Appendix V6-5E

Existing Conditions Food Chain Model and Predicted Concentrations of Contaminants of Potential Concern in the Tissues of Country Food Species and Wildlife Species

TMAC RESOURCES

Appendix V6-5E. Existing Conditions Food Chain Model and Predicted Concentrations of Contaminants of Potential Concern in the Tissues of Country Food Species and Wildlife Species

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1. Introduction

In the Human Health and Environmental Risk Assessment (HHERA; Volume 6, Section 5), existing conditions concentrations of contaminants of potential concern (COPCs) in the tissues of country food species and wildlife valued ecosystem components (VECs) were estimated using a food chain model. Modeled country food species include: caribou (*Rangifer tarandus*), Arctic ground squirrel (*Spermophilus parryii*), and willow ptarmigan (*Lagopus lagopus*). Country foods which were not modelled include local berries (i.e., *Empertrum nigrum*, *Arctostaphy alpine*, and *Vaccinium uliginosum*), arctic char (*Salvelinus alpinus*), and lake trout (*Salvelinus namaycush*) because existing conditions site-specific tissue concentrations are available for these foods. In addition, marine invertebrate (*Mytilus* ssp.) tissue metal concentrations were available from field collections.

The wildlife VECs (or species selected to represent a VEC) include: caribou, muskox (*Ovibos moschatus*), wolverine (*Gulo gulo*), grizzly bear (*Ursus arctos horribilis*), wolf (*Canis lupus arctos*), Arctic ground squirrel, Arctic shrew (*Sorex arcticus*), northern red-backed vole (*Myodes rutilus*), willow ptarmigan (*Lagopus lagopus*), American tree sparrow (*Spizella arborea*), peregrine falcon (*Falco peregrinus*), Canada goose, red-breasted merganser (*Mergus serrator*), least sandpiper (*Calidris minutilla*), long-tailed duck (*Clangula hyemalis*), herring gull (*Larus smithsonianus*), yellow warbler (*Setophaga petechia*), brant (*Branta bernicla*), and ringed seal (*Phoca hispida*).

The food chain model predicts COPC concentrations in animal tissue by estimating the fraction of COPCs that are retained in the tissues when wildlife ingests environmental media such as vegetation, prey, soil, sediment, and surface water. The food chain model followed the methodology described in Golder Associates Ltd. (2005), which is recommended by Health Canada (2010) and is the same type of model recommended by Environment Canada (2012a). The modeled existing conditions COPC concentrations in tissue were used in the existing conditions human health risk assessment (HHRA) and the existing conditions environmental risk assessment (ERA) to assess the potential for the country foods to affect human health and the prey species to affect wildlife health prior to Madrid-Boston Project development.

2. Methods

The following equation was used to predict COPC concentrations in animal tissue (C_{total} in mg/kg):

$$C_{total} = C_{m[soil\ or\ sediment]} + C_{m[water]} + C_{m[veg]} + C_{m[prey]}$$ [Equation 1]

where:

$C_{m[soil]}$ = Concentration in meat from exposure to COPCs in soil
$C_{m[sediment]}$ = Concentration in meat from exposure to COPCs in sediment
$C_{m[water]}$ = Concentration in meat from exposure to COPCs in water
$C_{m[veg]}$ = Concentration in meat from exposure to COPCs in vegetation
$C_{m[prey]}$ = Concentration in meat from exposure to COPCs in prey

The wildlife uptake equations used to estimate the concentrations in animal tissue (meat) from exposure to soil or sediment, vegetation, prey, and water are presented in Table V6-5E1.

Table V6-5E1. Wildlife Uptake Equations for Contaminants of Potential Concern

Pathway	Equation and Parameters
Generic Equation	$C_{m[media]}$ = BTF x C x IR x ET x fw
Ingestion Equations	
Soil Ingestion	$C_{m[soil]}$ = $BTF_{tissue\text{-}food}$ x C_{soil} x IR_{soil} x ET x fw
Sediment Ingestion	$C_{m[sediment]}$ = $BTF_{tissue\text{-}food}$ x $C_{sediment}$ x $IR_{sediment}$ x ET x fw
Vegetation Ingestion	$C_{m[veg]}$ = $BTF_{tissue\text{-}food}$ x C_{veg} x IR_{veg} x ET x fw
Prey Ingestion	$C_{m[prey]}$ = $BTF_{tissue\text{-}food}$ x C_{prey} x IR_{prey} x ET x fw
Water Ingestion	$C_{m[water]}$ = $BTF_{tissue\text{-}food}$ x C_{water} x IR_{water} x ET x fw

Notes:
$C_{m[media]}$ = concentration of COPCs in wildlife tissue (mg/kg wet weight) from ingestion of environmental media (e.g., soil, sediment, vegetation, prey, water)
$BTF_{tissue\text{-}food}$ = biotransfer factor for the wildlife species and COPC (day/kg)
$C_{[media]}$ = COPC concentration in soil, sediment, vegetation, prey, or water (mg/kg or mg/L)
$IR_{soil/sediment/veg/prey/water}$ = daily ingestion rate of environmental media for wildlife species (kg/day or L/day)
ET = exposure time spent in the area for wildlife species (unitless)
fw = fraction of daily consumption for wildlife species (assumed 1; unitless)

2.1 BIOTRANSFER FACTORS

The tissue uptake calculations were based, in part, on COPC specific biotransfer factors (BTFs), which are rates at which COPCs are taken up and absorbed into wildlife tissue from their food.

A scientific literature search on uptake or biotransfer factors (BTFs) was conducted for various wildlife species and country food species included in the HHERA (see table V6-5E7, Appendix V6-5E for a list of species) using the Web of Science search engine. Search terms used in the query included common and scientific names of country food and wildlife receptors in combination with “uptake factor”, “biotransfer factor”, “bio transfer factor”, “bioaccumulation factor”, and “bioconcentration factor” for each COPC. The scientific literature search did not identify any species-specific BTFs for the COPCs included in the FEIS.

The predicted COPC concentrations in wildlife and country food tissue in this FEIS are based on a food web bioaccumulation model that takes into account various uptake factors such as ingestion of various vegetation and prey items, drinking water, and incidental ingestion of soil/sediment. The regression models included in the US EPA (2007) guidance do not incorporate bioaccumulation via various exposure pathways as the bioaccumulation food web model does. The US EPA (2007) document uses a more basic relationship based on regression models to predict the tissue concentrations of biota from soil concentrations only. The regression equations presented in the US EPA (2007) document for the identified COPCs used to predict the uptake of metals from soil into tissue of small mammals are compilations of equations and relationships from various older documents including Sample et al (1998) and Baes et al. (1984). Therefore, although the US EPA (2007) guidance document is a relatively recent publication, the actual data used in the publication is no more recent than the data used in US EPA (1999), Staven et al. (2003), US EPA (2005), and the Risk Assessment Information System (RAIS 2017), which were the sources of BTFs used in this HHERA (Table V6-5E2).

Table V6-5E2. Biotransfer Factors Used to Predict Uptake of Contaminants of Potential Concern into Wildlife Tissue

	BTF_{beef}		$BTF_{chicken}$	
COPC	**day/kg**	**Reference**	**day/kg**	**Reference**
Aluminum	0.0015	1	0.8	2, 3
Arsenic	0.002	1	0.83	2
Cadmium	0.00055	1	0.106	4
Chromium	0.0055	1	0.2	2
Copper	0.01	1	0.5	2
Lead	0.0003	2	0.8	2
Manganese	0.0004	1	0.05	2
Mercury	0.25	1	0.03	2
Nickel	0.006	1	0.001	2
Selenium	0.00227	4	1.13	4
Thallium	0.04	4	10.8	2
Zinc	0.00009	4	0.00875	4

Notes:
COPC = contaminant of potential concern
BTF_{beef} = biotransfer factor for beef; $BTF_{chicken}$ = biotransfer factor for chicken
References: 1. RAIS (2017)
2. Staven et al. (2003).
3. $BTF_{chicken}$ for aluminum is based on $BTF_{chicken}$ for gallium.
4. US EPA (2005).

In addition, the uptake equations presented in the US EPA (2007) guidance document are designed to predict tissue concentrations in wildlife dietary items based only on exposure to soil concentrations (in contrast to the multiple exposure routes that were incorporated into the food chain model described herein). Also, the US EPA (2007) guidance does not provide uptake factors from soil to mammals for any of the identified COPCs in this assessment.

Using the soil-to-chicken BTFs for avian species and soil-to-beef BTFs for mammalian species in absence of species-specific BTFs is based on methodology recommended by Health Canada (Golder Associates Ltd. 2005), and is a common standard practice not unique to this Project. This methodology has been employed in various DEIS and FEIS environmental risk assessments for northern projects (e.g., Gahcho Kuè project for ungulates and Back River project for both mammalian and avian species) and in other environmental risk assessments for Canadian projects (e.g., Kemess Underground project, Kerr-Sulphurets-Mitchel project, Brucejack project, and Murray River project).

Gahcho Kuè referenced RAIS (2017) as a source of BTFs associated with ungulate species. For other mammals, the authors used the US EPA (2007) uptake equations to calculate the tissue concentrations of the mammalian species based on soil concentration on site. The authors then divided the predicted tissue concentrations that were derived from these equations by the soil concentrations used in the same equations to derive an uptake factor. In other words, the derived uptake factors used in the Gahcho Kuè project are a result of a circular calculation methodology from regression models and are no more species- or site-specific or recent than the BAFs offered by (RAIS 2017), Staven et al. (2003), or US EPA (2005). Given the circular nature of the calculations used in derivation of uptake factors from the US EPA (2007) formulas, and the fact that the US EPA (2007) guidance document is based on older data (e.g., Sample et al 1998), we have adopted RAIS (2017), Staven et al. (2003), and US EPA (2005) BTFs in this FEIS.

