Technical Reports

Safety Report - Public Summary

Cameco Fuel Manufacturing

Environmental Risk Assessment

Cameco Corporation's (Cameco) Cameco Fuel Manufacturing (CFM) facility holds an operating licence from the Canadian Nuclear Safety Commission (CNSC) to fabricate fuel bundles for use as fuel for nuclear generating stations. CFM is located at 200 Dorset Street East in the Municipality of Port Hope (MPH). The developed portion of the CFM site is approximately 4.1 hectares (ha) of which approximately half (2.3 ha), is within a security fence. CFM also includes 12 ha of property to the north and east of the fenced perimeter of the plant.

Figure 1: Cameco Fuel Manufacturing

In accordance with its licence requirements, Cameco has completed an environmental risk assessment (ERA) to align with the standardized requirements found in Canadian Standards Association (CSA) N288.6-12, Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills. An ERA is a systematic process used to identify and assess the risk posed by contaminants and physical stressors in the environment on biological receptors. There are two parts to an ERA – an assessment of the facility's effect on human receptors through a human health risk assessment (HHRA) and an assessment on non-human environmental receptors through an ecological risk assessment (EcoRA).

The CFM ERA was completed to address the following question:

> ***Is there potential for significant environmental (i.e. ecological and human health) effects from current emissions associated with Cameco's CFM facility operations?***

This summary provides the ERA methodology and results, which concludes there are no radiological or non-radiological human health risks expected to members of the public. Similarly, there are no radiological or non-radiological ecological risks to any of the terrestrial or aquatic receptors.

Environmental risk assessment follows a general tiered-approach methodology supported by CSA and various agencies, such as Health Canada (HC), Canadian Council of Ministers of the Environment (CCME) and the CNSC. Potential effects on humans or the environment are measured in terms of "screening indices". In simple terms, a screening index (SI) is the concentration or exposure level divided by a published criteria that has been deemed unlikely to have a significant effect on the receptor. These criteria can come from research or field studies, regulatory standards and objectives, scientific literature or other credible sources.

SI is the ratio of

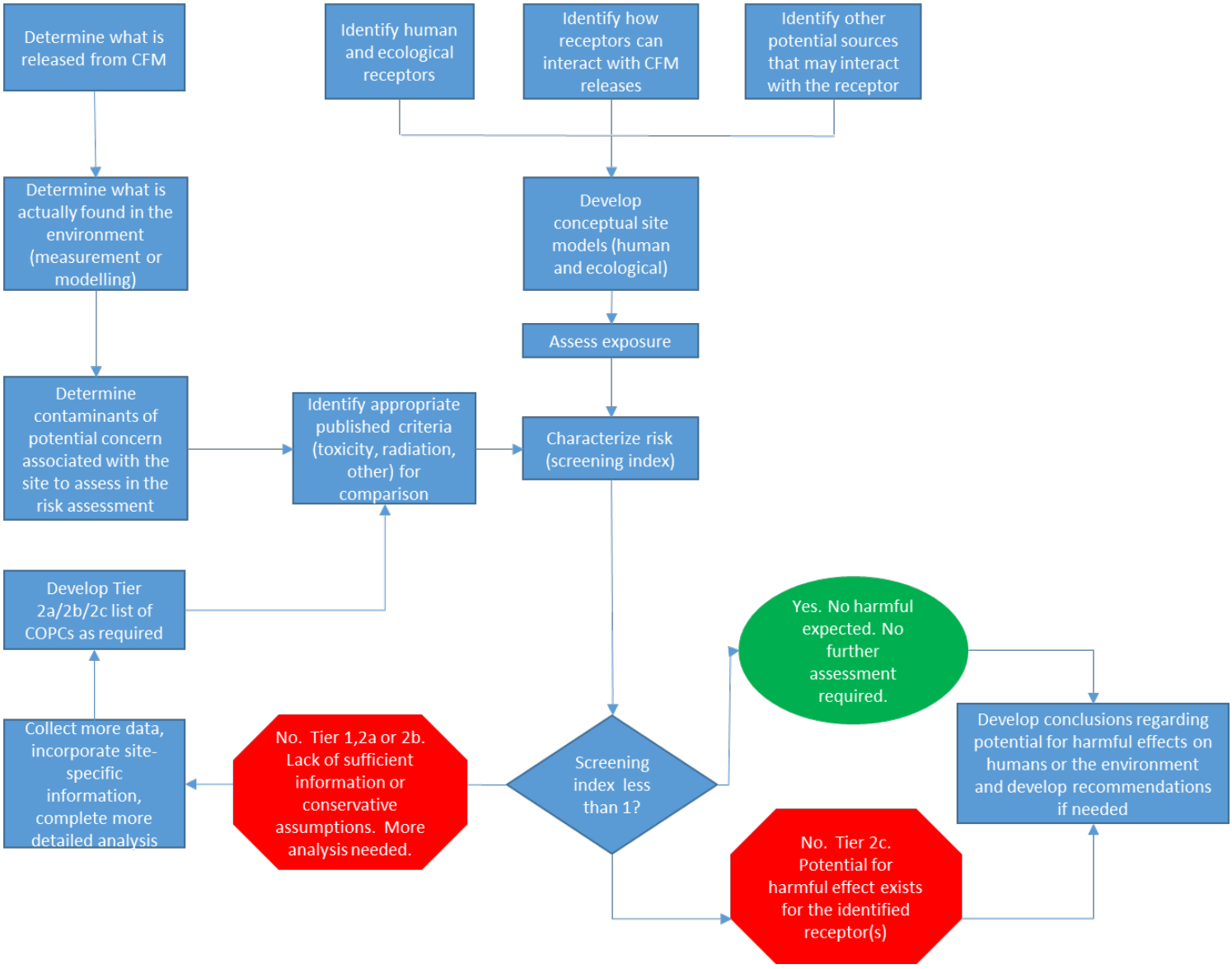
$$\frac{\text{Exposure Level (or Concentration)}}{\text{Criterion}}$$

