concentration that is below a threshold for concern, or whether the concentration could potentially cause harm to one or more ecological receptors. In the former case, the substance is not of interest to the ERA. In the latter case, the substance is deemed to be a CoPC and is carried forward into the quantitative ERA.

For inorganic substances, as indicated in Table 17, the maximum boron, cadmium, chromium, copper, lead, and zinc concentrations in soils were greater than the corresponding ecological health-based guidelines and these substances were subsequently carried forward in the ERA. The maximum concentrations in soil for the remaining metals (*i.e.*, antimony, barium, beryllium, and tin) were less than the applicable guidelines, if available, but these were carried forward to be consistent with the human health risk assessment. The exposure point concentrations (EPCs) for all metals except antimony and beryllium were greater than site-specific background data. All metals, with the exception of antimony, were less than typical background values (OTR data for rural parkland), if available. All metals were carried forward in the ERA because maximum soil concentrations were greater than site-specific background data, and it was felt that the ERA would help to determine whether clean-up of localized hotspots would be worthwhile. Additionally, all metals, with the exception of beryllium and boron, had maximum soil concentrations greater than OTR rural parkland data.

For organic compounds, as indicated in Table 17, the maximum concentrations of total xylenes, TPH F1, F2, F3, and F4 fractions, and total PCBs were greater than the corresponding ecological health-based guidelines. Because TPH and BTEX petroleum hydrocarbon products can be assumed to have similar modes of toxic action, and similar target organs, it is reasonable to sum the hazards for these substances. Therefore, all BTEX substances (benzene, toluene, ethylbenzene, and xylene), TPHs, and total PCBs were carried forward in the ERA. No site-specific background data were available for organic CoPCs, however, typical background values for TPHs should be non-detectable (CCME 2001). EPCs for BTEX and total PCBs were all greater than OTR data.

5.2.1.1 Surface Water

To assess CoPC uptake as part of the drinking water pathway for ecological receptors, concentrations of CoPCs in surface water were assessed (Table 18). This assessment compared the maximum detected concentration in surface water samples taken at the site with the generic CCME freshwater quality guidelines for the protection of aquatic life (CCME 1999).

No new CoPCs were identified in the screening of surface water, although substances in the water were carried forward if they had previously been identified as CoPCs through the screening of soils data. Surface water was not carried forward in relation to aquatic receptors, since there were no exceedances that required this. However, for completeness, surface water was carried forward as a source of drinking water for terrestrial receptors.

Table 17 Soil Hazard Screening Procedure for CAM-F ERA

CoPC	Soil Concentration (mg/kg)		Generic Ecological Health Guidelines (mg/kg)		Carried Forward Y/N	EPC*	Background Soil Concentration (mg/kg)				Carried Forward Y/N
	Max. Obs. Soil Conc.	No. of Samples	Guideline	Exceeds Guideline Y/N			SSB**	EPC > SSB Y/N	OTR Rural Parkland[f]	EPC > OTR Y/N	
Inorganics											
Antimony	19.50	63	20.00 [b]	N	Y	1.65	1.70	N	0.43	Y	Y
Barium	735.00	63	750.00 [b]	N	Y	53.90	50.80	Y	160.00	N	Y
Beryllium	0.55	63	4.00 [b]	N	Y	0.21	0.28	N	1.10	N	Y
Boron	3.80	63	1.50 [b]	Y	Y	0.67	bd	Y	30.00	N	Y
Cadmium	19.20	119	10.00 [a]	Y	Y	0.48	0.08	Y	0.71	N	Y
Chromium (total)	93.00	119	64.00 [a]	Y	Y	29.89	27.50	Y	58.00	N	Y
Copper	940.00	119	63.00 [a]	Y	Y	22.79	13.90	Y	41.00	N	Y
Lead	800.00	119	300.00 [a]	Y	Y	19.41	6.40	Y	45.00	N	Y
Tin	53.00	63	na	n/a	Y	2.44	1.90	Y	na	n/a	Y
Zinc	5740.00	119	200.00 [a]	Y	Y	85.32	36.90	Y	120.00	N	Y
Organics											
Benzene	0.10	28	25.00 [c]	N	Y	0.02	na	n/a	4.00E-05	Y	Y
Toluene	3.63	28	150.00 [c]	N	Y	0.02	na	n/a	1.30E-03	Y	Y
Ethylbenzene	0.03	28	25.00 [e]	N	Y	0.01	na	n/a	4.60E-04	Y	Y
Total Xylenes (m,p,o)	47.70	28	1.00[a]	Y	Y	0.08	na	n/a	9.20E-04	Y	Y
F1 C6 C10	1440.00	28	260 [d]	Y	Y	10.50	na	n/a	na	n/a	Y
F2 C10 C16	13300.00	28	900 [d]	Y	Y	184.46	na	n/a	na	n/a	Y
F3 C16 C34	18300.00	28	800 [d]	Y	Y	1917.54	na	n/a	na	n/a	Y
F4 C34 C50	41100.00	28	5600 [d]	Y	Y	825.51	na	n/a	na	n/a	Y
Total PCBs	25.20	43	5.00 [b]	Y	Y	0.35	na	n/a	1.50E-02	Y	Y
Acenaphthene	0.97	24	40.0 [e]	N	N	-	-	-	-	-	N
Acenaphthylene	bd	24	na	N	N	-	-	-	-	-	N
Anthracene	bd	24	40.0 [c]	N	N	-	-	-	-	-	N
Benzo(a)anthracene	bd	24	40.0 [c]	N	N	-	-	-	-	-	N
Benzo(a)pyrene	bd	24	0.7 [a]	N	N	-	-	-	-	-	N
Benzo(b)fluoranthene	bd	24	na	N	N	-	-	-	-	-	N
Benzo(g,h,i)perylene	bd	24	40.0 [b]	N	N	-	-	-	-	-	N
Benzo(j)fluoranthene	bd	24	na	N	N	-	-	-	-	-	N
Benzo(k)fluoranthene	bd	24	12.0 [b]	N	N	-	-	-	-	-	N
Chrysene	0.15	24	12.0 [b]	N	N	-	-	-	-	-	N
Dibenzo(a,h)anthracene	bd	24	1.2 [b]	N	N	-	-	-	-	-	N
Fluoranthene	bd	24	40.0 [b]	N	N	-	-	-	-	-	N
Fluorene	0.84	24	350.0 [b]	N	N	-	-	-	-	-	N