Food-to-tissue BTFs are used for water, sediment, and soil transfer calculations in the absence of BTFs for these media, as recommended by Golder Associates Ltd. (2005). As no species-specific BTFs for the country food or wildlife species were available, beef BTFs were used for mammals (Table V6-5E2; US EPA 2005; RAIS 2017). The use of beef BTFs for wild mammals is considered to be a conservative approach (RAIS 2017). No BTFs were identified for specific avian wildlife species; therefore, chicken BTFs were used for bird species. The chicken BTFs were obtained from the Pacific Northwest National Laboratory's (PNNL) report and the US EPA (Staven et al. 2003; US EPA 2005).

When BTF values were not available for specific COPCs, the BTF for a COPC with similar physicochemical characteristics was substituted. Metal COPCs were considered similar in their physicochemical characteristics if they were immediately above or below each other on the periodic table of elements. For example, the $BTF_{chicken}$ for aluminum was not available; therefore, the $BTF_{chicken}$ value for gallium was substituted because gallium is below aluminum on the periodic table of the elements.

Food chain models can over- or under-predict contaminant concentrations in the tissues of wildlife species, and the concentrations predicted with the Golder Associates Ltd. (2005) food chain model are for the whole-body and are not tissue specific. However, Inuit frequently consume the liver and kidney of caribou, which may have much higher metal concentrations than other tissues. Therefore, to obtain liver and kidney tissue concentrations for caribou, tissue distribution ratios were applied to the predicted whole-body tissue concentrations based on muscle, liver, and kidney concentrations in caribou tissue reported in peer reviewed literature. Tissue distribution ratios were calculated based on Canadian data provided in the following studies:

- Crete et al. (1989): cadmium concentrations reported in muscle, kidney, and liver tissue of caribou from Quebec;
- Elkin and Bethke (1995): metal concentrations (i.e., aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc) reported in kidney and liver tissue of caribou from the Northwest Territories;
- Gamberg (2000): metal concentrations (i.e., arsenic, cadmium, copper, lead, mercury, and zinc) reported in muscle, kidney, and liver tissue of caribou from the Yukon;
- Gamberg (2004): metal concentrations (i.e., aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese,

mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, uranium, vanadium, and zinc) reported in kidney tissue of caribou from the Yukon;

- Gamberg et al. (2005): metal concentrations (i.e., aluminum, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, selenium, and zinc) reported in kidney tissue of caribou from Alaska and the Yukon;
- Gamberg (2010): metal concentrations (i.e., arsenic, cadmium, copper, lead, mercury, selenium, and zinc) reported in kidney tissue of caribou from the Yukon and Northwest Territories;
- Gamberg and Scheuhammer (1994): cadmium concentrations reported in kidney and liver tissue of caribou from the Yukon and Northwest Territories;
- Kim, Chan, and Receuver (1998): cadmium concentrations reported in muscle, kidney, and liver tissue of caribou from the Northwest Territories;
- Larter et al. (2010): metal concentrations (i.e., aluminum, cadmium, copper, lead, mercury, nickel, selenium, and zinc) reported in kidney tissue of caribou from the Northwest Territories;
- Macdonald et al. (2002): metal concentrations (i.e., aluminum, cadmium, chromium, copper, lead, mercury, and zinc) reported in muscle, kidney, and liver tissue of caribou from the Northwest Territories and Nunavut;
- Pollock et al. (2009): metal concentrations (i.e., cadmium, lead, mercury, and selenium) reported in kidney tissue of caribou from Labrador; and
- Robillard et al. (2002): metal concentrations (i.e., cadmium, lead, and mercury) reported in muscle, kidney, and liver tissue in caribou from Northern Quebec.

Tissue distribution ratios for liver and kidney tissue were obtained by dividing the measured median liver or kidney concentrations by the measured median muscle concentration. The liver and kidney tissue calibration factors were then multiplied by the caribou whole body tissue concentration to obtain liver and kidney tissue concentrations. Calibration factors for organs could not be calculated for COPCs that were not measured in both muscle and kidney or liver; therefore, those COPCs were assumed to have a tissue distribution ratio of one, based on a lack of data to determine appropriate distribution ratios for organs compared to muscle. The tissue distribution ratios presented in Table V6-5E3 were used to estimate organ meat (i.e., liver and kidney tissue) concentrations based on predicted whole-body concentrations.

Table V6-5E3. Literature Derived Muscle Tissue Metal Concentrations in Caribou and Tissue Distribution Ratios used to Predict Kidney and Liver Tissue Metal Concentrations in Caribou

Metal	Median Muscle Tissue Concentration (mg/kg wet weight)	Median Liver Tissue Concentration (mg/kg wet weight)	Median Kidney Tissue Concentration (mg/kg wet weight)	Tissue Distribution Ratio for Liver	Tissue Distribution Ratio for Kidney
Arsenic	0.129	0.174	0.146	1.35	1.13
Cadmium	0.0382	5.33	46.1	140	1207
Copper	2.83	130	20.7	46.0	7.30
Lead	0.0540	9.77	1.18	181	21.8
Mercury	0.0186	2.02	9.63	109	518
Zinc	47.0	74.0	88.9	1.57	1.89

2.2 CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL CONCERN IN ENVIRONMENTAL MEDIA AND BIOTA

A summary of the data used as inputs into the food chain model for vegetation, soil, water, sediment, fish tissue, and mussel tissue quality is presented in Table V6-5E4.

The vegetation existing conditions sampling programs included the collection of tissue metal samples from within the human health LSA. The species sampled included: crowberries (*Empetrum nigrum*), bog blueberry (*Vaccinium uliginosum*), bearberry (*Arctostaphylos alpina*), and lichen (*Flavocetraria nivas* and *F. cucullata*). The vegetation tissue metal samples were used to support food chain modeling of country food species and wildlife species. An online search was conducted to determine if there were additional existing conditions vegetation data available from nearby (i.e., within the Human Health RSA) existing or proposed projects to increase the variety of vegetation species in the assessment. However, the nearby projects (e.g., Back River, Gahcho Kue, Mary River, Kiggavik, Meliadine, Meadowbank, etc.) are located outside the Human Health RSA. As surface soil and rock mineralization characteristics are site-specific and can lead to differences in plant tissue metal concentrations, vegetation samples from those projects were not included in the assessment as they were not considered to be sufficiently site-specific. Overall, 36 crowberry, 10 bearberry, 1 bog blueberry, 17 mixed berries (species unidentified), and 81 lichen tissue metal samples from two species were included in the food chain model. For berry producing plants, the berries were submitted for analysis. For lichens, the entire plant was collected and analyzed. The vegetation value (diet) used in the food chain model was the mean of the 95th percentile concentration of COPCs in the berries and lichen collected.

The vegetation diet items for the wildlife species that required food chain modeling were limited to the vegetation species that were available for collection at the time of sampling; thus, they may not entirely represent the actual diet of these wildlife species. Furthermore, diets shift during the year (e.g., due plant abundance during the growing season versus winter) whereas the model uses a generalized diet for the year. Therefore, there are several assumptions for the diet composition of the country food and wildlife species modeled and best professional judgement was used in the diet determination. Uncertainties with the use of the vegetation data are presented in Sections 5.3.6 and 5.5.5 of the existing conditions HHRA and ERA.

Data used from the soil sampling program included 100 soil samples collected from depths ranging from 0 to 20 cm below ground surface (US EPA 2012). The 95th percentile soil concentration of COPCs were used in the incidental soil ingestion pathway to predict the tissue concentrations of COPCs in caribou, Arctic ground squirrel, muskox, wolverine, grizzly bear, wolf, Arctic shrew, northern red-backed vole, willow ptarmigan, American tree sparrow, peregrine falcon, and yellow warbler.

The data used for freshwater quality was from the base case existing conditions surface water quality model from 13 surface water quality model nodes (see Section 5.3.2.3 in Volume 6 for more information).

Data used from the freshwater sediment sampling program (stream and lake samples) included 349 samples collected between 2007 and 2017. The higher of the stream or lake sediment concentrations were used in the incidental freshwater sediment ingestion pathway to predict the tissue concentrations of COPCs in Canada goose, red-breasted merganser, least sandpiper, and long-tailed duck.

Data used from the marine sediment sampling program (i.e., Roberts Bay) included 103 samples collected between 2007 and 2017. The 95th percentile concentrations of COPCs were used in the incidental marine sediment ingestion pathway to predict the tissue concentrations of COPCs in herring gull, brant, and ringed seal.

Fish tissue samples included 17 samples of marine Arctic Char (*Salvelinus alpinus*) collected in 2017; 69 samples of Lake Trout (*S. namaycush*) collected in 2009 and 2010; seven samples of Whitefish (*Coregonus* spp.) collected in 2009; 134 samples of Ninespine Stickleback (*Pungitius pungitius*) collected in 2010. There were also 28 samples of bay mussel (*Mytilus trossulus*) collected in 2010. The 95th percentile of COPC concentrations in fish and bay mussel tissue were used in the food chain model.

2.3 INVERTEBRATE TISSUE CONCENTRATIONS

Several of the wildlife species included in the food chain model consume invertebrates; however, invertebrate tissue was not analyzed for COPC concentrations during the existing conditions sampling program, except for marine bay mussels. Therefore, existing conditions COPC concentrations in tissue of freshwater invertebrates and soil invertebrates were calculated using published bioconcentration factors (BCFs). To calculate existing conditions COPC concentrations in invertebrate tissue, the 95th percentile COPC concentration in environmental media (i.e., freshwater and soil) was multiplied by the applicable BCF to obtain the COPC concentration in invertebrate tissue. The 95th percentile COPC concentrations in the environmental media, the invertebrate BCFs, and the calculated COPC concentrations in invertebrate tissue are presented in Tables V6-5E5 and V6-5E6.