SI **below one** indicates that no harmful effects on living things are expected.

SI **above one** indicates that further analysis is required.

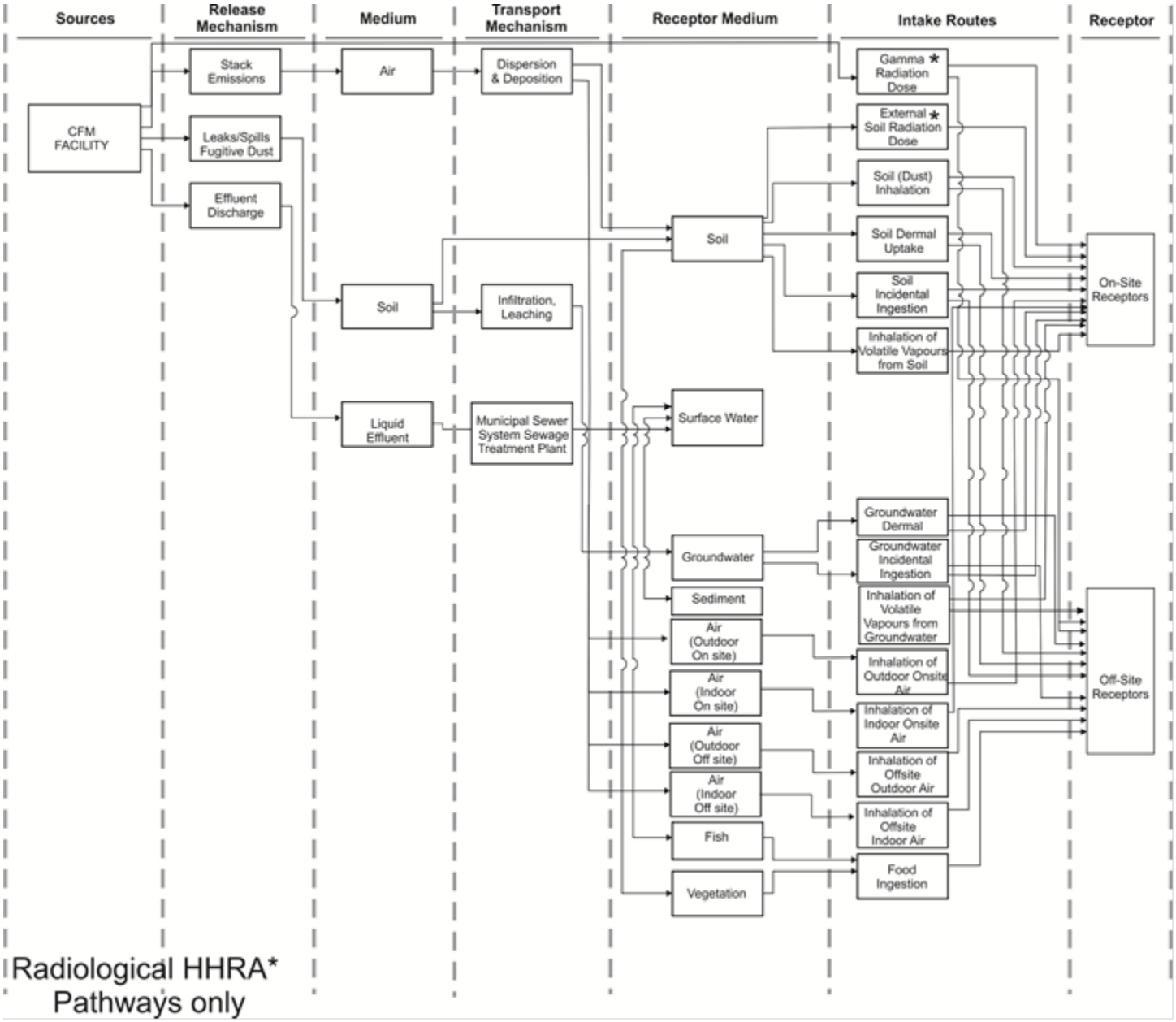
As depicted in Figure 2, the first level or tier of the assessment starts with very broad assumptions designed to uncover any potentially significant environmental effects. If no potential effects are identified (SI is less than 1), then the assessment stops. If a potential effect is identified (SI greater than 1), then the analysis continues to determine whether that potential effect is due to lack of sufficient information or assumptions that are too conservative. Another tier or step of analysis (in Tiers 2a, 2b and 2c as required) would follow with more detailed analysis, additional field data, and more site specific information. As data gaps are closed and assumptions become more realistic, it becomes possible to determine if a stressor is actually having an effect. Each step results in increasing levels of certainty about environmental risk factors. Once the assessment is complete, a conclusion with associated recommendations to address potential impacts to people or the environment is developed.