CoPC	Soil Concentration (mg/kg)		Generic Ecological Health Guidelines (mg/kg)		Carried Forward Y/N	EPC*	Background Soil Concentration (mg/kg)				Carried Forward Y/N
	Max. Obs. Soil Conc.	No. of Samples	Guideline	Exceeds Guideline Y/N			SSB**	EPC > SSB Y/N	OTR Rural Parkland[f]	EPC > OTR Y/N	
Indeno(1,2,3-c,d)pyrene	bd	24	12.0 [b]	N	N	-	-	-	-	-	N
Naphthalene	5.10	24	40.0 [b]	N	N	-	-	-	-	-	N
Phenanthrene	1.05	24	40.0 [b]	N	N	-	-	-	-	-	N
Pyrene	0.08	24	0.7 [e]	N	N	-	-	-	-	-	N

[a] CCME. 1999. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment.
[b] MOE. 1997. Guideline for Use at Contaminated Sites in Ontario. Revised February 1997. Ontario Ministry of Environment and Energy. Appendix A.2.2: Table B Criteria Components - Coarse Textured Soil (Surface/Full Depth) - Non-Potable Groundwater Situation.

[c] Netherlands Criteria in MOE 1997.

[d] CCME. 2001. Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil. Canadian Council of Ministers of the Environment.

[e] screened versus more toxic compound (i.e., benzene, anthracene, benzopyrene)

[f] Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags and Snow. December 1993. Ontario Ministry of Environment and Energy.

* if n>=5, then Exposure Point Concentration (EPC) = 95% UCL of the geometric mean. If n<5, then EPC = maximum observed soil concentration.

**n=4 therefore Site-Specific Background (SSB) = maximum observed soil concentration

bd - below detection limit

na - not available

n/a - not applicable

Table 18 Surface Water Hazard Screening for CAM-F ERA

CoPC	Max. Obs. Surface Water Concentration (mg/L)	Number of Samples	Guideline (mg/L)	Exceeds Guideline Y/N	Carried Forward Y/N
Inorganics					
Aluminum	0.076	5	0.1	N	N
Antimony	0.0003	5	-	n/a	Y
Arsenic	0.0003	5	0.005	N	N
Barium	0.01	5	-	n/a	Y
Beryllium	bd	5	-	n/a	Y
Bismuth	bd	5	-	n/a	N
Boron	0.011	5	-	n/a	Y
Cadmium	bd	5	0.000023	N	Y
Chromium	0.0005	5	0.0089	n/a	Y
Cobalt	bd	5	-	n/a	N
Copper	0.002	5	0.002	N	Y
Iron	bd	4	0.3	n/a	N
Lead	bd	5	0.002	N	Y
Lithium	0.007	5	-	n/a	N
Magnesium	12.3	4	-	n/a	N
Manganese	bd	4	-	n/a	N
Mercury	bd	5	-	n/a	N
Molybdenum	bd	5	0.073	N	N
Nickel	bd	5	0.065	N	N
Nitrate	bd	5	-	n/a	N
Nitrite	bd	5	-	n/a	N
Potassium	2.4	4	-	n/a	N
Selenium	bd	5	0.001	N	N
Silicon	0.5	5	-	n/a	N
Silver	bd	5	0.0001	N	N
Sodium	4.6	4	-	n/a	N
Strontium	0.051	5	-	n/a	N
Sulphate	14.9	4	-	n/a	N
Sulphur	4.59	5	-	n/a	N
Thallium	bd	5	0.0008	N	N
Tin	bd	5	-	n/a	Y
Titanium	0.004	5	-	n/a	N
Uranium	0.0084	5	-	n/a	N
Vanadium	0.0005	5	-	n/a	N
Zinc	0.005	5	0.03	N	Y
Organics					
Total PCBs	bd	5	-	n/a	Y