2.4 WILDLIFE CHARACTERISTICS

Wildlife characteristics are species-specific parameters that were used to estimate the amount of time an animal would spend in the wildlife RSA and the amount of environmental media that each species would be exposed to during that time. Tables V6-5E7 and V6-5E8 presents the species-specific characteristics that were used to predict country food and wildlife tissue concentrations of COPCs.

Concentrations of COPCs in tissue were not measured in prey species (except for fish and bay mussels); thus, tissue concentrations in prey species were modeled and used as diet items for carnivores and omnivores. Only the wildlife VECs were considered as prey species which is a simplification of the food chain. The diet items of the species included in the assessment is provided in Table V6-5E7.

Many of the ingestion rates for different wildlife species were not available in the literature, thus were calculated from equations provided in ORNL (1997). The calculations required the percent moisture of the food items, which are presented in Table V6-5E8.

The exposure time (ET) in the wildlife LSA for the different wildlife species was determined using information previously collected (e.g., collared caribou data), information available in the literature, and best professional judgement. A description of the ETs used for the different wildlife species are described in the sections below.

2.4.1 Caribou

The Madrid-Boston Project area lies within the seasonal ranges of the island caribou (Dolphin and Union herd) and mainland caribou (Beverly and Ahiak sub-populations).

TMAC held a series of caribou workshops with Elders and landusers during 2016 and 2017. Workshop participants identified and rated potential risks to the caribou populations due to the Madrid-Boston project, including habitat loss, disturbance and contamination of the environment by dust and water from the Project. An assessment of the effects of altered environmental media (soil, vegetation and water) is addressed with the Madrid-Boston Project-related ERA.

Table V6-5E4. Summary of the 95th Percentile Concentrations of Contaminants of Potential Concern in Vegetation, Soil, Sediment, Marine Water, Freshwater, Fish Tissue, and Mussel Tissue Samples

COPC	95th Percentile Baseline Berry Species Concentration (mg/kg ww; n=64)	95th Percentile Baseline Lichen Species Concentration (mg/kg ww; n=81)	Mean of 95th Percentiles of Berries and Lichen C_{veg}	95th Percentile Baseline Soil Concentration (mg/kg dw; n=100) C_{soil}	95th Percentile Baseline Freshwater Sediment Concentration [a] (mg/kg; n=349) $C_{f\text{-}sediment}$	95th Percentile Baseline Marine Sediment Concentration (mg/kg; n=103) $C_{m\text{-}sediment}$	95th Percentile Baseline Freshwater Concentration (mg/L; n=13 modelling nodes) $C_{f\text{-}water}$	95th Percentile Baseline Marine Water Concentration (mg/L; n = 323-325) $C_{m\text{-}water}$	95th Percentile Arctic Char Tissue Concentration (mg/kg, n=17) $C_{arcticchar}$	95th Percentile Lake Trout Tissue Concentration (mg/kg, n=69) $C_{laketrout}$	95th Percentile Whitefish Tissue Concentration (mg/kg, n =7) $C_{whitefish}$	95th Percentile Stickleback Tissue Concentration (mg/kg, n =134) $C_{stickleback}$	95th Percentile Bay Mussel Tissue Concentration (mg/kg, n =24) C_{mussel}
Aluminum	5.48	354	180	21330	29422	22790	0.1423	0.131	2.40	4.24	3.05	57.3	113
Arsenic	0.00362	0.207	0.105	3.78	19.1	16.80	0.000523	0.00132	2.01	0.144	0.175	0.105	2.77
Cadmium	0.00380	0.150	0.0771	0.250	0.262	0.1836	0.00001428	0.0000600	0.00250	0.00250	0.00250	0.0447	0.741
Chromium	9.33	5.79	7.56	65.6	81.0	65.8	0.000811	0.02500	0.0192	0.326	0.110	0.333	19.5
Copper	1.33	2.75	2.04	38.3	52.5	27.1	0.00295	0.00115	1.72	0.333	0.301	2.05	1.58
Lead	0.0133	0.797	0.405	15.0	12.7	8.42	0.0001316	0.000500	0.00828	0.0752	0.116	0.0738	0.191
Manganese	23.5	113	68.3	370	2490	400	0.0384	0.00767	0.203	0.263	0.769	20.2	3.42
Mercury	0.000500	0.0897	0.0451	0.0506	0.0950	0.0179	0.00000278	0.00000500	0.0446	1.08	0.311	0.118	0.0206
Nickel	5.25	2.72	3.98	34.7	48.6	32.4	0.001266	0.000794	0.113	0.196	0.274	0.265	10.5
Selenium	0.0100	0.100	0.0550	0.250	0.650	0.538	0.000542	0.00100	0.000500	0.600	0.277	0.460	0.937
Thallium	0.000200	0.0138	0.00702	0.500	0.313	0.265	0.00000599	0.00500	0.00724	0.0110	0.00500	0.0150	0.00231
Zinc	2.15	28.4	15.3	59.1	105	77.6	0.00570	0.00250	7.91	4.75	3.90	76.9	20.4

Notes:

COPC = contaminant of potential concern

ww = wet weight

dw = dry weight

(-) = not calculated because that parameter was not measured in environmental media.

Mercury concentrations in aquatic biota are assumed to be 100% methymercury

[a] *The freshwater sediment concentration is the higher 95th percentile concentration of either lake or stream samples.*

Table V6-5E5. Calculated Concentration of Contaminants of Potential Concern in Freshwater Aquatic Invertebrate Tissue

Parameter	95th Percentile Surface Water Concentration (mg/L)	BCF Water-to-Aquatic Invertebrates	BCF Source	Aquatic Invertebrate Tissue Concentration (mg/kg ww)
Aluminum	0.129	231	US EPA (1988) in Sample et al. (1996)	29.8
Arsenic	0.000444	73	US EPA (1999)	0.0324
Cadmium	0.0000143	3461	US EPA (1999)	0.0494
Chromium	0.000732	3000	US EPA (1999)	2.20
Copper	0.00243	3718	US EPA (1999)	9.04
Lead	0.000117	5059	US EPA (1999)	0.590
Manganese	0.0314	4066	US EPA (1999)	128
Mercury	0.00000278	20184	US EPA (1999)	0.0562
Methylmercury	0.00000278	55000	US EPA (1999)	0.153
Nickel	0.00107	28	US EPA (1999)	0.0299
Selenium	0.000536	1262	US EPA (1999)	0.676
Thallium	0.00000599	15000	US EPA (1999)	0.0899
Zinc	0.00470	4578	US EPA (1999)	21.5

Notes:
BCF = bioconcentration factor (unitless; BCF = $C_{invertebrate}$ (in mg/kg ww)/C_{water} (in mg/L))
ww = wet weight
Freshwater aquatic invertebrates are trophic level 2.
** Dissolved concentrations are typically applied in BCF calculations. In the absence of the dissolved concentrations for metals, total metals were conservatively used in the calculations.*

Table V6-5E6. Calculated Concentration of Contaminants of Potential Concern in Terrestrial Invertebrate Tissue

Parameter	95th Percentile Soil Concentration (mg/kg)	BCF Soil-to-Terrestrial Invertebrates	BCF Source	Terrestrial Invertebrate Tissue Concentration (mg/kg ww)
Aluminum	21330	0.22	US EPA (1999)	4693
Arsenic	3.78	0.11	US EPA (1999)	0.416
Cadmium	0.250	0.96	US EPA (1999)	0.240
Chromium	65.6	0.01	US EPA (1999)	0.656
Copper	38.3	0.04	US EPA (1999)	1.53
Lead	15.0	0.03	US EPA (1999)	0.450
Manganese	370	0.054	CHPPM (2004)	20.0
Mercury	0.0506	0.04	US EPA (1999)	0.00202
Nickel	34.7	0.02	US EPA (1999)	0.694
Selenium	0.250	0.22	US EPA (1999)	0.0550
Thallium	0.500	0.22	US EPA (1999)	0.110
Zinc	59.1	0.56	US EPA (1999)	33.1

Notes:
BCF = bioconcentration factor (unitless; BCF = Cinvertebrate (in mg/kg ww)/Csoil (in mg/kg))
ww = wet weight
Terrestrial invertebrates are trophic level 2.