Figure 2: Environmental Risk Assessment Overview



The first step in conducting an ERA is to understand how materials released from Cameco's operations may enter the natural environment. This is illustrated in Figure 3.

Figure 3: Transport Pathways



Once this is understood, the Contaminants of Potential Concern (COPCs) are identified. This is a list of all radiological and non-radiological contaminants released to air and water from site operations. It is developed from operational knowledge of the facility, routine monitoring data, other available monitoring data and field investigations. Screening for COPCs at CFM included the following broad categories: CFM routine monitoring parameters; general chemistry parameters, metals and radionuclide analysis. Data from both Cameco and non-Cameco sources were utilized. In developing the list of COPCs, some contaminants are removed from further consideration if they are released in very small quantities, are present at or below natural background levels, or are determined not to be a concern from a human or ecological health perspective. The concentration(s) in the environment are then determined for each source (i.e. soil, groundwater, surface water, air emissions) in the natural areas near the facility using field measurements, modelling or a combination of both. Where multiple samples are available, the maximum concentration or "worst-case" is used for the first or screening level assessment in the ERA.

The pathways assessment (also called risk characterization or risk assessment) is a series of calculations following the standardized requirements of the CSA N288.6-12 standard that are used to estimate the exposure of the human or ecological receptor to each of the COPCs. The calculations estimate the uptake of COPCs from the different environmental media and how the COPCs are passed up the food chain. The calculated exposure levels are compared to scientifically accepted benchmarks to determine whether there is a potential for an effect to human health or biota which results in a screening index.

It is important to understand that the first tier of the assessment begins with conservative assumptions about both estimated exposure and the criteria used to assess the risks of that exposure, especially where information is not readily available.

The assumptions used to derive the SI are conservative to ensure that if the index is estimated to be less than 1, there's a high level of confidence that, despite any uncertainty in the data, the index value won't exceed 1. If the screening index is estimated to be greater than 1, however, follow-up work is required in a higher tier assessment to determine whether this is due to conservatism in the assumptions, lack of sufficient data or a real impact. Tier 1 assessments are typically based on literature reviews. Higher tier assessments require field studies.

