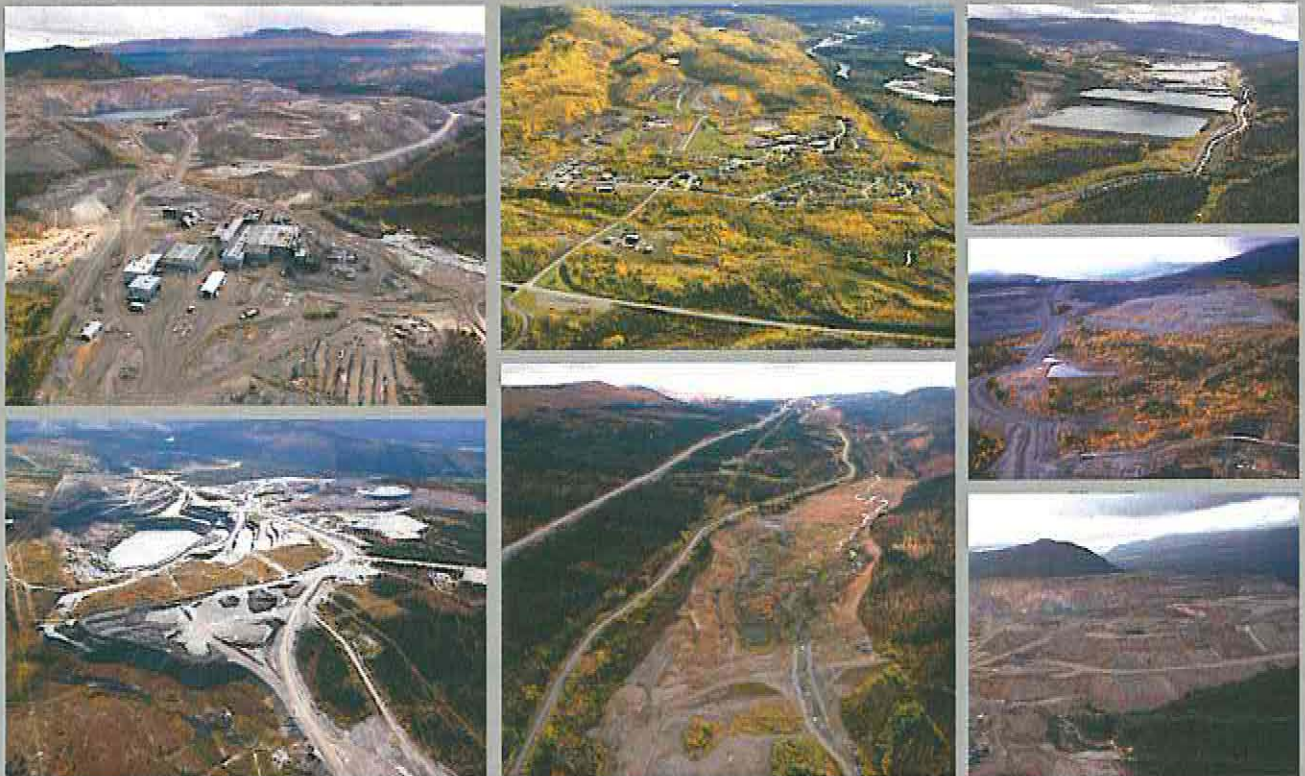


PROBABILISTIC HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT OF FINAL CLOSURE AND REMEDIATION PLAN FOR FARO MINE COMPLEX



Prepared For:

Government of Yukon

Prepared By:

SENES Consultants Limited

June 2010



DRAFT

SUMMARY REPORT

FARO MINE COMPLEX

PROBABILISTIC RISK ASSESSMENT OF

FINAL CLOSURE AND REMEDIATION PLAN

Prepared for:

Government of Yukon

Prepared by:

SENES Consultants Limited
121 Granton Drive, Unit 12
Richmond Hill, Ontario
L4B 3N4