Table V6-5E7. Wildlife Diet Items and Proportions

Wildlife Species	Diet Item	% of Diet	Diet Reference	% Moisture of Diet Item	% Moisture Reference
Caribou	Vegetation	100	Environment Yukon (2016)	50.3	Existing conditions data
Muskox	Vegetation	100	Barboza, Peltier, and Forster (2006)	50.3	Existing conditions data
Wolverine	Caribou	8.33	State of Alaska (2015e)	70	Willmer, Stone, and Johnston (2009)
	Muskox	8.33			
	Arctic Ground Squirrel	8.33			
	Arctic Shrew	8.33			
	Northern Red-backed Vole	8.33			
	Willow Ptarmigan	8.33			
	Canada Goose	8.33			
	Red-breasted Merganser	8.33			
	Least sandpiper	8.33			
	American golden-plover	8.33			
	Yellow Warbler	8.33			
	American Tree Sparrow	8.33			
Grizzly Bear	Caribou	35.3	Gau et al. (2002)	70	Willmer, Stone, and Johnston (2009)
	Muskox	7.56			
	Arctic Ground Squirrel	7.56			
	Canada Goose	0.93			
	Willow Ptarmigan	0.93			
	Vegetation	46.8	Gau et al. (2002)	50.3	Existing conditions data
	Fish (all species)	0.93		77.0	Existing conditions data
Wolf	Muskox	16.7	Mech (2007)	70	Willmer, Stone, and Johnston (2009)
	Caribou	16.7			
	Arctic Ground Squirrel	16.7			
	Arctic Shrew	16.7			
	Northern Red-backed Vole	16.7			
	Fish (freshwater)	16.7	ERM field photo	76.0	Existing conditions data
Arctic Ground Squirrel	Vegetation	100	State of Alaska (2015a)	50.3	Existing conditions data
Arctic Shrew	Terrestrial Invertebrates	100	Environment Canada (2012b)	71.3	ORNL (1997)
Northern Red-backed Vole	Vegetation	80	Linzey et al. (2008)	50.3	Existing conditions data
	Terrestrial Invertebrates	20		71.3	ORNL (1997)
Willow Ptarmigan	Vegetation	100	Cornell Lab of Ornithology (2015i)	50.3	Existing conditions data

Wildlife Species	Diet Item	% of Diet	Diet Reference	% Moisture of Diet Item	% Moisture Reference
American Tree Sparrow	Vegetation	50	Cornell Lab of Ornithology (2015a)	50.3	Existing conditions data
	Terrestrial Invertebrates	50		71.3	ORNL (1997)
Peregrine Falcon	Arctic Ground Squirrel	2.5	Cornell Lab of Ornithology (2015g)	70	Willmer, Stone, and Johnston (2009)
	Arctic Shrew	2.5			
	Northern Red-backed Vole	2.5			
	Canada Goose	10			
	King Eider	10			
	Red-breasted Merganser	10			
	Least Sandpiper	10			
	American Golden Plover	10			
	Red-throated Loon	10			
	Herring Gull	10			
	Yellow Warbler	10			
	Brant	10			
	Fish (all species)	2.5	Cornell Lab of Ornithology (2015g)	77.0	Existing conditions data
Canada Goose	Vegetation	100	Cornell Lab of Ornithology (2015c)	50.3	Existing conditions data
Red-breasted Merganser	Fish (all species)	100	Cornell Lab of Ornithology (2015h)	77.0	Existing conditions data
Least Sandpiper	Freshwater Invertebrates	100	Cornell Lab of Ornithology (2015e)	78.5	ORNL (1997)
Long-tailed Duck	Vegetation	5	Cornell Lab of Ornithology (2015f)	50.3	Existing conditions data
	Freshwater Invertebrates	90		78.5	ORNL (1997)
	Fish (all species)	5		77.0	Existing conditions data
Herring Gull	Bay Mussel	50	(Cornell Lab of Ornithology 2015d)	87.9	Existing conditions data
	Fish (marine)	50		80.0	Existing conditions data
Yellow Warbler	Terrestrial Invertebrates	100	Cornell Lab of Ornithology (2015j)	71.3	ORNL (1997)
Brant	Vegetation	100	Cornell Lab of Ornithology (2015b)	50.3	Existing conditions data
Ringed Seal	Fish (marine)	80	NOAA (2014)	80.0	Existing conditions data
	Bay Mussel	20		87.9	Existing conditions data

Notes:
Diet items were specified in the references listed but the percent of the item in the diet was typically not provided and instead best professional judgement was used.

Table V6-5E8. Wildlife Characteristics

Wildlife Species	Mean Body Weight (kg)	Body Weight Reference	Diet Items	Food Ingestion Rate (IR_{food}; kg-ww/day)	Soil/Sediment Ingestion Rate (IR_{soil}; kg-dw/day)	Soil/Sediment Ingestion Rate Reference	Water Ingestion Rate (IR_{water}; L/day)	Exposure Time in Area (ET)	Fraction of Daily Consumption (fw)
Caribou	150	Environment Yukon (2016)	Vegetation	6.72	1.344	MacDonald and Gunn (2004)	9.00	0.00134	1
Muskox	273	State of Alaska (2015c)	Vegetation	10.4	0.706	Beyer et al. (1994)	15.4	1	1
Wolverine	12.0	State of Alaska (2015e)	Caribou	0.147	0.0353	Beyer and Fries (2003)	0.93	1	1
			Muskox	0.147					
			Arctic Ground Squirrel	0.147					
			Arctic Shrew	0.147					
			Northern Red-backed Vole	0.147					
			Willow Ptarmigan	0.147					
			Canada Goose	0.147					
			Red-breasted Merganser	0.147					
			Least sandpiper	0.147					
			Long-tailed duck	0.147					
			Herring Gull	0.147					
			Brant	0.147					
Grizzly Bear	450	State of Alaska (2015b)	Caribou	12.3	1.27	Gau et al. (2002)	24.2	0.458	1
			Muskox	2.63					
			Arctic Ground Squirrel	2.63					
			Canada Goose	3.23					
			Willow Ptarmigan	10.7					
			Vegetation	9.80					
			Fish (all species)	4.22					

Wildlife Species	Mean Body Weight (kg)	Body Weight Reference	Diet Items	Food Ingestion Rate (IR_{food}; kg-ww/day)	Soil/Sediment Ingestion Rate (IR_{soil}; kg-dw/day)	Soil/Sediment Ingestion Rate Reference	Water Ingestion Rate (IR_{water}; L/day)	Exposure Time in Area (ET)	Fraction of Daily Consumption (fw)
Wolf	49.5	State of Alaska (2015d)	Caribou	0.94	0.118	Beyer and Fries (2003)	3.32	1	1
			Muskox	0.94					
			Arctic Ground Squirrel	0.94					
			Arctic Shrew	0.94					
			Northern Red-backed Vole	0.94					
			Fish (freshwater)	1.18					
Arctic Ground Squirrel	1.01	State of Alaska (2015a)	Vegetation	0.0620	0.00434	Beyer and Fries (2003)	0.100	0.417	1
Arctic Shrew	0.00410	Environment Canada (2012b)	Terrestrial Invertebrates	0.00116	0.0000815	Beyer and Fries (2003)	0.000703	1	1
Northern Red-backed Vole	0.0300	Smithsonian National Museum of Natural History (2015)	Vegetation	0.00344	0.000660	Beyer and Fries (2003)	0.00422	1	1
			Terrestrial Invertebrates	0.00598					
Willow Ptarmigan	0.620	Cornell Lab of Ornithology (2015i)	Vegetation	0.0857	0.00171	Beyer and Fries (2003)	0.0428	1	1
American Tree Sparrow	0.0285	Cornell Lab of Ornithology (2015a)	Vegetation	0.0115	0.000631	Beyer and Fries (2003)	0.00544	0.417	1
			Terrestrial Invertebrates	0.0200					

Wildlife Species	Mean Body Weight (kg)	Body Weight Reference	Diet Items	Food Ingestion Rate (IR_{food}; kg-ww/day)	Soil/Sediment Ingestion Rate (IR_{soil}; kg-dw/day)	Soil/Sediment Ingestion Rate Reference	Water Ingestion Rate (IR_{water}; L/day)	Exposure Time in Area (ET)	Fraction of Daily Consumption (fw)
Peregrine Falcon	0.815	Environment Canada (2012b)	Arctic Ground Squirrel	0.00425	0.00683	Environment Canada (2012b)	0.0514	0.417	1
			Arctic Shrew	0.00425					
			Northern Red-backed Vole	0.00425					
			Willow Ptarmigan	0.0170					
			American Tree Sparrow	0.0170					
			Canada Goose	0.0170					
			Red-breasted Merganser	0.0170					
			Least Sandpiper	0.0170					
			Long-tailed duck	0.0170					
			Herring Gull	0.0170					
			Yellow Warbler	0.0170					
			Brant	0.0170					
			Fish (all species)	0.00514					
Canada Goose	3.16	US EPA (1993)	Vegetation	0.247	0.0198	Beyer and Fries (2003)	0.128	0.417	1
Red-breasted Merganser	1.08	Cornell Lab of Ornithology (2015h)	Fish (freshwater)	0.247	0.00494	Beyer and Fries (2003)	0.0621	0.417	1
Least Sandpiper	0.0245	Cornell Lab of Ornithology (2015e)	Freshwater Invertebrates	0.0242	0.000484	Beyer and Fries (2003)	0.00492	0.417	1
Long-tailed Duck	0.800	Cornell Lab of Ornithology (2015f)	Vegetation	0.00506	0.00452	Beyer and Fries (2003)	0.0508	0.417	1
			Freshwater Invertebrates	0.211					
			Fish (freshwater)	0.0102					

Wildlife Species	Mean Body Weight (kg)	Body Weight Reference	Diet Items	Food Ingestion Rate (IR_{food}; kg-ww/day)	Soil/Sediment Ingestion Rate (IR_{soil}; kg-dw/day)	Soil/Sediment Ingestion Rate Reference	Water Ingestion Rate (IR_{water}; L/day)	Exposure Time in Area (ET)	Fraction of Daily Consumption (fw)
Herring Gull	1.03	(Cornell Lab of Ornithology 2015d)	Bay Mussel Fish (marine)	0.245 0.109	0.00707	(Beyer and Fries 2003)	0.0602	0.417	1
Yellow Warbler	0.0100	Cornell Lab of Ornithology (2015j)	Terrestrial Invertebrates	0.0101	0.000203	Beyer and Fries (2003)	0.00270	0.417	1
Brant	1.50	Cornell Lab of Ornithology (2015b)	Vegetation	0.152	0.00305	Beyer and Fries (2003)	0.07742	0.417	1
Ringed Seal	54.4	NOAA (2014)	Fish (marine) Bay Mussel	7.34 3.03	0.207	Environment Canada (2012b)	N/A	1	1

Notes:
ww = wet weight
dw = dry weight
N/A = not applicable
The food and water ingestion rates were obtained from ORNL (1997) and are based on equations for mammals and birds.
Many of the wildlife species were assumed to be similar to closely related species if species specific information was not available (e.g., assumed that soil ingestion by muskox was similar to that for bison).

