s total fish and shellfish consumption per day; they do not provide advice regarding consumption limits or constitute a fishing advisory. Exceedances of a SV may indicate that further investigation to assess human health risk at a particular site is warranted; however, exceeding a SV does not imply risk to human health. As several of the contaminants are naturally occurring, SVs should also be compared to naturally occurring background concentrations.

The SV method is considered appropriate for protecting the health of individuals who consume fish and shellfish for the following reasons (Reinert et al. 1991):

- it provides a link between potential risks and consumption rate (i.e., between dose and response);
- it generally leads to conservative estimates of potential risk; and
- it is designed for protection of consumers of locally caught fish, including sport and subsistence fishers who are at potentially greater risk than the general adult population because they tend to consume greater quantities of fish and repeatedly fish at the same locations.

Example SVs are included below, but do not represent an exhaustive list of contaminants of potential concern in Burrard Inlet. Additional SVs using the same methodology as described below are being calculated and published for other contaminants as part of the work to update the Water Quality Objectives for Burrard Inlet (TWN and ENV 2021).

2. RISK-BASED APPROACH TO DEVELOPING SCREENING VALUES

A risk-based approach was used to develop SVs. A risk-based approach considers: the *receptors* (people who are exposed to the contaminant, in this case subsistence fishers, recreational fishers, general BC population, women of child-bearing age, and toddlers); *exposure* to the contaminant (how much fish the receptors are consuming); and the contaminant *toxicity* (what is known about the contaminant and how it affects different receptors).

2.1 Screening Value Variables and Assumptions

2.1.1 Receptors and their Characteristics

Receptors considered in this document include subsistence, recreational, and low-level (general BC population) fishers and their families who may catch and consume fish from Burrard Inlet. SVs were calculated for key receptors (i.e., adults and toddlers who are the most exposed or are most sensitive to the contaminant) for each receptor group. All fishers were assumed to be adults ($\geq$ 20 years old), and toddlers were considered to be 7 months to 4 years old. SVs were calculated for adults and toddlers for subsistence, recreational and low-level fisher receptor groups. Women of child-bearing age were also considered a key receptor (i.e. most sensitive receptor) when developing the SV for mercury to protect against developmental effects in fetuses and infants.

The mean adult human body weight in Canada is 76.5 kg and was used in all the SV calculations for adults. The mean adult female body weight is 69.8 kg; this body weight was used to develop a mercury SV for women of child-bearing age. The average toddler body weight of 16.5 kg was used (Richardson 2013). It should be noted that these receptor characteristics differ from those recommended by Health Canada's Contaminated Sites Division (Health Canada 2010a), and that the SVs derived herein should not be used for derivation of remediation or other guidelines for contaminated sites under the B.C. Contaminated Sites Regulation.

2.1.2 Exposure: Fish Ingestion Rates

Receptor populations are differentiated by their fish ingestion rate (IR). Estimated IRs of fish tissue consumed by adult subsistence fishers (220 g/day) and adult recreational fishers (111 g/day) were used to represent high-end consumption rates for Canadian Indigenous Groups and the general population, respectively (Richardson 1997). Exposure characteristics (ingestion rates) should be obtained from the community where possible. The low-level consumption IR of 21.5 g/day reflects a recommended two servings of fish per week. The IR for a toddler (94 g/day) represents that of a toddler from a subsistence fisher population (Richardson 1997). The Canadian data upon which these IRs were based are somewhat dated (1970-72); however, pending the collection and publication of more recent data, these IRs represent the best available Canadian data (Health Canada 2010b). When developing SVs, the need to accurately characterize the target fisher population of interest to establish sufficiently protective values cannot be overemphasized. Because shellfish harvesting in Burrard Inlet has been closed since 1972 due to contamination concerns, the fish ingestion rates applied to the calculation of SVs in this document consider Tsleil-Waututh Nation's aspirational, rather than current, IRs of marine country foods. This approach is in keeping with TWN values, as well as with provincial guidance on human health risk assessment (e.g. BC MOH 2021).