June 2010

Printed on Recycled Paper Containing Post-Consumer Fibre



Introduction

The Government of Yukon commissioned SENES Consultants Limited to carry out an assessment of the potential for metals present at the Faro Mine Complex in groundwater, surface water, sediments, soils, fish, and vegetation after remedial activities to harm animals on and close to the site as well as people who would use the site for hunting, trapping and gathering in the future. The Faro Mine Complex includes facilities at two locations, the Faro mine site and the Grum and Vangorda mine site. The Faro mine site is located within the Rose Creek watershed, a tributary of the Anvil Creek watershed, while the Grum and Vangorda mine site is located within the Vangorda Creek watershed. The Anvil Creek and Vangorda Creek watersheds both empty into the Pelly River.

The assessment completed was a step-wise process for answering the following questions:

- How safe is the site?
 - Used measured data from the site and future water concentrations provided by the engineering team
- How sure are we?
 - Probabilistic assessment was used to represent the uncertainty in some of the assumptions and future concentrations
- Is it acceptable?
 - Used scientific guidance from Health Canada and Environment Canada

Data Used in the Assessment

The site was studied for the conditions that would be expected in the future when the final closure and remediation plan has been implemented. As part of remediation, the tailings will be covered and it is hoped that animals will return to the site and use it as they did before mining activities. The assessment considered future water quality based on concentrations provided by Gomm Environmental Engineering Consulting. The calculations used for the assessment are typical calculations that are used by the scientific community. The terrestrial environment was represented by measured data collected from the site between 2002 and 2004. Although the waste rock and tailings areas will be covered in the final closure and remediation plan, metal levels in soils and vegetation in the vicinity of the mine facilities are still expected to be at or near levels measured in the future. Most effects on the terrestrial environment were associated with emissions while the mine was operating and therefore the metal levels in soils and vegetation that have been measured in recent times would not be expected to decline rapidly. Risks associated with direct exposure to waste materials (tailings and/or waste rock) were not assessed since they will be covered as indicated in the final closure and remediation plan for the site.

Identification of Metals of Potential Concern

A selection process was used to identify metals that may have the potential to cause harm at the Faro Mine Complex. The process involved determining whether the measured concentrations of metals in water and soils were different from areas which were considered not to be affected by mining operations (these areas are termed background or reference areas). If the measured concentrations were higher than background concentrations, they were then compared to guideline values established by the federal government. Metals that were present at concentrations above these guideline values were then considered in the risk assessment. Seep water was also evaluated to identify metals that might have higher concentrations in the surface water in the future. Based on this screening procedure: antimony, arsenic, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver, strontium, tin, vanadium, and zinc were identified and carried forward in the assessment.