The Dolphin-Union herd winters on the mainland coast and migrates north at the end of April and May to Victoria Island to calve and spend the summer, returning to the mainland during the fall when the sea ice has frozen (typically in early November). The range of the Dolphin-Union caribou herd overlaps with the wildlife RSA during spring and fall migration, and during winter. More information on the caribou herds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.6.

The Ahiak caribou herd calves and spends the summer to the east of the Madrid-Boston Project area in the Queen Maud Gulf Migratory Bird Sanctuary. This herd winters on the tundra, including in the Project area.

Estimation of occurrence of caribou in the Phase 2 Project area is based on baseline collar data (for details of this program see Volume 4, Section 9.8.3.2). The area used in this assessment is based on the air quality assessment area. The air quality assessment evaluated dust deposition within a 2 km Property Boundary (PB) zone. This modeling predicted that maximum TSP and $PM_{2.5}$ concentrations met applicable standards at the PB, within 2 km from the Doris, Madrid North, Madrid South and Boston PDA's. PM_{10} was predicted to exceed the applicable 24-hour average guideline by 19% along the PB to the southeast of Madrid South. However, exceedances were predicted to be infrequent (no more than one day per year).

In order to match the assessment used in the air quality assessment, the HHERA evaluated the residency time of caribou within the 2 km PB. For the island caribou, which spend the greatest time in the Project area, a total of 5% of collars interact with the PB across all years of collar data. The residency time was calculated as 0.38 days per year for spring migration, fall migration and winter combined and 0.4 days per year during the winter, when caribou are actively feeding in the PB zone. An initial (i.e., preliminary) residency time of 0.49 days per year was originally estimated for caribou (Volume 4, Section 9.8.3.7). As a conservative approach, this initial value of 0.49 days per year (ET = 0.00134) was used in the food chain model instead of the newer (and shorter) frequency of 0.4 days per year.

TMAC held a series of caribou workshops with Elders and landusers during 2016 and 2017. Workshop participants identified and rated potential risks to the caribou populations due to the Madrid-Boston project, including habitat loss, disturbance and contamination of the environment by dust and water from the Project. An assessment of the effects of altered environmental media (soil, vegetation and water) is addressed with the Madrid-Boston Project-related ERA.

2.4.2 Muskox

Muskoxen do not migrate and spend their entire lives in the Arctic (State of Alaska 2015c). The winter home range for muskox is 27 to 70 km^2, while the summer home range is 223 km^2 (Volume 4, Section 9.2.6.1). Thus, they could be present year round (ET = 1) in the terrestrial wildlife LSA (563 km^2). More information on muskoxen that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 97.

2.4.3 Arctic Ground Squirrel

The study area is large enough that it could overlap with the entire home range of an individual Arctic ground squirrel (less than 3 ha; Hubbs and Boonstra 1998). Arctic ground squirrels hibernate over winter from early-September to late-April and would not be exposed to COPCs during that time. Therefore, the residency time in the study area was assumed to be five months of the year (ET = 0.417). Ecological Risk Assessment guidance (Environment Canada 2012a) indicates that certain terrestrial receptor types require assessment in an ERA. Therefore, Arctic ground squirrel was selected to represent small herbivorous mammals and they were also selected to represent the wildlife VEC "less conspicuous species that may be maximally exposed to contaminants".

2.4.4 Canada Goose

Canada geese arrive on the central Canadian Arctic barrens in early to mid-May, and generally depart by mid-September (Cornell Lab of Ornithology 2015c). If a pair of geese were to nest and raise young in the study area, it is conceivable that residency in the Madrid-Boston Project area would be for the entire time that they are in the Arctic. Therefore, the residency of Canada goose in the study area is at most five months of the year (ET = 0.417). Freshwater sediment concentrations were used in predicting the Canada goose tissue concentrations of COPCs as Canada goose may ingest freshwater sediments while grazing. More information on the waterbirds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.11.

2.4.5 Wolverine

Wolverines (*Gulo gulo*) are members of the mustelid family, which includes weasels, badgers, and marten. Very large home ranges and low population densities are characteristics of this solitary species. Females have a home range of 100 km^2, and males 600 km^2 (Volume 4, Section 9.2.9.1); thus and they could be present in the terrestrial wildlife LSA (563 km^2) during the entire year. The wolverine is listed as being of Special Concern by COSEWIC (2016). Wolverines do not migrate or hibernate and spend their entire lives in the Arctic (State of Alaska 2015e). Thus, they could be present year round in the wildlife LSA (ET = 1). More information on wolverines that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.9.

2.4.6 Grizzly Bear

Barren-ground grizzly bears (*Ursus arctos horribilis*) inhabit the northern extent of the grizzly bear range in North America and are known to occur in the existing conditions wildlife LSA and RSA from satellite-collar data and observations made during existing conditions studies (Rescan 2011b). Average annual ranges of male and female grizzly bears are approximately 7,245 km^2 and 2,100 km^2, respectively, and home range overlap is relatively high (McLoughlin, Ferguson, and Messier 2000). These home ranges are much larger than the terrestrial wildlife LSA (563 km^2), thus a dose adjustment factor (DAF) was applied to the estimated daily intake of COPCs for grizzly bears. The DAF was calculated by dividing the area of the terrestrial wildlife LSA by the home range for females (DAF = 0.268).

In the Canadian Arctic typically emerge from hibernation in early to mid-May and resume hibernation in mid to late-October (Gau et al. 2002). Thus the maximum amount of time that a grizzly bear could possibly spend in the wildlife LSA is five and a half months of the year (ET = 0.458).

Barren-ground grizzly bears are listed by COSEWIC (2016) as being of Special Concern but they are not listed under SARA. More information on barren-ground grizzly bears that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.8.

2.4.7 Wolf

The grey wolf (*Canis lupis*) is the largest member of the *Canis* genus and is widespread throughout much of northern Canada, including the West Kitikmeot region of Nunavut. Three subspecies of grey wolf occur in Nunavut, all of which may be found within the wildlife RSA (Chambers et al. 2012): the northern timber wolf (*Canis lupis occidentalis*), the plains wolf (*Canis lupis nubilus*), and the Arctic wolf (*Canis lupis arctos*). The northern timber wolf and plains wolf subspecies are listed by COSEWIC (2016) as Not at Risk, while the Arctic wolf subspecies is listed as Data Deficient.

Wolves do not migrate or hibernate and spend their entire lives in the Arctic (State of Alaska 2015d). Thus, they could be present year round in the wildlife LSA (ET = 1). However, the home range for female wolves is 45,000 km^2, while that for males is 63,000 km^2 (Volume 4, Section 9.2.8.1), both of which are much larger than the terrestrial wildlife LSA (563 km^2). Thus a DAF was applied to the estimated daily intake of COPCs for wolves. The DAF was calculated by dividing the area of the terrestrial wildlife LSA by the home range for females (DAF = 0.0125). More information on wolves that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.9.

2.4.8 Arctic Shrew

The study area is large enough that it could overlap with the entire home range of the Arctic shrew (0.1 ha; Hammerson 2008). Arctic shrews do not hibernate over winter; therefore, the residency time in the study area was assumed to be the entire year (ET = 1). Ecological Risk Assessment guidance (Environment Canada 2012a) indicates that certain terrestrial receptor types require assessment in an ERA. Therefore, Arctic shrew was selected to represent insectivorous mammals and they were also selected to represent the wildlife VEC “less conspicuous species that may be maximally exposed to contaminants”.

2.4.9 Northern Red-backed Vole

The study area is large enough that it could overlap with the entire home range of the northern red-backed vole (0.5 ha; Batzli 1999). Northern red-backed voles do not hibernate over winter; therefore, the residency time in the study area was assumed to be the entire year (ET = 1). Ecological Risk Assessment guidance (Environment Canada 2012a) indicates that certain terrestrial receptor types require assessment in an ERA. Therefore, northern red-backed vole was selected to represent small omnivorous mammals and they were also selected to represent the wildlife VEC “less conspicuous species that may be maximally exposed to contaminants”.

2.4.10 Willow Ptarmigan

Willow ptarmigans make short local migrations depending on weather conditions, but are otherwise resident species that overwinter on the tundra. Willow ptarmigan migrate between summer and winter ranges that can be separated by a few kilometers to over a 100 kilometers (State of Alaska 2016). To provide a conservative risk estimate it was assumed that willow ptarmigan could be in the study area the entire year (ET = 1). More information on the upland birds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.12.

2.4.11 American Tree Sparrow

American tree sparrows have a medium distance migration, with breeding occurring in the far north of North America and wintering occurring in north and central North America (Cornell Lab of Ornithology 2015a). If a pair of sparrows were to nest and raise young in the study area, it is conceivable that residency in the Madrid-Boston Project area would be for the entire time that they are in the Arctic. Therefore, the residency of American tree sparrow in the study area is at most five months of the year (ET = 0.417). More information on the upland birds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.12.

2.4.12 Peregrine Falcon

Peregrine falcons (*Falco peregrinus*) are cliff-nesting raptors and have the potential to breed in the wildlife RSA. There are three subspecies of peregrine falcon in Canada, and the tundra peregrine falcon (*Falco peregrinus tundrius*) is highly migratory and breeds in the Canadian Arctic, Alaska, and Greenland (Rescan 2011b). They have the greatest distance migration of any North American bird, with some falcons nesting in the Arctic tundra and wintering as far south as Argentina and Chile (Cornell Lab of Ornithology 2015g). Thus, they could be present for five months of the year in the study area due to migration (ET = 0.417). The tundra peregrine falcon is ranked as of Special Concern by (COSEWIC 2016) and is federally listed on Schedule 1 as a population of Special Concern under SARA (Government of Canada 2015). More information on the raptors that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.10.