2.1.3 Toxicity: Toxicological Reference Values

Toxicological reference values (TRVs) are prescribed by Health Canada and other national and international agencies (i.e., United States Environmental Protection Agency [USEPA] and the World

Health Organization [WHO]), to characterize risks associated with exposure to environmental contaminants. Health Canada TRVs were prioritized, when available.

For noncarcinogenic contaminants, the TRV is the daily dose that is deemed to be tolerable or acceptable (i.e., the dose that is “safe”), based on the assumption that a threshold dose exists at or below a level which toxic effects are not expected to occur. Non-carcinogenic TRVs for oral ingestion are identified by Health Canada as tolerable daily intakes (TDIs). Noncarcinogenic SVs are calculated with the TDI of the specific contaminant, human IR of fish, exposure pathway (orally for fish ingestion), and the mean human receptor body weight (BW).

For substances that are carcinogenic, the TRV represents an upper bound estimate of the slope between exposure and the occurrence of cancer. For ingestion of contaminants, the slope of the dose-response relationship is referred to as an oral slope factor (OSF) (Health Canada 2010a). Carcinogenic fish tissue SVs for Burrard Inlet are based on a negligible increase in incremental lifetime cancer risk of 1 in 100,000, mean human receptor BW, OSF, life expectancy, fish consumption rates, frequency of consumption, and the years exposed to the contaminant (USEPA 2000b, Health Canada 2012).

TRVs used in these calculations are from Health Canada (2010a) except for lead, which is from Health Canada (2019). References to specific TRVs, their sources, and supplemental information regarding their derivation (e.g. target organs, health effects, uncertainty factors) are provided in those same Health Canada documents.

2.2 General Equations for Calculating Screening Values in BC

British Columbia’s noncarcinogenic and carcinogenic SVs were calculated using the general equation for calculating the ingested contaminant dose via consumption of contaminated food recommended in Health Canada (2010c). See Appendix A for worked example. SVs for non-carcinogens and carcinogens are calculated differently in consideration of the different approaches to each as described in section 2.1.3.

2.2.1 Noncarcinogens

$$SV_n = \frac{TDI \times BW \times AF}{IR_{Food} \times RAF_{Oral}} + BC \qquad \text{(Equation 1)}$$

Where:

- SV_n = screening value for a noncarcinogen (µg/g);
- TDI = tolerable daily intake (µg/kg BW/day); the contaminant dose deemed safe or acceptable;
- BW = body weight (kg);
- AF = allocation factor; the fraction of the contaminant allocated to come from country foods; an AF of 0.2 was applied to all contaminants except mercury, for which fish tissue was assumed to be the only significant source of exposure;
- IR_{Food} = ingestion rate of fish by humans (g/day);
- RAF_{Oral} = relative absorption factor from the gastrointestinal tract for a contaminant; and
- BC = background concentration (µg/g); the naturally occurring background concentration in environmental media or tissue.

Assumptions:

- For the purpose of setting SVs, it is conservatively assumed that fish are consumed on a daily basis throughout the year (i.e., 365 days per year);
- RAF_{Oral} = 1. Unless site-specific data have been collected, oral exposures should be assumed to have a relative absorption of 100% for comparison with an oral TRV (Health Canada 2010a);
- AF = 0.2 when applied; and
- BC = 0 µg/g, as background concentration estimates in fish tissue are not currently available for Burrard Inlet.

2.2.2 Carcinogens

For risk assessment in BC, the target incremental lifetime cancer risk (ILCR) is 1 in 100,000 persons exposed. Life expectancy is 80 years, and the total number of years of adult exposure to the contaminant is 60 (Health Canada 2012).

$$SV_c = \frac{\frac{ILCR}{OSF} \times BW \times LE}{IR_{Food} \times RAF_{Oral} \times ET} \quad \text{(Equation 2)}$$

Where:

- SV_c = screening value for a carcinogen (µg/g);
- *ILCR* = incremental lifetime cancer risk; 1/100,000;
- OSF = oral slope factor $(\mu g/kg\ BW/day)^{-1}$;
- *BW* = body weight (kg);
- *LE* = life expectancy (80 years);
- IR_{Food} = ingestion rate of fish by humans (g/day);
- RAF_{Oral} = relative absorption factor from the gastrointestinal tract for a contaminant; and
- *ET* = exposure term (60 years).