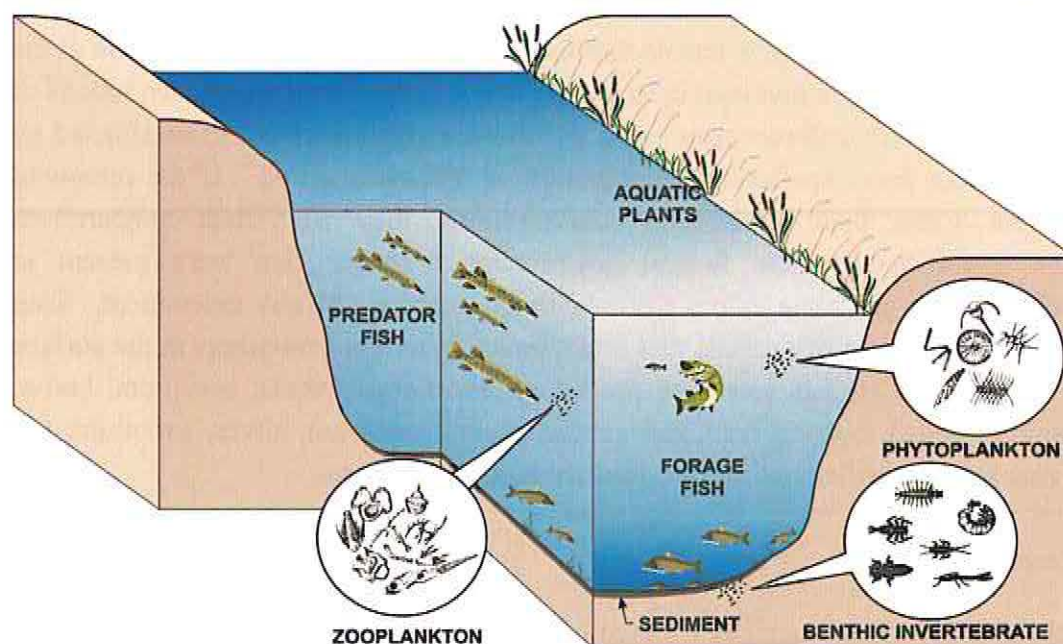
Probabilistic Assessment

The probabilistic risk assessment assigns a range of values (called a distribution function) to many of the parameters considered in the assessment. Some of these parameters are the ingestion rates of food, water, soil or sediment by the animals, and the concentrations of metals in the environment. The range of values selected (distribution function) is intended to represent the fact that we do not precisely know the values for these parameters. The results from a probabilistic assessment provide a most likely or expected result (represented by an arithmetic mean value) and a worst case result (represented by the 95th percentile value).

Animals Considered in the Assessment

The assessment for the aquatic environment considered aquatic plants (plants that live along the edge of the water), phytoplankton (small plants that live in the water), zooplankton (small animals that live in the water), benthic organisms (small animals that live in the sediments) and fish (predatory and forage) that would come in contact (exposed) with metals in the water as seen in Figure 1. Both the upstream and downstream areas of Rose Creek and Vangorda Creek as well as the Pelly River were considered in the assessment. Effects on the health of aquatic species were determined by comparing the future concentrations of metals in water to concentrations that are considered to protect these species. If the future metal concentrations are below the protective levels, then it can be concluded that the aquatic species are protected. This comparison is typically used in risk assessments.

FIGURE 1
AQUATIC RECEPTORS CONSIDERED IN THE ASSESSMENT



The terrestrial animals selected for the risk assessment were based on information provided by the Terrestrial Environment study team who held discussions as part of their program with the First Nations people who use the site. The species selected included bear, caribou, waterfowl (mallard, merganser and scaup), small furbearers (beaver and mink), fox, grouse, hare, hoary marmot, moose, Fannin sheep and wolf. From a risk assessment point of view, the ways (pathways) that the animals identified above come in contact with the metals present at the Faro Mine Complex cover all possible means of exposure for any other animals that may be present in the study area. The exposure pathways that were used in the assessment for all animals are identified on Figures 2a to 2d, which also show the typical amount of food, water and soil or sediment that each animal eats. This information was gathered from literature studies. Because this is a probabilistic risk assessment, the amount of food, water and soil or sediment that the animals eat are represented by a range of values (distribution functions) and the most commonly used value for the ingestion rates are provided in Figures 2a to 2d.

Pathways

The assessment considered the future concentrations at the site under a remediated condition. The basis of the assessment was the future water concentrations after remedial activities were completed at the site. Therefore, concentrations in the various species in the aquatic environment after remediation were estimated using factors applied to the water concentrations

to represent the transfer of metals from water to other things, such as aquatic plants, fish, sediment, and benthic invertebrates. When measured site data were available for these aquatic species, these factors were estimated using the actual site data and in the absence of measured data, literature-based factors were used. This is standard practice in risk assessment.