Note: Criteria based on CCME Freshwater Aquatic Life Guidelines 1999

5.2.1.2 Lake and River Sediment

Concentrations of inorganic CoPCs in sediments at Sarcpa Lake were assessed (Table 19). The assessment compared the maximum detected concentration in sediment samples with the generic CCME interim PEL sediment quality guidelines (CCME 1999). No new CoPCs were identified in the screening of sediments. Therefore, it was not necessary to carry sediments forward in the ERA as a potential source of contaminants to aquatic biota.

Table 19 Lake Sediments Hazard Screening for CAM-F ERA

Contaminant	Max. Observed Sediment Concentration (mg/kg)	Number of Samples	Guideline (mg/kg)	Exceeds Guideline Y/N	Carried Forward Y/N
Inorganics					
Antimony	2.9	4	-	n/a	N
Arsenic	2.5	4	17.0	N	N
Barium	137.0	4	-	n/a	N
Beryllium	0.4	4	-	n/a	N
Boron	0.3	4	-	n/a	N
Cadmium	0.1	4	3.5	N	N
Chromium	79.5	4	90.0	N	N
Cobalt	15.2	4	-	n/a	N
Copper	56.7	4	197.0	N	N
Hexavalent Chromium	bd	4	-	n/a	N
Lead	11.4	4	91.3	N	N
Mercury	bd	4	0.486	N	N
Molybdenum	0.8	4	-	n/a	N
Nickel	47.9	4	-	n/a	N
Selenium	bd	4	-	n/a	N
Silver	bd	4	-	n/a	N
Thallium	bd	4	-	n/a	N
Tin	2.0	4	-	n/a	N
Vanadium	66.6	4	-	n/a	N
Zinc	86.9	4	315.0	N	N

Note: 1. Criteria based on Interim CCME Freshwater Sediment Quality Guidelines, Probable Effect Levels (PELs), 1999

5.2.1.3 Summary of Hazards

Table 20 provides a summary of the CoPCs and EPCs identified in soils that were carried forward into the ERA.

Although the ERA is concerned with contaminants in soils (i.e., not surface water), drinking water was included as a potential exposure pathway.

Table 20 Summary of Hazards and Exposure Point Concentrations Used in the CAM-F ERA

CoPCs	Surface Soil Exposure Point Concentration (mg/kg)	Surface Water Exposure Point Concentration (mg/L)
Inorganics		
Antimony	1.65	0.000229
Barium	53.90	0.009430
Beryllium	0.21	0.000050
Boron	0.67	0.010600
Cadmium	0.48	0.000005
Chromium	29.89	0.000422
Copper	22.79	0.001420
Lead	19.41	0.000050
Tin	2.44	0.000500
Zinc	85.32	0.005430
Organics		
Benzene	0.02	-
Toluene	0.02	-
Ethylbenzene	0.01	-
Xylene (total)	0.08	-
F1 C6-C10	10.50	-
F2 C10-C16	184.46	-
F3 C16-C34	1917.54	-
F4 C34-C50	825.51	-
Total PCBs	0.35	0.000025

Notes:
1. The selection of hazards and exposure point concentrations are illustrated in Tables 16 and 17.
2. EPC = 95% UCL of the geometric mean.
3. If EPC is below detection limit, EPC = half of detection limit

5.2.2 Receptor Identification

Receptor selection was based on fundamental ecological considerations, but was also guided by observations made during a site visit, and information solicited from members of the local community. The following criteria were considered in selecting receptors for use in this ERA:

- keystone species known to be central to ecosystem function;
- exposed to surface soils, sediments, and/or freshwater at the site;
- representative of lower and higher trophic feeding levels (i.e., herbivorous and carnivorous animals),
- present on or near the site for some or most of the year;
- of significant cultural and/or economic significance; and
- possible endangered or sensitive species.

5.2.3 Valued Environmental Components (VECs)

Valued environmental components (VECs) are defined as resources or environmental features important to human populations that have economic and/or social value, and/or have intrinsic ecological significance. These components also provide a baseline from which the impacts of development can be evaluated, including changes in management or regulatory policies.

Based on the above criteria, and using information gathered by a Jacques Whitford biologist during a site visit (Jacques Whitford 2004), the following ecological receptors were selected for the Sarcpa Lake site: collared lemming, ermine, Arctic hare, ptarmigan, Snowy Owl, Arctic fox, and caribou. The presence of each of these animals has been documented on or near the site. The receptors are briefly described below.