The same assumptions listed above apply here, as well as:

- *LE* = 80 years; and
- *ET* = 60 years.

3. MERCURY

3.1 BC Health-based Screening Values for Mercury in Fish Tissue

The SVs should be compared against total mercury (Hg), as it is total mercury that is measured in the laboratory. For the purpose of deriving SVs, it is assumed that 100% of total Hg in fish is methyl mercury (MeHg) (Health Canada 2007a). SVs for methyl mercury are provided for five receptor populations (Table 1); SVs for toddlers and women of child-bearing age in recreational and low-level fisher populations can also be calculated as they are considered key receptors. The MeHg TDI of 0.47 µg/kg BW/day was used for adult subsistence, recreational and low-level fishers in general, while 0.2 µg/kg BW/day was used for the most sensitive populations to MeHg exposure: women of child-bearing age and children less than 12 years old (Health Canada 2019a, 2021).

Table 1. Total mercury screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	0.47	76.5	1	***0.16***
	Women of child-bearing age	220	0.20	69.8	1	***0.06***
	Toddler	94	0.20	16.5	1	***0.03***
Recreational fisher	Adult	111	0.47	76.5	1	***0.32***
Low-level fisher	Adult	21.5	0.47	76.5	1	***1.7***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

As low levels of mercury are present in most fish, exceedances of the mercury SV can also be compared against background concentrations compiled in Appendices I to III of Health Canada's Human Health Risk Assessment of Mercury in Fish (2007a), or additional lab analysis could be used to determine the proportion of total mercury which is methyl mercury, with the SV adjusted accordingly.

4. LEAD

4.1 BC Health-based Screening Values for Lead in Fish Tissue

As any exposure to lead is considered to pose some risk for harmful effects, lead (Pb) should be included in fish and shellfish monitoring programs if there is any evidence that it may be present in fish tissue (EFSA 2013). SVs for lead are provided for four receptor populations (Table 2) with the toddler being the most sensitive receptor. The lead TDI was obtained from Health Canada's lead guideline for Canadian drinking water quality (2019) and is for a toddler receptor, based on the endpoint of IQ loss.

Table 2. Lead screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	0.40	76.5	1	***0.14***
	Toddler	94	0.40	16.5	1	***0.07***
Recreational fisher	Adult	111	0.40	76.5	1	***0.28***
Low-level fisher	Adult	21.5	0.40	76.5	1	***1.4***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

5. ARSENIC

5.1 BC Health-based Screening Values for Arsenic in Fish Tissue

The arsenic (As) (inorganic) OSF of 1.8 (mg/kg BW-day)$^{-1}$ from Health Canada (2010a) has been applied. This OSF was used for the carcinogenic SV generation for three receptor populations (Table 3). Adult subsistence fishers are considered the most sensitive receptor because the contamination concerns are based on a lifetime of exposure.

Table 3. Arsenic (inorganic) screening values for human fish consumption.

Receptor (adults)$^{\alpha}$	**IR (g/day)**	**OSF (µg/kg bw-day)$^{-1}$**	**BW (kg)**	**RAF (fraction)**	***SV[5]* (µg/g, w/w)***
Subsistence fisher	220	0.0018	76.5	1	***0.0026***
Recreational fisher	111	0.0018	76.5	1	***0.0051***
Low-level fisher	21.5	0.0018	76.5	1	***0.026***

[1]IR = ingestion rate
[2]OSF = oral slope factor
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight
$^{\alpha}$Life expectancy is 80 yrs. Total years of adult exposure to contaminant is 60 yrs.
*Risk level = 10^{-5}

As low levels of arsenic may be naturally present in finfish and shellfish (Neff 1997), exceedances of the arsenic SV can also be compared against expected background concentrations. Adjustments to SVs may also be made based on bioavailability or other factors if supporting evidence is available.