Human Health Risk Assessment

The HHRA component of the ERA included the following COPCs:

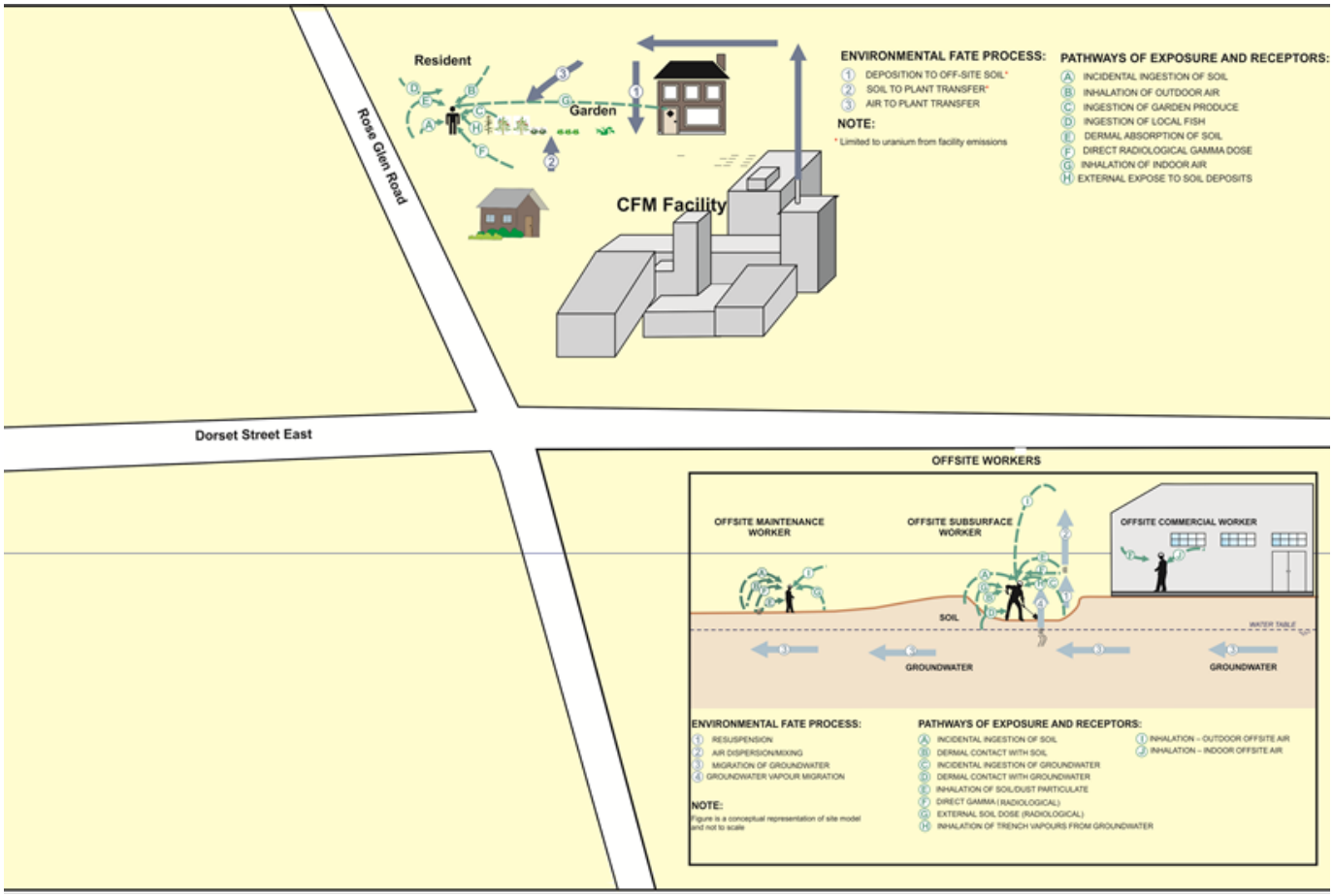
- Uranium
- Trichloroethylene (TCE) (and degradation products)

These COPCs were assessed in one or more of the following pathways in the HHRA:

- Groundwater
- Soil
- Air
- Contaminated food
- Gamma radiation

The human receptors and receptor characteristics are defined for the HHRA based on the members of the public who reside or use the natural areas near the facility who may be affected by the release of contaminants. Different scenarios are considered to assess nearby residents, such as their age, whether they work at or near the facility, or consume local produce. The different routes of exposure, or pathways (i.e. how the contaminants travel through the natural environment and ultimately interact with the human or biological receptors) are determined and are collectively referred to as the conceptual site model (CSM), as shown in Figure 4.