The Willow Ptarmigan (*Lagopus lagopus*) or Rock Ptarmigan (*L. mutus*) are small grouse-like birds, weighing approximately 0.5 kg, which live year-round throughout alpine and Arctic tundra. Ptarmigan nest on the ground soon after the snow melts. These birds are mainly herbivorous, feeding on willow buds and twigs throughout the year, and any other vegetation that might be available. Ptarmigan, especially chicks, will also feed on insects. Ptarmigan are estimated to consume approximately 0.124 kg (wet-weight) of food per day and drink 0.037 L of water, or its equivalent, per day. They are valued for their meat and hunted by local residents.

The Snowy Owl (*Nyctea scandiaca*), which weighs on average 2.05 kg, is a top predator that is found in the Canadian Arctic. By virtue of its location in the food chain, it may be susceptible to contaminants that accumulate in the tissue of its prey. Snowy Owls breed in the Arctic tundra and may make southerly migrations for the winter (as far as the northern United States), although some remain in the Arctic year-round. The diet of the Snowy Owl consists mainly of small mammals and birds (*e.g.*, lemmings, Arctic hares, ptarmigan, seabirds). On average, Snowy Owls will consume approximately 0.093 kg of dry-weight food per day (0.290 kg of wet-weight food per day) and will consume 0.095 L of water, or its equivalent, per day.

The collared lemming *(Dicrostonyx groenlandicus*) is a small burrowing rodent, which weighs approximately 0.04 kg and lives on the tundra throughout the high Arctic. It is the smallest of the mammals in the high Arctic and is a key species in Arctic ecosystems. The lemming is herbivorous, feeding on whatever vegetation exists within its habitat. In the winter, lemmings do not hibernate; rather, they forage in the space that forms between the snow and soil. Lemmings are an important food source for Arctic fox, Snowy Owl and other predatory species. On average, a lemming is estimated to consume 0.023 kg of wet-weight food per day and 0.009 L of water, or its equivalent, per day.

The Arctic hare (*Lepus arcticus*) is the largest hare in North America. Weighing approximately 4.3 kg, it inhabits the tundra regions of Canada from Newfoundland west to the Mackenzie Delta and north to the tip of Ellesmere Island. Immature Arctic hares are hunted by Arctic foxes, gyrfalcons, snowy owls, and ermine, however, as adults they have few enemies but wolves and people. Arctic hares are mainly herbivores and eat willow leaves, bark, shoots, other leaves, grasses, and herbs. They have also been observed to eat carrion and the meat from hunters' traps. An adult Arctic hare will consume approximately 1.149 kg of wet-weight food per day and 0.368 L of water, or its equivalent, per day.

Ermine, or short-tailed weasel *(Mustela erminea*), is one of the smaller predatory animals found on the Arctic tundra, weighing on average 0.128 kg. Ermine do not migrate, despite significant food shortages during the winter months. Ermine population densities fluctuate with prey abundance and home ranges vary from 10 to 20 ha. Home ranges of males are usually twice the size of female home ranges. Ermine play an important role in the small mammals communities in which they live. They are ferocious hunters that specialize in small mammals, preferably of rabbit size and smaller. When mammalian prey is scarce, ermine may eat (depending upon availability) birds, eggs, frogs, fish, insects, or berries. On average, an ermine will consume approximately 0.008 kg of dry-weight food per day (0.026 kg of wet-weight food per day) and will consume 0.009 L of water, or its equivalent, per day.

The Arctic fox (*Alopex lagopus*) is a relatively small canid mammal, weighing approximately 5.75 kg. Arctic fox are widely distributed throughout the Arctic. Each Arctic fox has its own home range which varies in size from 3 to 25 km^2. It is predominately carnivorous, preying mostly on lemmings, but also on ptarmigan and any other available meat (*e.g.*, small birds and mammals, Inuit meat caches, wolf kills). During the summer, the Arctic fox will also forage on any berries that might be available. These animals consume approximately 0.933 kg of wet-weight food per day and 0.478 L of water, or its equivalent, per day. Breeding dens are built in the surface soil and may be used for many generations. The Arctic fox is highly valued for its fur.

The caribou (*Rangifer tarandus*) is representative of a large ungulate found throughout Canada's Arctic and is valued as a food source to both humans and other wildlife.

Caribou are typically migratory in nature and make seasonal migrations from the tundra to the taiga, returning north in the springtime. These migratory patterns of movement can significantly decrease the exposure of caribou to localized contamination, although near-stationary populations of caribou are also known. During calving, even migratory herds may remain at a specific location for an extended period of time.

There are three major types of caribou in Canada: barren-ground, woodland, and Peary. Barren-ground caribou are found in the vicinity of the CAM-F site. The barren-ground caribou weighs on average 117.5 kg and spends much or all of the year on the tundra from Alaska to Baffin Island. Herds may migrate up to 700 km to their calving grounds.