6. POLYCHLORINATED BIPHENYLS

6.1 BC Health-based Screening Values for PCBs in Fish Tissue

SVs for total polychlorinated biphenyls (PCBs) were developed for four receptor populations (Table 4), using the TDI for the total of non-coplanar PCBs as per Health Canada (2010a, 2021). Dioxin like PCBs (PCB 77, PCB 81, PCB 126, and PCB 169), should be omitted from this SV and be evaluated against the SV calculated for dioxins (not included in this document).

Table 4. Polychlorinated biphenyl screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	0.01	76.5	1	***0.0007***
	Toddler	94	0.01	16.5	1	***0.0004***
Recreational fisher	Adult	111	0.01	76.5	1	***0.0014***
Low-level fisher	Adult	21.5	0.01	76.5	1	***0.0071***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

7. <u>CHLOROPHENOLS</u>

7.1 BC Health-based Screening Values for Chlorophenols in Fish Tissue

Screening values for various receptor populations were developed for chlorophenols (CPs) for which Health Canada has provided TDIs and/or an OSF: 2,4-dichlorophenol (DCP) in Table 5, 2,3,4,6-tetrachlorophenol (TTCP) in Table 6 and 2,4,6-trichlorophenol (TCP) in Table 7. The TDIs recommended in Health Canada (2010a) are 0.1 mg/kg BW/day and 0.01 mg/kg BW/day for DCP and TTCP, respectively, and an OSF of 0.020 (mg/kg BW/day)$^{-1}$ is recommended for TCP. An allocation factor of 0.2 was used to calculate these SVs, except for TCP. Adult subsistence fishers are considered the most sensitive receptor of the carcinogen 2,4,6-trichlorophenol because the contamination concerns are based on a lifetime of exposure.

Table 5. 2,4-Dichlorophenol screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	100	76.5	1	***7.0***
	Toddler	94	100	16.5	1	***3.5***
Recreational fisher	Adult	111	100	76.5	1	***14***
Low-level fisher	Adult	21.5	100	76.5	1	***71***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

Table 6. 2,3,4,6-Tetrachlorophenol screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	10	76.5	1	***0.70***
	Toddler	94	10	16.5	1	***0.35***
Recreational fisher	Adult	111	10	76.5	1	***1.4***
Low-level fisher	Adult	21.5	10	76.5	1	***7.1***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value

Table 7. 2,4,6-Trichlorophenol screening values for human fish consumption.

Receptor (adults)[α]	IR[1] (g/day)	OSF[2] (µg/kg bw-day)$^{-1}$	BW[3] (kg)	RAF[4] (fraction)	*SV[5*] (µg/g, w/w)*
Subsistence fisher	220	$2x10^{-5}$	76.5	1	***0.23***
Recreational fisher	111	$2x10^{-5}$	76.5	1	***0.46***
Low-level fisher	21.5	$2x10^{-5}$	76.5	1	***2.4***

[1]IR = ingestion rate
[2]OSF = oral slope factor
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
[α]Life expectancy is 80 yrs. Total years of adult exposure to contaminant is 60 yrs.
*Risk level = 10^{-5}

8. POLYCYCLIC AROMATIC HYDROCARBONS

8.1 BC Health-based Screening Values for PAHs in Fish Tissue

The development of screening values for the following polyaromatic hydrocarbons (PAHs) is described below: the non-carcinogens 2-methylnaphthalene (Table 8a), naphthalene (Table 8b), and pyrene (Table 8c), as well as the carcinogen benzo[a]pyrene (B[a])P) (Table 9). The TDIs are as recommended in Health Canada (2010a). Other common non-carcinogenic PAHs which could have a SV calculated for them using this same methodology include acenaphthene, anthracene, fluoranthene, fluorene, and phenanthrene. These additional PAHs, as well as information about their toxicity, are discussed further in the detailed chapter on PAHs (Braig et al. 2021). An allocation factor of 0.2 was used to calculate the non-carcinogen SV. Adult subsistence fishers are considered the most sensitive receptor of B[a]P because the contamination concerns are based on a lifetime of exposure.