Figure 4: Human Health Risk Assessment Conceptual Site Model



The CFM receptors considered are described in Table 1 for the HHRA.

Table 1: Human Receptor Exposure Locations and Environmental Media

Potential Environmental Media	Exposure Location Description	Resulting Exposure
Soil	Based on their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to residential yard soil or park soil. *Note that access to the site is controlled. Members of the public cannot enter the site and consequently be exposed to on-site soil.*	**Soil ingestion, inhalation or dermal contact**
Groundwater	Off-site member of the public receptors are not exposed to on-site groundwater, due to controlled access to the CFM site. Furthermore, groundwater is not the source of drinking water in Port Hope. Exposure to off-site groundwater (i.e., not associated with the CFM site) is not the focus of this study. *Members of the public cannot enter the site and consequently be exposed to on-site groundwater*	N/A
Garden Produce	As part of their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to contaminants via ingestion of garden produce grown in residential soil.	**Garden Produce** (estimated based on residential yard soil)
Local Fish	As part of their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to contaminants via ingestion of fish caught from the Harbour.	**Local Fish** (estimated based on Harbour surface water)
Outdoor Air	As part of their behaviours, off-site member of the public receptors could potentially be exposed to contaminants via inhalation of outdoor air.	**Outdoor Air** (Based on off-site soil concentrations from airborne deposition – measured and/or estimated)

Results

The radiological human health risk component involved dose calculations based on maximum measured radionuclide levels in environmental media (wherever such measured data were available). The resulting estimated doses are well below the dose limit to a member of the public (1 mSv/a) and, therefore, no undue impacts are expected to workers or members of the public.

The non-radiological human health risk component involved exposure calculations based on maximum concentrations measured in a particular media. Further analysis is completed for receptor-media combinations that exceed benchmark values. In this assessment, resident receptors (public) are not expected to have access to on-site groundwater, and therefore, the receptor-media combination is not feasible and therefore, no undue risk is anticipated.

Table 2 summarizes the results of the HHRA for CFM. For radioactive parameters, there are no effects expected to humans as a result of CFM operations. For non-radioactive parameters, the Tier 1 assessment did indicate the potential for effects from uranium and TCE; however, subsequent Tier 2 (U and TCE) carried out following the guidance of N288.6-12 identified no impact to the public.

Table 2: Results of the Human Health Risk Assessment

Receptor Name	Age Group	HHRA TIER 1 – Exceedances				HHRA TIER 2 - Exceedances				Comments
		Air (U)	*Soil (U)*	*SW (U, TCE)*	*GW (U, TCE)*	*Air (U)*	*Soil (U)*	*SW (U, TCE)*	*GW (U, TCE)*	
Resident	*Infant*	-	-	-	-	-	-	-	-	***No exceedances***
	Toddler	-	-	-	-	-	-	-	-	
	Child	-	-	-	-	-	-	-	-	
	Teen	-	-	-	-	-	-	-	-	
	Adult	-	-	-	-	-	-	-	-	
Resident who is also an employee	*Adult*	-	-	-	TCE	-	-	-	TCE	***Oral/dermal exposure route only***

Ecological Risk Assessment

The EcoRA component of the ERA included the following COPCs:

- Uranium
- Trichloroethylene (and degradation products)

These COPCs were assessed in one or more of the following pathways in the EcoRA:

- Groundwater
- Soil
- Surface water
- Sediment

The biological receptors and receptor characteristics are defined for the EcoRA based on the plants, invertebrates, mammals and birds who use the natural areas near the facility and may be affected by the release of contaminants. The CSM for the EcoRA, illustrating the different routes of exposure, or pathways (i.e. how the contaminants travel through the natural environment and ultimately interact with the biological receptors) is shown in Figure 6 and Table 3.