2.4.13 Red-breasted Merganser

Red-breasted mergansers spend the summer breeding season at northern latitudes and winter along the coast at locations further south (Cornell Lab of Ornithology 2015h). Thus, they could be present for five months of the year in the study area due to migration (ET = 0.417). Freshwater sediment concentrations were used in predicting the red-breasted merganser tissue concentrations of COPCs as they may ingest freshwater sediments while foraging. More information on the waterbirds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.11.

2.4.14 Least Sandpiper

Least sandpipers have long distance migrations that can range from the far north of North America to South America (Cornell Lab of Ornithology 2015e). Thus, they could be present for five months of the year in the study area due to migration (ET = 0.417). Freshwater sediment concentrations were used in predicting the least sandpiper tissue concentrations of COPCs as they may ingest freshwater sediments while foraging. More information on the waterbirds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.11.

2.4.15 Long-tailed Duck

North American long-tailed ducks breed in the Arctic and migrate to wintering grounds along the Pacific coast from the Bering Sea to California and as far west as Russia (Sea Duck Joint Venture 2003). Waterbirds can spend up to 50% of the year migrating between wintering and breeding areas, and up to 95% of that time staging in areas prior to and following breeding. Thus, they could be present for five months of the year in the study area due to migration (ET = 0.417). Freshwater sediment concentrations were used in predicting the long-tailed duck tissue concentrations of COPCs as they may ingest freshwater sediments while foraging. More information on the waterbirds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.11.

2.4.16 Herring Gull

Herring gulls have a short to medium distance migration and birds that breed in the far north of North America tend to move south or out to sea for the winter (Cornell Lab of Ornithology 2015d). Thus, herring gulls could be present for five months of the year in the study area due to migration (ET = 0.417). Marine sediment concentrations were used in predicting the herring gull tissue concentrations of COPCs as they may ingest marine sediments while foraging. Seabirds have the ability to drink salt water while at sea (National Audubon Society 2013), thus to be conservative the highest 95th percentile COPC concentration from either freshwater or marine water was used as the drinking water input in the food chain model. More information on the seabirds that can be found in the Madrid-Boston Project area can be found in Volume 5, Section 11.2.7.

2.4.17 Yellow Warbler

Yellow warblers have a long migration from breeding grounds in North America to wintering grounds in Central America and northern South America (Cornell Lab of Ornithology 2015j). Thus, yellow warblers could be present for five months of the year in the study area due to migration (ET = 0.417). More information on the upland birds that can be found in the Madrid-Boston Project area can be found in Volume 4, Section 9.2.12.

2.4.18 Brant

The breeding ground of brants is in the high Arctic tundra and wintering grounds are along the coasts of the Pacific and Atlantic oceans of the US. Thus, brants could be present for five months of the year in the study area due to migration (ET = 0.417). Marine sediment concentrations were used in predicting the brant tissue concentrations of COPCs as they may ingest marine sediments while foraging. Seabirds have the ability to drink salt water while at sea (National Audubon Society 2013), thus to be conservative the highest 95^{th} percentile COPC concentration from either freshwater or marine water was used as the drinking water input in the food chain model. More information on the seabirds that can be found in the Madrid-Boston Project area can be found in Volume 5, Section 11.2.7.

2.4.19 Ringed Seal

Ringed seals inhabit Arctic waters and are often found near ice floes and pack ice as they use ice to haul out on (NOAA 2014). To provide a conservative risk estimate it was assumed that ringed seals could be in the study area the entire year (ET = 1). Marine sediment concentrations were used in predicting the ringed seal tissue concentrations of COPCs as they may ingest marine sediments while foraging. Ringed seal are listed by COSEWIC (2016) as being Not at Risk. More information on the marine mammals that can be found in the Madrid-Boston Project area can be found in Volume 5, Section 11.2.6.

2.5 SAMPLE CALCULATION AND COMPLETE MODEL RESULTS

To calculate the amount of COPCs that each ingestion pathway contributes, an equation for all ingestion routes is presented in Table V6-5E9, followed by media specific equations. Table V6-5E9 also provides a sample calculation for the copper concentration in caribou tissue resulting from ingesting soil, water, and vegetation during existing conditions. As described in Section 2.1, the food chain model predicts whole-body tissue concentrations; therefore, Table V6-5E9 also provides a sample calculation for the calibrated muscle, liver, and kidney tissue copper concentration in caribou.

Table V6-5E9. Sample Calculation of Copper Concentration in Caribou Tissue due to Uptake from Soil, Surface Water, and Vegetation

Overall equation:	
$C_{total} = C_{m[veg]} + C_{m[soil]} + C_{m[water]}$	
where:	$C_{m[veg]} = BTF_{tissue\text{-}food} \times C_{veg} \times IR_{veg} \times ET \times fw$
	$C_{m[soil]} = BTF_{tissue\text{-}food} \times C_{soil} \times IR_{soil} \times ET \times fw$
	$C_{m[water]} = BTF_{tissue\text{-}food} \times C_{water} \times IR_{water} \times ET \times fw$
Parameters:	
C_{total}	= Total concentration of COPC (copper) in animal tissue (caribou) from all ingestion pathways (mg/kg)
$C_{m[veg]}$	= Total concentration of COPC (copper) in animal tissue (caribou) from vegetation ingestion (mg/kg)
$C_{m[soil]}$	= Total concentration of COPC (copper) in animal tissue (caribou) from soil ingestion (mg/kg)
$C_{m[water]}$	= Total concentration of COPC (copper) in animal tissue (caribou) from water ingestion (mg/kg)
$BTF_{tissue\text{-}food}$	= Biotransfer factor from food consumption to tissues for a selected COPC (mg/kg)
$C_{m[media]}$	= 95^{th} percentile COPC concentration in media (mg/kg)
$IR_{soil/veg/water}$	= Ingestion rate of media (i.e., soil, vegetation, or water; kg/day or L/day)
ET	= Exposure time in the Project area (unitless)
fw	= Fraction of daily consumption for animal (assumed 1; unitless)

Sample calculation for whole-body concentration:	
$C_{m[veg]}$	= (0.01 day/kg) x (2.04 mg/kg ww) x (6.72 kg/day) x 0.00134 x 1
	= 0.000184 mg/kg
$C_{m[soil]}$	= (0.01 day/kg) x (38.3 mg/kg dw) x (1.34 kg/day) x 0.00134 x 1
	= 0.000688 mg/kg
$C_{m[water]}$	= (0.01 day/kg) x (0.00145 mg/L) x (9 L/day) x 0.00134 x 1
	= 0.000000175 mg/kg
C_{total}	= 0.000184 mg/kg + 0.000688 mg/kg + 0.000000175 mg/kg
	= 0.000872 mg/kg
Sample calculation for concentrations in liver and kidney tissue using the tissue distribution ratio:	
C_{liver}	= C_{total} x liver distribution ratio
	= 0.000872 mg/kg x 46.0
	= 0.0401 mg/kg
C_{kidney}	= C_{total} x kidney distribution ratio
	= 0. 000872 mg/kg x 7.30
	= 0.00637 mg/kg

Table V6-5E10 presents the modeled concentrations of COPCs in tissue of country food species (caribou, Arctic ground squirrel, and willow ptarmigan) and wildlife species (caribou, muskox, wolverine, grizzly bear, wolf, Arctic ground squirrel, Arctic shrew, northern red-backed vole, willow ptarmigan, American tree sparrow, peregrine falcon, Canada goose, red-breasted merganser, least sandpiper, long-tailed duck, herring gull, yellow warbler, brant, and ringed seal) for the existing conditions HHRA and ERA. Each ingestion pathway (i.e., soil or sediment, water, prey, and vegetation) contributes to the total concentration of COPCs in these species.

The existing conditions concentrations of COPCs modeled in country food tissue (caribou, Arctic ground squirrel, and willow ptarmigan) were used in the existing conditions HHRA to calculate the estimated daily intake of COPCs for people who eat these foods from within the human health RSA. The existing conditions concentrations of COPCs modeled in wildlife species were used in the existing conditions ERA to calculate the estimated daily intake (EDI) of COPCs from ingestion of prey items for carnivores and omnivores who eat these prey items from within the wildlife RSA.