Table 8a. 2-Methylnaphthalene screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg bw/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	4.0	76.5	1	***0.28***
Toddler	Toddler	94	4.0	16.5	1	***0.14***
Recreational fisher	Adult	111	4.0	76.5	1	***0.55***
Low-level fisher	Adult	21.5	4.0	76.5	1	***2.9***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

Table 8b. Naphthalene screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg bw/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	20	76.5	1	***1.4***
	Toddler	94	20	16.5	1	***0.7***
Recreational fisher	Adult	111	20	76.5	1	***2.7***
Low-level fisher	Adult	21.5	20	76.5	1	***14.2***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

Table 8c. Pyrene screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg bw/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	30	76.5	1	***2.1***
	Toddler	94	30	16.5	1	***1.0***
Recreational fisher	Adult	111	30	76.5	1	***4.1***
Low-level fisher	Adult	21.5	30	76.5	1	***21.3***

[1]IR = ingestion rate
[2]TDI = tolerable daily intake
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
w/w = wet weight

Table 9. Benzo[a]pyrene screening values for human fish consumption.

Receptor (adults)α	**IR[1] (g/day)**	**OSF[2] (µg/kg bw-day)$^{-1}$**	**BW[3] (kg)**	**RAF[4] (fraction)**	***SV[5]* (µg/g, w/w)***
Subsistence fisher	220	0.00129	76.5	1	***0.0036***
Recreational fisher	111	0.00129	76.5	1	***0.0071***
Low-level fisher	21.5	0.00129	76.5	1	***0.037***

[1]IR = ingestion rate
[2]OSF = oral slope factor
[3]BW = body weight
[4]RAF = relative absorption factor
[5]SV = screening value
αLife expectancy is 80 yrs. Total years of adult exposure to contaminant is 60 yrs.
*Risk Level = 10^{-5}

Exposures to mixtures of carcinogenic PAHs should be assessed according to the potency equivalence factor (PEF) (Health Canada 2012) (Table 10). High molecular weight PAH concentrations are expressed on a B[a]P toxic equivalency (TEC) basis. The concentration of individual PAHs are multiplied by their respective toxic equivalency factor (TEF) to generate a concentrations based on their relative toxicity compared to the most toxic PAH, which is B[a]P.

For example: If B[a]P concentration in fish tissue was 1 mg/kg, benzo(k)fluoranthene was 4 mg/kg, chrysene was 5 mg/kg, and phenanthrene was 6 mg/kg:
The B[a]P TEC equivalent concentration = 1 + (4 x 0.1) + (5 x 0.01) + (6 x 0.001) = 1.456 mg/kg B[a]P TEC. This is the number to compare to the B[a]P SV.

Table 10. Carcinogenic PAHs and their TEFs to calculate B[a]P TEC concentration.

Carcinogenic PAH	**Potency Equivalence Factor (PEF)**
anthracene	0.1
benzo(a)pyrene	1
benzo(a)anthracene	0.1
benzo(b)fluoranthene	0.1
benzo(g,h,i)perylene	0.01
benzo(k)fluoranthene	0.1
chrysene	0.01
dibenzo(a,h)anthracene	1
fluoranthene	0.001
indeno(1,2,3-cd)pyrene	0.1
phenanthrene	0.001

9. COPPER

SVs were developed for copper (Table 11) using the TDIs recommended in Health Canada (2010a).

Table 11. Copper screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	426	76.5	1	***30***
	Toddler	94	426	16.5	1	***15***
Recreational fisher	Adult	111	426	76.5	1	***59***
Low-level fisher	Adult	21.5	426	76.5	1	***300***

10. ZINC

SVs were developed for Zinc (Table 12) using the TDIs recommended in Health Canada (2010a).