The caribou diet depends on seasonal availability, but lichens are the caribou's primary food source for much of the year. They will also feed on willow, herbs, mosses, flowers, grasses, and leaves of shrubs. On average, a barren-ground caribou will consume approximately 18.66 kg of wet-weight food per day and will consume 7.22 L of water, or its equivalent, per day. Caribou prefer habitats where vegetation is abundant and the ground conditions are dry.

Receptors were selected to be typical and representative of potential wildlife receptors . t the site, including birds and mammals; herbivores and predators. This approach was based on the premise that if highly exposed components of the ecosystem are protected, then populations of other exposed biota will also be adequately protected. Although this approach is considered reasonable by CCME (1996a, b), it is recognized that protection of selected ecological receptors for particular endpoints (*e.g.*, reproduction) may not always adequately protect all endpoints for all ecological receptors at the site. The choice of representative receptors was made, in part, on a trophic level approach in that they were chosen to represent lower and higher trophic levels. As a result, representative species were not chosen because of their sensitivity (information on sensitivity of Arctic receptors is lacking), but because of their ecological significance and trophic level.

Lemming, Arctic hare, and ptarmigan were chosen as representative of "highly exposed" biota for herbivore mammals and birds, as they remain in close contact with potentially contaminated soil year-round in a relatively restricted area. Caribou were selected because they are representative of a large ungulate which may use this site, and ermine, Arctic fox, and Snowy Owl were chosen to represent higher trophic levels that might be more likely to be exposed to contaminants via prey. Concentrations of CoPCs in the meat of caribou and small mammals (also considered to be representative of birds) were also estimated in the ERA, for inclusion in the HHRA. Selection of receptors was made to ensure that risk estimates for the specific receptors could be representative of other wildlife receptors at the site.

5.2.4 Rare, Threatened, or Endangered Species and Species of Special Concern

Three species at risk are found in the region of CAM-F (see Table 21).

Table 21 Species at Risk in the CAM-F Area

Common Name	Scientific Name	Status under *Species at Risk Act (SARA)*
Peregrine Falcon, tundrius subspecies	*Falco peregrinus*	Special Concern on Schedule 3
Wolverine, western population	*Gulo gulo*	Special Concern on Schedule 3, pending public consultation for addition to Schedule 1
Polar Bear	*Ursus maritimus*	Special Concern on Schedule 3, pending public consultation for addition to Schedule 1

These species were not chosen as representative receptors because the Snowy Owl, ermine, and Arctic fox have similar exposure pathways but have smaller home ranges and subsequently greater exposure to contaminants at the site. Therefore, if contaminant levels are below toxic thresholds for these species, it can be deduced that concentrations are also safe for the Peregrine Falcon, wolverine, and polar bear.

5.3 EXPOSURE ASSESSMENT

5.3.1 Potential Exposure Pathways

In order for chemicals to have deleterious effects, they need to gain access to the organism or receptor. The route by which this occurs is referred to as an exposure pathway, and is dependent on the nature of both the chemical and receptor. A complete exposure pathway is one that meets the following four criteria (USEPA 1989):

- a source of contaminants of concern must be present;
- release and transport mechanisms and media must be available to move the chemicals from the source to the ecological receptors;
- an opportunity must exist for the ecological receptors to contact the affected media; and
- a means must exist by which the chemical is taken up by ecological receptors, such as ingestion, inhalation, or direct contact.

The sources of the CoPC for the study area were surface soil and surface water. Subsurface soils and groundwater were not considered as potential sources of contaminant exposure for wildlife. There are no direct exposure pathways for ecological receptors for either of these environmental media and transport of contaminants from these sources to surface soil, surface water and sediments was expected to be negligible.

An exposure route is the mechanism by which a receptor species might be exposed to a chemical from the source. For surface soils and terrestrial receptors, including mammals and birds, exposure to the CoPC may occur through the following routes:

- dermal contact with soils:

- incidental ingestion of soil (i.e., as a result of feeding or grooming);
- ingestion of plants or prey species that have accumulated chemicals from the soil; or
- inhalation of volatile contaminants migrating from the soil to ambient air.

The inhalation pathway is typically of negligible importance for wildlife receptors in open air situations, and the CoPCs for the ERA typically have low or negligible vapour pressures. Therefore, inhalation has not been considered a significant exposure pathway for the ERA at CAM-F. Assessment of dermal contact with soils is included with incidental ingestion of soil.

The choice of site-specific exposure pathways is dependent on the nature of the contaminants, their source environmental media, and nature of VECs being considered in the ecological risk assessment. These are explained, for the CAM-F site, in the following section.