Table V6-5E10. Modeled Concentrations of Contaminants of Potential Concern in the Tissues of Country Food Species (Caribou, Arctic Ground Squirrel, and Canada Goose) and Wildlife Species (Muskox, Wolverine, Grizzly Bear, Wolf, Peregrine Falcon, Short-eared Owl, King/Common Eider, Red-breasted Merganser, and Ringed Seal)

	Caribou				Muskox				Wolverine				Grizzly Bear				
COPC	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$
Aluminum	2.43E-03	5.77E-02	2.33E-06	**6.01E-02**	2.80E+00	2.26E+01	2.98E-03	**2.54E+01**	1.04E-01	1.13E+00	1.79E-04	**1.23E+00**	1.21E+00	8.63E-01	1.86E+01	2.14E-03	**2.06E+01**
Arsenic	1.90E-06	1.36E-05	1.07E-08	**1.55E-05**	2.19E-03	5.33E-03	1.37E-05	**7.53E-03**	1.81E-04	2.67E-04	8.22E-07	**4.49E-04**	9.46E-04	2.75E-03	4.38E-03	9.84E-06	**8.08E-03**
Cadmium	3.83E-07	2.48E-07	9.48E-11	**6.31E-07**	4.40E-04	9.71E-05	1.21E-07	**5.38E-04**	9.57E-07	4.85E-06	7.28E-09	**5.82E-06**	1.91E-04	1.59E-05	7.98E-05	8.70E-08	**2.86E-04**
Chromium	3.75E-04	6.51E-04	4.87E-08	**1.03E-03**	4.32E-01	2.55E-01	6.21E-05	**6.86E-01**	1.46E-03	1.27E-02	3.73E-06	**1.42E-02**	1.87E-01	1.30E-02	2.09E-01	4.46E-05	**4.09E-01**
Copper	1.84E-04	6.91E-04	2.94E-07	**8.75E-04**	2.12E-01	2.70E-01	3.75E-04	**4.82E-01**	2.60E-03	1.35E-02	2.25E-05	**1.61E-02**	9.16E-02	3.63E-02	2.22E-01	2.69E-04	**3.50E-01**
Lead	1.10E-06	8.12E-06	4.23E-10	**9.21E-06**	1.26E-03	3.18E-03	5.40E-07	**4.44E-03**	1.46E-05	1.59E-04	3.24E-08	**1.74E-04**	5.46E-04	1.62E-04	2.61E-03	3.88E-07	**3.32E-03**
Manganese	2.46E-04	2.67E-04	1.52E-07	**5.14E-04**	2.84E-01	1.05E-01	1.93E-04	**3.88E-01**	2.12E-04	5.23E-03	1.16E-05	**5.45E-03**	1.23E-01	5.49E-03	8.59E-02	1.39E-04	**2.14E-01**
Mercury	1.02E-04	2.28E-05	8.40E-09	**1.24E-04**	1.17E-01	8.93E-03	1.07E-05	**1.26E-01**	4.66E-03	4.47E-04	6.45E-07	**5.11E-03**	5.06E-02	2.13E-01	7.34E-03	7.71E-06	**2.71E-01**
Nickel	2.16E-04	3.76E-04	7.75E-08	**5.91E-04**	2.48E-01	1.47E-01	9.89E-05	**3.95E-01**	3.53E-04	7.35E-03	5.94E-06	**7.71E-03**	1.07E-01	5.18E-03	1.21E-01	7.11E-05	**2.33E-01**
Selenium	1.12E-06	1.02E-06	1.47E-08	**2.16E-06**	1.29E-03	4.00E-04	1.87E-05	**1.71E-03**	9.81E-05	2.00E-05	1.12E-06	**1.19E-04**	5.60E-04	2.04E-03	3.28E-04	1.34E-05	**2.95E-03**
Thallium	2.53E-06	3.61E-05	2.89E-09	**3.86E-05**	2.91E-03	1.41E-02	3.70E-06	**1.70E-02**	1.25E-03	7.06E-04	2.22E-07	**1.96E-03**	1.26E-03	6.64E-03	1.16E-02	2.66E-06	**1.95E-02**
Zinc	1.24E-05	9.60E-06	5.11E-09	**2.20E-05**	1.43E-02	3.76E-03	6.52E-06	**1.80E-02**	1.77E-06	1.88E-04	3.92E-07	**1.90E-04**	6.17E-03	3.78E-03	3.09E-03	4.69E-06	**1.30E-02**

	Wolf				Arctic Ground Squirrel				Arctic Shrew				Northern Red-backed Vole				
COPC	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$
Aluminum	3.62E-02	3.77E+00	6.41E-04	**3.81E+00**	6.97E-03	5.79E-02	8.04E-06	**6.49E-02**	8.20E-03	2.61E-03	1.36E-07	**1.08E-02**	9.30E-04	4.21E-02	2.11E-02	8.15E-07	**6.41E-02**
Arsenic	1.43E-05	8.91E-04	2.94E-06	**9.08E-04**	5.44E-06	1.37E-05	3.69E-08	**1.91E-05**	9.68E-07	6.16E-07	6.24E-10	**1.58E-06**	7.26E-07	4.97E-06	4.98E-06	3.74E-09	**1.07E-05**
Cadmium	2.81E-07	1.62E-05	2.60E-08	**1.65E-05**	1.10E-06	2.49E-07	3.27E-10	**1.35E-06**	1.54E-07	1.12E-08	5.52E-12	**1.65E-07**	1.46E-07	7.89E-07	9.07E-08	3.31E-11	**1.03E-06**
Chromium	3.58E-03	4.26E-02	1.34E-05	**4.61E-02**	1.07E-03	6.53E-04	1.68E-07	**1.73E-03**	4.20E-06	2.94E-05	2.83E-09	**3.36E-05**	1.43E-04	2.16E-05	2.38E-04	1.70E-08	**4.03E-04**
Copper	4.58E-03	4.52E-02	8.07E-05	**4.98E-02**	5.27E-04	6.93E-04	1.01E-06	**1.22E-03**	1.78E-05	3.12E-05	1.71E-08	**4.91E-05**	7.02E-05	9.16E-05	2.53E-04	1.03E-07	**4.15E-04**
Lead	1.26E-06	5.31E-04	1.16E-07	**5.32E-04**	3.14E-06	8.14E-06	1.46E-09	**1.13E-05**	1.57E-07	3.67E-07	2.46E-11	**5.24E-07**	4.19E-07	8.07E-07	2.97E-06	1.48E-10	**4.19E-06**
Manganese	1.47E-04	1.75E-02	4.16E-05	**1.77E-02**	7.06E-04	2.68E-04	5.22E-07	**9.74E-04**	9.31E-06	1.21E-05	8.82E-09	**2.14E-05**	9.41E-05	4.78E-05	9.77E-05	5.29E-08	**2.40E-04**
Mercury	2.98E-02	1.49E-03	2.31E-06	**3.13E-02**	2.91E-04	2.29E-05	2.90E-08	**3.14E-04**	5.89E-07	1.03E-06	4.89E-10	**1.62E-06**	3.88E-05	3.02E-06	8.34E-06	2.93E-09	**5.02E-05**
Nickel	2.25E-03	2.46E-02	2.13E-05	**2.68E-02**	6.18E-04	3.77E-04	2.67E-07	**9.95E-04**	4.85E-06	1.70E-05	4.51E-09	**2.18E-05**	8.23E-05	2.49E-05	1.37E-04	2.71E-08	**2.45E-04**
Selenium	3.68E-06	6.68E-05	4.02E-06	**7.45E-05**	3.22E-06	1.02E-06	5.05E-08	**4.29E-06**	1.45E-07	4.61E-08	8.53E-10	**1.92E-07**	4.29E-07	7.45E-07	3.73E-07	5.12E-09	**1.55E-06**
Thallium	6.48E-04	2.36E-03	7.95E-07	**3.01E-03**	7.25E-06	3.62E-05	9.97E-09	**4.34E-05**	5.12E-06	1.63E-06	1.69E-10	**6.75E-06**	9.67E-07	2.63E-05	1.32E-05	1.01E-09	**4.05E-05**
Zinc	1.54E-06	6.27E-04	1.40E-06	**6.30E-04**	3.55E-05	9.62E-06	1.76E-08	**4.51E-05**	3.47E-06	4.34E-07	2.97E-10	**3.90E-06**	4.73E-06	1.78E-05	3.51E-06	1.78E-09	**2.61E-05**

	Willow Ptarmigan				American Tree Sparrow					Peregrine Falcon				Canada Goose			
COPC	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[sediment]}$	$C_{m[water]}$	$C_{m[total]}$
Aluminum	1.23E+01	2.92E+01	4.41E-03	**4.16E+01**	6.92E-01	3.13E+01	4.49E+00	2.34E-04	**3.65E+01**	2.87E+00	4.85E+01	2.21E-03	**5.14E+01**	1.48E+01	1.94E+02	5.48E-03	**2.09E+02**
Arsenic	7.49E-03	5.37E-03	1.58E-05	**1.29E-02**	4.20E-04	2.88E-03	8.25E-04	8.35E-07	**4.12E-03**	4.69E-03	8.92E-03	7.90E-06	**1.36E-02**	9.01E-03	1.31E-01	1.96E-05	**1.40E-01**
Cadmium	7.02E-04	4.55E-05	6.50E-08	**7.48E-04**	3.94E-05	2.13E-04	6.99E-06	3.44E-09	**2.59E-04**	1.17E-05	7.56E-05	3.25E-08	**8.73E-05**	8.45E-04	2.30E-04	8.06E-08	**1.07E-03**
Chromium	1.30E-01	2.25E-02	6.27E-06	**1.52E-01**	7.27E-03	1.10E-03	3.45E-03	3.32E-07	**1.18E-02**	1.68E-03	3.73E-02	3.14E-06	**3.90E-02**	1.56E-01	1.34E-01	7.78E-06	**2.89E-01**
Copper	8.73E-02	3.28E-02	5.21E-05	**1.20E-01**	4.90E-03	6.39E-03	5.04E-03	2.76E-06	**1.63E-02**	5.80E-03	5.45E-02	2.61E-05	**6.03E-02**	1.05E-01	2.16E-01	6.46E-05	**3.22E-01**
Lead	2.78E-02	2.06E-02	4.00E-06	**4.83E-02**	1.56E-03	3.00E-03	3.16E-03	2.11E-07	**7.72E-03**	2.03E-03	3.41E-02	2.00E-06	**3.62E-02**	3.34E-02	8.37E-02	4.96E-06	**1.17E-01**
Manganese	2.93E-01	3.17E-02	6.72E-05	**3.24E-01**	1.64E-02	8.34E-03	4.87E-03	3.55E-06	**2.96E-02**	1.72E-03	5.27E-02	3.36E-05	**5.44E-02**	3.52E-01	1.03E+00	8.33E-05	**1.38E+00**
Mercury	1.16E-04	2.60E-06	3.58E-09	**1.19E-04**	6.50E-06	5.07E-07	3.99E-07	1.89E-10	**7.41E-06**	1.03E-07	4.32E-06	1.79E-09	**4.42E-06**	1.39E-04	2.35E-05	4.44E-09	**1.63E-04**
Nickel	3.41E-04	5.95E-05	4.58E-08	**4.01E-04**	1.92E-05	5.79E-06	9.13E-06	2.42E-09	**3.41E-05**	4.77E-07	9.88E-05	2.29E-08	**9.93E-05**	4.11E-04	4.01E-04	5.68E-08	**8.12E-04**
Selenium	5.31E-03	4.83E-04	2.58E-05	**5.82E-03**	2.98E-04	5.17E-04	7.41E-05	1.37E-06	**8.90E-04**	3.49E-03	8.01E-04	1.29E-05	**4.30E-03**	6.39E-03	6.04E-03	3.21E-05	**1.25E-02**
Thallium	6.49E-03	9.26E-03	2.77E-06	**1.58E-02**	3.64E-04	9.91E-03	1.42E-03	1.47E-07	**1.17E-02**	1.65E-02	1.54E-02	1.39E-06	**3.19E-02**	7.81E-03	2.79E-02	3.44E-06	**3.57E-02**
Zinc	1.14E-02	8.87E-04	1.76E-06	**1.23E-02**	6.42E-04	2.42E-03	1.36E-04	9.32E-08	**3.20E-03**	4.45E-04	1.47E-03	8.81E-07	**1.92E-03**	1.38E-02	7.57E-03	2.18E-06	**2.13E-02**