Table 12. Zinc screening values for human fish consumption.

Receptor population	Receptor life stage	IR[1] (g/day)	TDI[2] (µg/kg BW/day)	BW[3] (kg)	RAF[4] (fraction)	*SV[5] (µg/g, w/w)*
Subsistence fisher	Adult	220	570	76.5	1	***40***
	Toddler	94	480	16.5	1	***17***
Recreational fisher	Adult	111	570	76.5	1	***79***
Low-level fisher	Adult	21.5	570	76.5	1	***406***

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APPENDIX A: SCREENING VALUE WORKED EXAMPLES

1) Noncarcinogen example calculation for ingestion of mercury by a low-level adult fish eater using the general equation recommended in Health Canada (2010c) for calculating the ingested contaminant dose via consumption of contaminated food. An allocation factor was not used in this calculation given that fish and shellfish is the primary source of mercury ingestion in humans.

$$Dose = \frac{(\sum(C_{Foodi} \times IR_{Foodi} \times RAF_{Orali} \times D_i)) \times ET}{BW \times 365 \times LE} \qquad \text{(Equation 1)}$$

Where:

- *Dose* = predicted intake of contaminant (mg/kg BW/day);
- C_{Foodi} = concentration of contaminant in food *i* (mg/kg);
- IR_{Foodi} = receptor ingestion rate for food *i* (g/day);
- RAF_{Orali} = relative absorption factor from the gastrointestinal tract for contaminant *i* (unitless);
- D_i = days per year during which consumption of food *i* will occur;
- *ET* = exposure term; total years exposed to site (only used for assessment of carcinogens);
- *BW* = mean body weight of receptor (kg);
- 365 = total days per year (constant); and
- LE = life expectancy (only used for assessment of carcinogens).

Assumptions:

- For the purpose of setting SVs, it is assumed that fish are consumed on a daily basis throughout the year: D_i = 365 days.
- RAF_{Orali} = 1. Unless site-specific data have been collected, oral exposures should be assumed to have a relative absorption of 100% for comparison with an oral TRV (Health Canada 2010a).

Equation 1 was reorganized to Equation 2 to solve for $C_{Foodi.}$ The equation is simplified as the *ET* and *LE* variables are not used in the noncarcinogen calculation. Equation 1 is simplified further as it is assumed that food ingestion occurs every day of the 365 day year, therefore D_1 and 365 cancel each other out.

$$C_{Foodi} = \frac{Dose \times BW}{IR_{Foodi} \times RAF_{Orali}} \qquad \text{(Equation 2)}$$

Where:

- C_{Foodi} = concentration of contaminant in food *i* (mg/kg);
- *Dose* = predicted intake of contaminant (mg/kg BW/day);
- *BW* = mean body weight of receptor (kg);
- IR_{Foodi} = receptor ingestion rate for food *i* (g/day); and
- RAF_{Orali} = relative absorption factor from the gastrointestinal tract for contaminant *i*.

Equation 2 becomes equation 3 by substituting in the variables; SV_n for C_{Foodi}, and *TDI* (the safe or acceptable contaminant dose) for the *Dose*. C_{Foodi} is equal to SV_n when the appropriate *TDI* is substituted for the *Dose*.

$$SV_n = \frac{TDI \times BW}{IR_{Foodi} \times RAF_{Orali}} \qquad \text{(Equation 3)}$$

Where:

- SV_n = screening value for a noncarcinogen (µg/g);
- *TDI* = tolerable daily intake = 0.47 µg/kg BW/day (equal to µg/kg-day);
- *BW* = body weight = 76.5 kg;
- IR_{Foodi} = ingestion rate of fish by humans = 21.5 g/day; and
- RAF_{Orali} = relative absorption factor from the gastrointestinal tract for mercury = 100%.