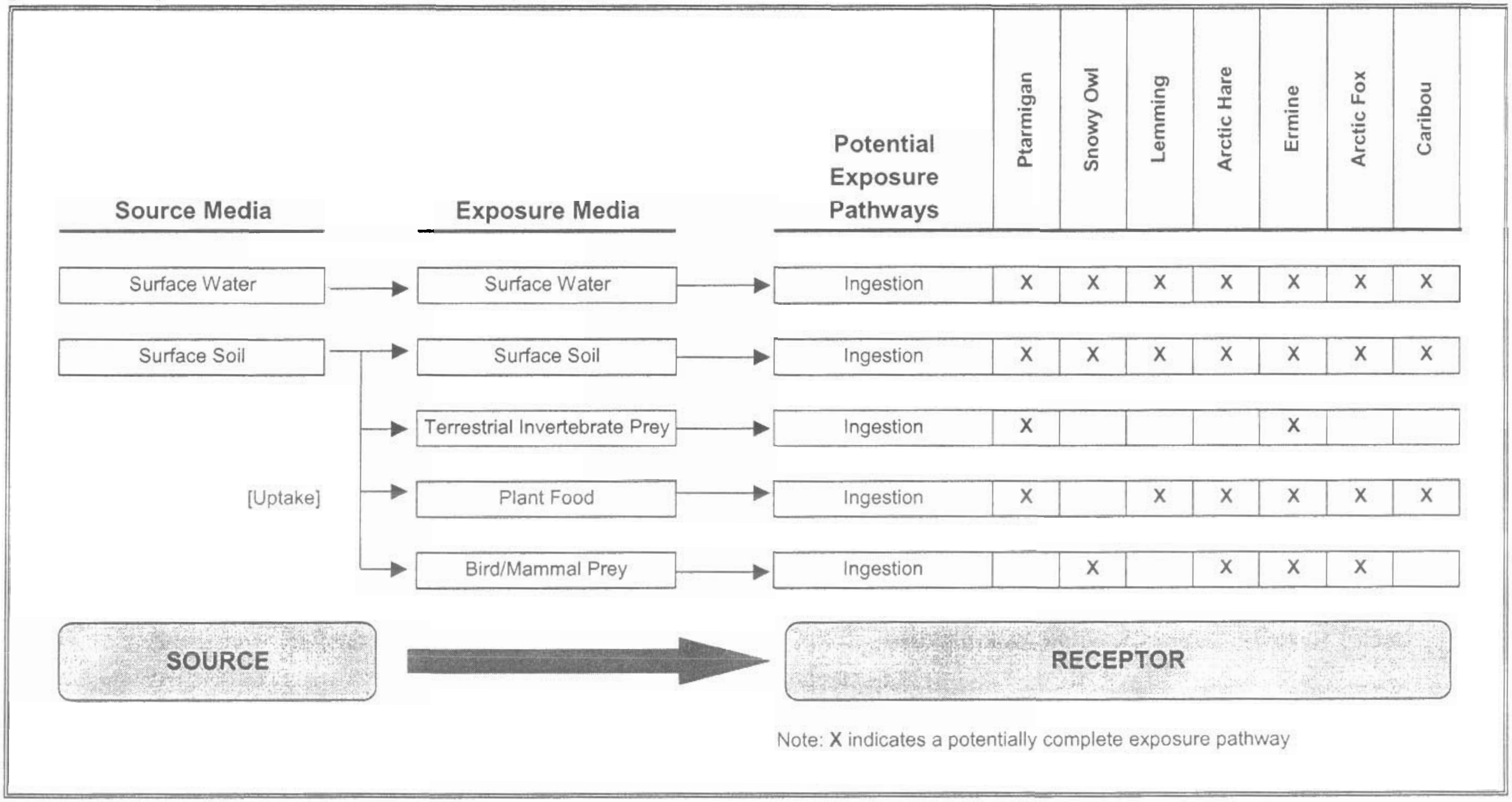
5.3.2 Conceptual Site Model

A conceptual site model was developed for CAM-F and is presented in Figure 15. This figure schematically represents the interactions between the VECs and the CoPCs, via the exposure pathways identified. The relevant exposure pathways are designated by arrows leading from the contaminant source media to each VEC. The pathway is considered to be complete (i.e., functioning) for a VEC when the exposure pathway box is marked with an X. The conceptual model shows how the pathways representing soil and water ingestion, and ingestion of food items (including terrestrial plants, and small mammal prey items) have been conceptualized and implemented for each VEC.

5.3.3 Selection of Assessment and Measurement Endpoints

Assessment endpoints are explicit expressions of environmental values or characteristics to be protected at a site, and reflect societal and ecological values (Suter 1993). Societal values address the need to protect species that are endangered, threatened, of special interest, important as game or commercial species, or widely recognized as having aesthetic value. Ecological relevance refers to importance of the species to the function of the ecosystem. Therefore, evaluation of potential for adverse effects at the population level is used to infer potential for adverse effects at higher levels of organization, such as communities and ecosystems. For birds and mammals inhabiting CAM-F, assessment endpoints focus on maintenance and protection of their populations, such that contaminants in the surface water, sediment, or soil would not significantly impact either species abundance or diversity through increased mortality or decreased reproduction.