Table V6-5E10. Modeled Concentrations of Contaminants of Potential Concern in the Tissues of Country Food Species (Caribou, Arctic Ground Squirrel, and Canada Goose) and Wildlife Species (Muskox, Wolverine, Grizzly Bear, Wolf, Peregrine Falcon, Short-eared Owl, King/Common Eider, Red-breasted Merganser, and Ringed Seal)

	Red-breasted Merganser				Least Sandpiper				Long-tailed Duck					Herring Gull			
COPC	$C_{m[prey]}$	$C_{m[sediment]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[prey]}$	$C_{m[sediment]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[prey]}$	$C_{m[sediment]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[prey]}$	$C_{m[sediment]}$	$C_{m[water]}$	$C_{m[total]}$
Aluminum	1.77E+00	4.84E+01	2.67E-03	**5.02E+01**	2.40E-01	4.75E+00	2.11E-04	**4.99E+00**	3.03E-01	2.16E+00	4.43E+01	2.18E-03	**4.68E+01**	9.29E+00	5.38E+01	2.63E-03	**6.31E+01**
Arsenic	1.21E-02	3.27E-02	9.53E-06	**4.48E-02**	2.71E-04	3.20E-03	7.54E-07	**3.47E-03**	1.84E-04	2.86E-03	2.99E-02	7.80E-06	**3.29E-02**	3.11E-01	4.11E-02	2.75E-05	**3.52E-01**
Cadmium	1.81E-04	5.74E-05	3.93E-08	**2.39E-04**	5.29E-05	5.62E-06	3.11E-09	**5.86E-05**	1.73E-05	4.68E-04	5.25E-05	3.21E-08	**5.38E-04**	8.03E-03	5.75E-05	1.60E-07	**8.09E-03**
Chromium	5.28E-03	3.33E-02	3.79E-06	**3.86E-02**	4.43E-03	3.27E-03	3.00E-07	**7.70E-03**	3.19E-03	3.88E-02	3.05E-02	3.10E-06	**7.25E-02**	3.98E-01	3.88E-02	1.25E-04	**4.37E-01**
Copper	4.60E-02	5.40E-02	3.15E-05	**1.00E-01**	4.56E-02	5.29E-03	2.49E-06	**5.09E-02**	2.15E-03	3.99E-01	4.94E-02	2.57E-05	**4.50E-01**	1.19E-01	3.99E-02	3.05E-05	**1.59E-01**
Lead	7.26E-03	2.09E-02	2.41E-06	**2.82E-02**	4.76E-03	2.05E-03	1.91E-07	**6.81E-03**	6.83E-04	4.17E-02	1.91E-02	1.98E-06	**6.15E-02**	1.59E-02	1.99E-02	1.00E-05	**3.58E-02**
Manganese	3.65E-02	2.56E-01	4.06E-05	**2.93E-01**	6.43E-02	2.51E-02	3.21E-06	**8.94E-02**	7.20E-03	5.61E-01	2.34E-01	3.32E-05	**8.03E-01**	1.79E-02	5.89E-02	3.93E-05	**7.69E-02**
Mercury	1.55E-03	5.87E-06	2.16E-09	**1.56E-03**	4.63E-05	5.75E-07	1.71E-10	**4.69E-05**	2.85E-06	4.67E-04	5.37E-06	1.77E-09	**4.75E-04**	1.24E-04	1.58E-06	3.76E-09	**1.26E-04**
Nickel	2.52E-05	1.00E-04	2.77E-08	**1.25E-04**	3.02E-07	9.80E-06	2.19E-09	**1.01E-05**	8.40E-06	3.66E-06	9.15E-05	2.26E-08	**1.04E-04**	1.07E-03	9.56E-05	1.99E-08	**1.17E-03**
Selenium	5.16E-02	1.51E-03	1.56E-05	**5.32E-02**	7.68E-03	1.48E-04	1.24E-06	**7.83E-03**	1.31E-04	6.90E-02	1.38E-03	1.28E-05	**7.05E-02**	1.37E-01	1.79E-03	2.82E-05	**1.38E-01**
Thallium	1.15E-02	6.96E-03	1.67E-06	**1.84E-02**	9.79E-03	6.82E-04	1.33E-07	**1.05E-02**	1.60E-04	8.57E-02	6.37E-03	1.37E-06	**9.22E-02**	3.54E-03	8.44E-03	1.35E-03	**1.33E-02**
Zinc	2.57E-02	1.89E-03	1.06E-06	**2.76E-02**	1.90E-03	1.85E-04	8.42E-08	**2.08E-03**	2.81E-04	1.76E-02	1.73E-03	8.70E-07	**1.96E-02**	2.13E-02	2.00E-03	1.03E-06	**2.33E-02**

	Yellow Warbler				Brant				Ringed Seal		
COPC	$C_{m[prey]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[sediment]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[prey]}$	$C_{m[sediment]}$	$C_{m[total]}$
Aluminum	1.58E+01	1.44E+00	1.16E-04	**1.73E+01**	9.14E+00	2.31E+01	3.38E-03	**3.23E+01**	5.40E-01	7.09E+00	**7.63E+00**
Arsenic	1.46E-03	2.65E-04	4.14E-07	**1.72E-03**	5.55E-03	1.77E-02	3.53E-05	**2.33E-02**	4.64E-02	6.97E-03	**5.33E-02**
Cadmium	1.08E-04	2.24E-06	1.70E-09	**1.10E-04**	5.20E-04	2.48E-05	2.06E-07	**5.45E-04**	1.24E-03	2.09E-05	**1.26E-03**
Chromium	5.54E-04	1.11E-03	1.65E-07	**1.66E-03**	9.60E-02	1.67E-02	1.61E-04	**1.13E-01**	3.26E-01	7.51E-02	**4.02E-01**
Copper	3.23E-03	1.62E-03	1.37E-06	**4.85E-03**	6.47E-02	1.72E-02	3.92E-05	**8.19E-02**	1.74E-01	5.62E-02	**2.30E-01**
Lead	1.52E-03	1.01E-03	1.05E-07	**2.53E-03**	2.06E-02	8.55E-03	1.29E-05	**2.91E-02**	1.92E-04	5.24E-04	**7.16E-04**
Manganese	4.22E-03	1.56E-03	1.76E-06	**5.78E-03**	2.17E-01	2.54E-02	5.06E-05	**2.42E-01**	4.75E-03	3.32E-02	**3.79E-02**
Mercury	2.56E-07	1.28E-07	9.38E-11	**3.84E-07**	8.58E-05	6.82E-07	4.84E-09	**8.65E-05**	9.74E-02	9.28E-04	**9.83E-02**
Nickel	2.93E-06	2.93E-06	1.20E-09	**5.86E-06**	2.53E-04	4.12E-05	2.56E-08	**2.94E-04**	1.96E-01	4.04E-02	**2.36E-01**
Selenium	2.61E-04	2.38E-05	6.78E-07	**2.86E-04**	3.93E-03	7.70E-04	3.63E-05	**4.74E-03**	1.59E-02	2.53E-04	**1.61E-02**
Thallium	5.01E-03	4.56E-04	7.27E-08	**5.47E-03**	4.81E-03	3.63E-03	1.74E-03	**1.02E-02**	8.79E-04	2.20E-03	**3.08E-03**
Zinc	1.22E-03	4.37E-05	4.62E-08	**1.27E-03**	8.48E-03	8.62E-04	1.33E-06	**9.34E-03**	1.08E-02	1.45E-03	**1.22E-02**

Notes:

All concentrations in mg/kg wet weight.

COPC = contaminant of potential concern

$C_{m[veg]}$ = concentration of COPC in meat tissue from vegetation consumption

$C_{m[prey]}$ = concentration of COPC in meat tissue from prey consumption

$C_{m[soil]}$ = concentration of COPC in meat tissue from soil consumption

$C_{m[sediment]}$ = concentration of COPC in meat tissue from sediment consumption

$C_{m[water]}$ = concentration of COPC in meat tissue from water consumption

$C_{m[total]}$ = total concentration of COPC in meat tissue from soil, vegetation, and water consumption

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