Figure 6: Ecological Risk Assessment Conceptual Site Model

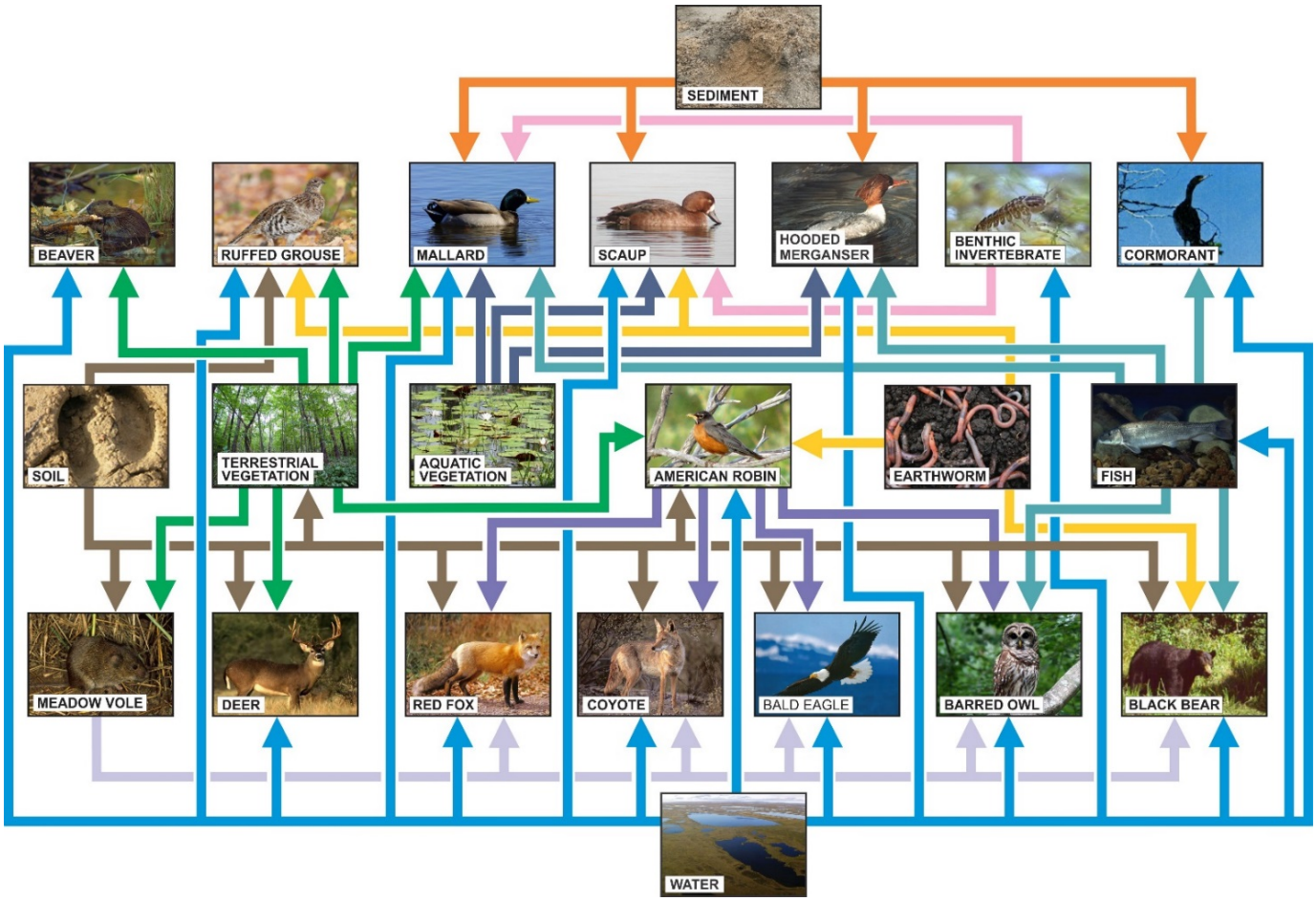


Table 3: EcoRA Exposure Pathways Summary

Receptor	Environmental Media Exposed	Modes of Exposure	Risk Calculation Method	
			Non-Radioactive	Radioactive
Fish	Sewage Plant Outfall • surface water • sediment	• uptake from water; • immersion in water; • exposure to sediment (benthic fish, radiological only).	Comparison of surface water concentrations with corresponding benchmark values.	**Pelagic fish:** • Internal dose from water; • External dose from water. **Benthic fish:** • Internal dose from water; • External dose from water; • External dose from sediment.
Benthic Invertebrates	Sewage Plant Outfall • surface water • sediment	• uptake from water; • immersion in water (radiological only); • immersion in sediment (radiological only).	Comparison of water concentrations with benchmark values.	• Internal dose from water; • External dose from water; • External dose from sediment.
Aquatic Plants	Sewage Plant Outfall • surface water	• uptake from water; • immersion in water (radiological only).	Comparison of water concentrations with benchmark values.	• Internal dose from water; • External dose from water.
Aquatic Birds	Sewage Plant Outfall • surface water sediment	• uptake from water; • immersion in water (radiological only); • ingestion: - aquatic vegetation; - aquatic invertebrates; - fish; - sediment;	Comparison of dose from intake with benchmark values.	• Internal dose from ingestion; • External dose from water.
Terrestrial Invertebrates	• soil • groundwater	• uptake from soil; • immersion in soil (radiological only); • uptake from groundwater; • immersion in groundwater (radiological only).	Comparison of soil or groundwater concentrations with benchmark values.	• Internal dose from soil or groundwater; • External dose from soil or groundwater.
Terrestrial Birds	• soil	• ingestion: - terrestrial vegetation; - terrestrial invertebrates; - small mammals and birds; - soil; • direct exposure to soil (radiological only).	Comparison of dose from intake with benchmark values.	• Internal dose from ingestion; • External dose from soil; • Direct gamma dose.
Terrestrial Mammals	• soil	• ingestion (as appropriate): - terrestrial invertebrates; - terrestrial vegetation; - soil; - mammals and birds (fox); • direct exposure to soil (radiological only).	Comparison of dose from intake with benchmark values.	• Internal dose from ingestion; • External dose from soil; • Direct gamma dose.