Figure 15 Conceptual Site Model for Ecological Risk Assessment



The information needed to deal directly with the assessment endpoint is difficult to generate and rarely available; thus measurement endpoints are used to bridge the gap. Measurement endpoints are measurable responses to stressors related to assessment endpoints, and are intended to provide a basis for assessing risk potential for the assessment endpoint. They may be defined in terms of an unacceptable level of impact to ecological receptors, such as a certain relative percent decrease in survival, growth or reproduction of ecological populations (Suter 1993). As part of a weight-of-evidence approach, one or more measurement endpoints may be used for each assessment endpoint. Choice of measurement endpoints for each interaction between a VEC and a contaminant of concern is typically limited by available toxicity data. Those most commonly used to quantify the survival, growth and reproduction of receptors in bioassays include the LC_{50} and LD_{50} (concentrations or doses that will be lethal to 50% of exposed organisms, over a defined period of exposure); the EC_{50} and ED_{50} (concentrations or doses that elicit a defined response or effect over a defined period of time); the Lowest Observable Adverse Effect Level (LOAEL); and the No-observable Adverse Effect Level (NOAEL). Although the dose-response relationships derived from these measurement endpoints are characteristic of test species exposed under controlled conditions, appropriate safety factors are included in order to consider the response of species in the natural environment.

The measurement endpoints for the assessment endpoints focus on whether observed concentrations of chemicals in water or soils are likely to result in doses to birds or mammals that are greater than those observed to result in increased mortality or decreased reproduction upon chronic exposure.

Therefore, the key components of this ecological risk assessment are:

- characterization of relationships between amount of a chemical present in surface water or sediments and a thresholds for adverse effects; and
- characterization of relationships between the dose resulting from the amount of a chemical present in surface soils and a threshold dose for adverse effects.

The dose-response relationships that have been incorporated into this ERA are based upon Lowest Observed Adverse Effect Levels, in relation to survival or reproduction of birds and mammals after chronic exposure to the CoPCs. These relationships are expressed in terms of the daily ingested dose, normalized to body weight of the test organism (i.e., the reference toxicity dose or RTD value expressed as mg substance ingested / kg body weight-day). Where such data were not available, LOAEL values were estimated from other endpoints including the NOAEL, or the LD_{50} value. Standard conversion factors were implemented including division by 5 to convert an acute dose to a chronic dose; dividing by 6 to convert an LD_{50} value to a LOAEL value, or multiplication by 5 to convert a NOAEL to a LOAEL value. These conversion factors are cumulative, so an acute LD_{50} would be converted to a chronic LOAEL value by dividing by 30.

If data for the specific representative mammalian receptors was not available, a body-size scaling factor (Sample and Arenal 1999) was used for extrapolation of available data between species. The body-size scaling factor is calculated as:

Mammal Body Weight SF= $(BWt/BWr)^{0.06}$

where:

SF	= scaling factor
BWt	= mean body weight for test species
BWr	= mean body weight for receptor species

If data for the specific representative avian receptors was not available, a body-size scaling factor (Sample and Arenal 1999) was used for extrapolation of available data between species. The body-size scaling factor is calculated as:

Bird Body Weight SF= $(BWt/BWr)^{-0.20}$

5.4 RISK CHARACTERIZATION

Risk characterization is the final step of an ecological risk assessment. It includes a quantification of the potential nature and magnitude of adverse effects that may occur to receptor species due to presence of chemicals in identified ecological habitats at the site. In this step, characterization of exposure and characterization of ecological effects for each chemical, is integrated into quantitative estimates (hazard quotients or HQ values) of the potential for adverse effects to ecological receptors.

5.4.1 Approach

For this assessment, ecological hazard quotient (HQ) values were calculated by dividing exposure (as the exposure point concentrations or total ingested dose values) derived for each receptor by their appropriate reference toxicity dose (RTD), as follows:

HQ = (Exposure)/(Reference Toxicity Dose)

For birds and mammals, the exposure measure is the total ingested dose (mg/kg-day) summed over all exposure pathways.

A HQ value of less than 1.0 indicates the exposure concentration is less than the threshold for adverse effects, and a low probability exists that adverse effects might occur. Given the overall tendency to introduce conservatism (through the use of data or assumptions that are likely to overstate, rather than understate risk) into risk assessments, it is likely no adverse effect would occur. Alternatively, a HQ value of >1.0 does not automatically indicate that there is an unacceptable level of risk. In this case, the conservative approach reduces the certainty of this conclusion, and dictates a need for more careful review of both predicted exposure levels and exposure limit derivations. As a result, HQ values greater than 1.0 should be examined carefully, and further more focused investigations may be required to reduce conservatism and provide a more realistic assessment of the actual risk level. If it is ultimately determined that the HQ value is indeed greater than 1.0, then site management or remedial activities may be appropriate in order to reduce risks to ecological receptors.