$$SV_{Hg} = \frac{0.47\ \frac{\mu\text{g}}{\text{kg}\cdot\text{day}} \times 76.5\ \text{kg}}{21.5\frac{g}{day} \times 1}$$

$$SV_{Hg} = 1.67\ \mu\text{g/g}$$

2) Carcinogen example calculation for ingestion of arsenic by a low-level adult fish eater using Health Canada's (2012) recommended general equation for calculating the ingested contaminant dose via consumption of contaminated food.

$$Dose = \frac{(\sum(C_{Foodi} \times IR_{Foodi} \times RAF_{Orali} \times D_i)) \times ET}{BW \times 365 \times LE} \qquad \text{(Equation 4)}$$

Where:

- *Dose* = predicted intake of contaminant (mg/kg BW/day);
- C_{Foodi} = concentration of contaminant in food *i* (mg/kg);
- IR_{Foodi} = receptor ingestion rate for food *i* (g/day);
- RAF_{Orali} = relative absorption factor from the gastrointestinal tract for contaminant *i* (unitless);
- D_i = days per year during which consumption of food *i* will occur;
- *ET* = exposure term; total years exposed to site (only used for assessment of carcinogens);
- *BW* = mean body weight of receptor (kg);
- 365 = total days per year (constant); and
- LE = life expectancy (only used for assessment of carcinogens).

Assumptions:

- For the purpose of setting SVs, it is assumed that fish are consumed on a daily basis throughout the year: D_i = 365 days; and
- RAF_{Orali} = 1. Unless site-specific data have been collected, oral exposures should be assumed to have a relative absorption of 100% for comparison with an oral TRV (Health Canada 2010a).

Equation 4 was reorganized to Equation 5 to solve for C_{Foodi}. Equation 4 is simplified further as it is assumed that food ingestion occurs every day of the 365 day year, therefore D_1 and 365 cancel each other out.

$$C_{Foodi} = \frac{Dose \times BW \times LE}{IR_{Foodi} \times RAF_{Orali} \times ET} \qquad \text{(Equation 5)}$$

Where:

- C_{Foodi} = concentration of contaminant in food *i* (mg/kg);
- *Dose* = predicted intake of contaminant (mg/kg BW/day);
- *BW* = mean body weight of receptor (kg);
- *LE* = life expectancy
- IR_{Foodi} = receptor ingestion rate for food *i* (g/day);
- RAF_{Orali} = relative absorption factor from the gastrointestinal tract for contaminant *i*; and
- *ET* = exposure term (years).

The same assumptions listed in the noncarcinogen example apply here, as well as:

- *LE* = 80 years (Health Canada 2012); and
- *ET* = 60 years (Health Canada 2012).

Equation 5 becomes Equation 6 by substituting in the variables SV_C for C_{Foodi} and *RL*/*OSF* for the *Dose*. C_{Foodi} is equal to the SV_c when a maximum acceptable risk level and *OSF* are substituted for the dose.

$$SV_c = \frac{\frac{RL}{OSF} \times BW \times LE}{IR_{Foodi} \times RAF_{Orali} \times ET} \qquad \text{(Equation 6)}$$

Where:

- SV_c = Screening value for a carcinogen (µg/g)
- *RL* = Risk level = 1/100 000
- OSF = Oral slope factor = 0.0018 $(\mu g/kg\ BW/day)^{-1}$ (equal to $\mu g/kg\text{-}day)^{-1}$
- *BW* = body weight = 76.5 kg
- *LE* = life expectancy = 80 years
- IR_{Foodi} = ingestion rate of fish by humans = 21.5 g/day
- RAF_{Orali} = relative absorption factor from the gastrointestinal tract for arsenic = 1.0
- *ET* = exposure term; total years exposed to site = 60 years

$$SV_{As} = \frac{\frac{0.00001}{0.0018\ \frac{\mu\text{g}}{\text{kg}\cdot\text{day}}} \times 76.5\ kg \times 80\ yrs}{21.5\,\frac{g}{day} \times 1 \times 60\ yrs}$$

$$SV_{As} = 0.026\ \mu\text{g/g}$$