Terrestrial Plants	• soil	• uptake from soil; • exposure to soil (radiological only).	Comparison of soil concentrations with benchmark values.	• Internal dose from soil; • External dose from soil; • Direct gamma dose.

Results

Table 4 summarizes the results of the EcoRA for CFM. For radioactive parameters, there are no effects expected on ecological (terrestrial and aquatic) receptors as a result of CFM operations. With respect to non-radioactive parameters, the Tier 1 assessment did indicate the potential for effects from uranium downstream of the municipal sewage treatment plant. However, subsequent Tier 2 analysis carried out following the guidance of N288.6-12 confirmed that no ecological effects are expected as a result of CFM operations.

Table 4 Results of the Ecological Risk Assessment

Receptor Type	Receptor	HHRA TIER 1 - Exceedances	HHRA TIER 2 - Exceedances
Terrestrial	*American Robin*	-	***No residual exceedances***
	Cotton-Tail Rabbit	-	
	Earthworm	-	
	Great Horned Owl	-	
	Meadow Vole	-	
	Red Fox	-	
	Terrestrial Vegetation	-	
	Yellow Warbler	-	
	Earthworm (GW)	-	
Aquatic	*Aquatic Vegetation*	-	
	Benthic Fish	-	
	Benthos	**Uranium**	
	Horned Grebe	-	
	Pelagic Fish	-	
	Lesser Scaup	-	

Conclusions

In summary, as indicated in Table 5, there are no radiological or non-radiological human health risks expected to members of the public. Similarly, there are no radiological or non-radiological ecological risks to any of the terrestrial or aquatic receptors.

Table 5: Summary of ERA Results

Stressor Type	Members of the Public	Aquatic Biota	Terrestrial Biota
Radiological	No adverse effect expected from COPCs associated with CFM operations.	No adverse effect expected from COPCs associated with CFM operations.	No adverse effect expected from COPCs associated with CFM operations.
Non-Radiological	No adverse effect expected from COPCs associated with CFM operations.	No adverse effect expected from COPCs associated with CFM operations.	No adverse effect expected from COPCs associated with CFM operations.

The ERA was consistent with the standard, CSA N288.6-12.As a result of this ERA, Cameco has implemented a new environmental protection program that considers this risk assessment, its conclusions and meets the requirements of additional CSA environmental standard for monitoring program.

The next scheduled update of this ERA is in 2021 in accordance with the CSA N288.6-12 recommended update cycle.