5.4.2 Determination of Media to Biota Uptake Factors

The concentrations of substances evaluated in this ERA were measured empirically in water, plants, and soils from CAM-F. However, in order to complete assessment of exposure of the VECs to each substance, it is necessary to estimate concentrations of each CoPC in a variety of biological compartments. This task is accomplished generically using uptake factors (UF) that relate the concentration in various types of biota (such as invertebrates or small mammals) to concentrations in water or soil.

Substances retained in the ERA as CoPCs include BTEX, TPH, total PCBs, and selected metals. The approaches used to estimate uptake factors for each of these groups of substances, for each of the required biological food groups, are described below. The specific uptake factors used, with references as to the source of the uptake factor, can be found in the ERA model printouts located in Appendix C. Some general information on the sources of data used for media to biota accumulation factors is presented below.

Soil to Plant Uptake Factors

Soil to plant uptake factors for organic substances were generally calculated using the equation of Travis and Arms (1988):

$$\log(UF_{SP}) = (1.588 - 0.578 \log(K_{ow})) \times 0.19,$$

where UF_{SP} is the uptake factor from soil to plant (mg/kg dry plant / mg/kg dry soil), K_{ow} is the octanol-water partition coefficient for the organic substance under consideration, and 0.19 is a conversion factor to adjust dry weight plant tissue concentrations to wet weight values.

For some inorganic substances (Cd, Cr, Cu, Pb, Zn) and total PCBs, data on plant tissue metal concentrations were collected from the site by the Environmental Sciences Group of the Royal Military College in 1994 (RRMC 1994). EPC values were calculated by taking the 95% upper confidence limit of the geometric mean and multiplying the value by a conversion factor representing the average dry solids fraction (0.40) to obtain wet-weight tissue concentrations.

For other inorganic substances, a variety of approaches and data sources were used, although the equations of Efroymson et al. (2001), which adjust the soil to plant uptake factor according to the CoC concentration in soil, were preferred.

Soil to Animal Uptake Factors

For organic substances, soil to animal (caribou meat) uptake factors were generally calculated using the equation of Travis and Arms (1988):

$$\log(Ba_{p,s,w}) = -7.6 + \log(K_{ow}),$$

where $Ba_{p,s,w}$ is the transfer factor from soil to beef (day/kg), which is assumed to also be applicable to caribou meat. These transfer factors are multiplied by the CoPC concentration in soil, feed and drinking water (mg/kg or mg/L), and by the ingestion rates of soil, feed and drinking water (kg/day or L/day) to estimate the concentration in meat (mg/kg). For the TPH substances, which are not as readily absorbed and which are more readily metabolized than the pesticide compounds that form the basis of the

Travis and Arms data, a bioavailability factor (which can range from 0 to 1) is also applied.

For inorganic substances in meat, a similar approach is used for concentrations in meat, except that the transfer factors to meat (Bap,s,w) were obtained from the compilation of Baes et al. (1984).

For small animal prey items, including lemming, ptarmigan and Arctic hare, a variety of approaches and data sources were used. For organics, the approach of Travis and Arms (1988) was followed. For inorganic substances, data on lemming tissue concentrations (n=1) were collected from the site by the Environmental Sciences Group of the Royal Military College in 1994 (RRMC 1994).

Soil to Soil Invertebrate Uptake Factors

For soil to soil invertebrate uptake factors (UPSI) for the BTEX and TPH compounds, conservative default uptake factors of 0.1 were assumed. For inorganic substances, the equations of Sample et al. (1998) were preferred, although an empirical uptake factor of 0.036 was used for tin.

5.4.3 Determination of Reference Toxicity Doses

Reference toxicity doses (RTDs) for terrestrial receptors are included in the risk assessment model results for each receptor, and are presented in Appendix C. The RTD values are unique to each CoPC.

5.4.4 Risk Characterization for Avian Receptors

Tables showing the derivation of risk estimates for avian receptors can be found in Appendix C. Table 22 shows the HQ values for each VEC. The text below provides a synopsis of the risk estimates for each VEC.

5.4.4.1 Risk Estimates for Ptarmigan

For the ptarmigan the intake pathways included surface water, soil, soil to plants, and soil to soil invertebrates. The ptarmigan feeds primarily on vegetation such as leaves, flowers, buds and twigs of willow and birch, seeds and berries, and will also consume insects, especially as chicks.

Risks (HQ values) for the ptarmigan were less than 1 for all substances. However, two inorganic substances had HQ values that lay between 0.1 and 1.0. These substances were chromium (HQ = 0.276) and zinc (HQ = 0.315). All other substances that were assessed had HQ values that lay below 0.1. Examination of the pathways leading to the high HQ values for chromium and zinc shows the HQ values were dominated by the plant ingestion pathway, based on measured (1994) concentrations of chromium and zinc in plant tissue from the CAM-F site. Risks due to ingestion of soil, terrestrial invertebrates, and surface water are negligible.