Site Areas

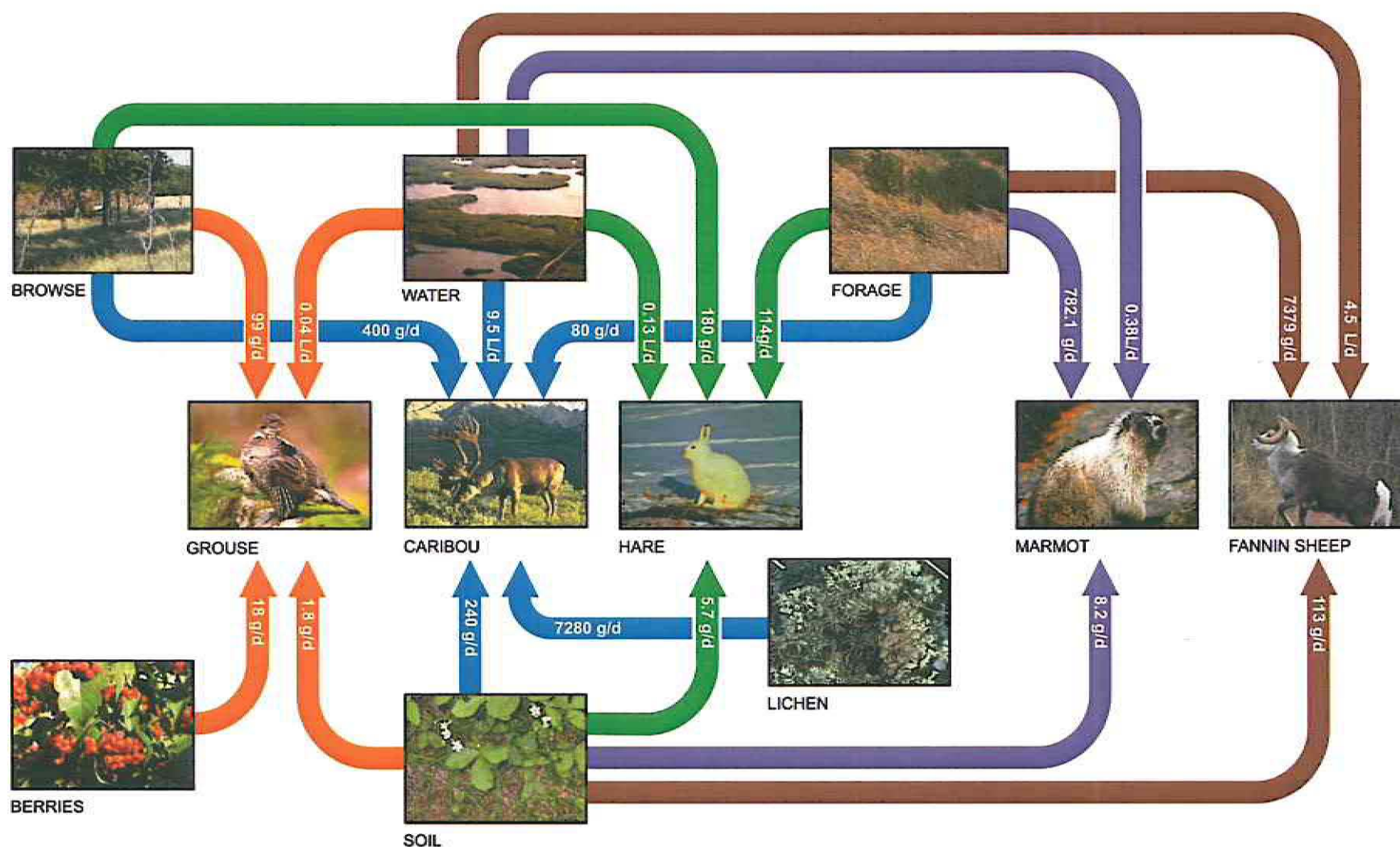
The site was divided into different areas depending on the distance that each animal typically travels from day to day. Small terrestrial mammals such as hare, grouse and marmot, do not move over large distances and therefore were considered at several different locations across the site as seen in Figure 3. Fox and bear which travel larger distances were considered in larger areas on the site (see Figure 3) and animals such as caribou, moose and wolf that travel long distances were considered to move across the whole site (see Figure 3). Sheep were evaluated in the Mount Mye area and part of the Vangorda mine site. Terrestrial animals that have a large aquatic based diet such as waterfowl and small furbearers were evaluated on Rose Creek, Vangorda Creek and the Pelly River.

Assessment Results for Animals, Fish and Plants

The results of the assessment for animals, fish and plants that would be present at the Faro Mine Complex after the final closure and remediation activities found:

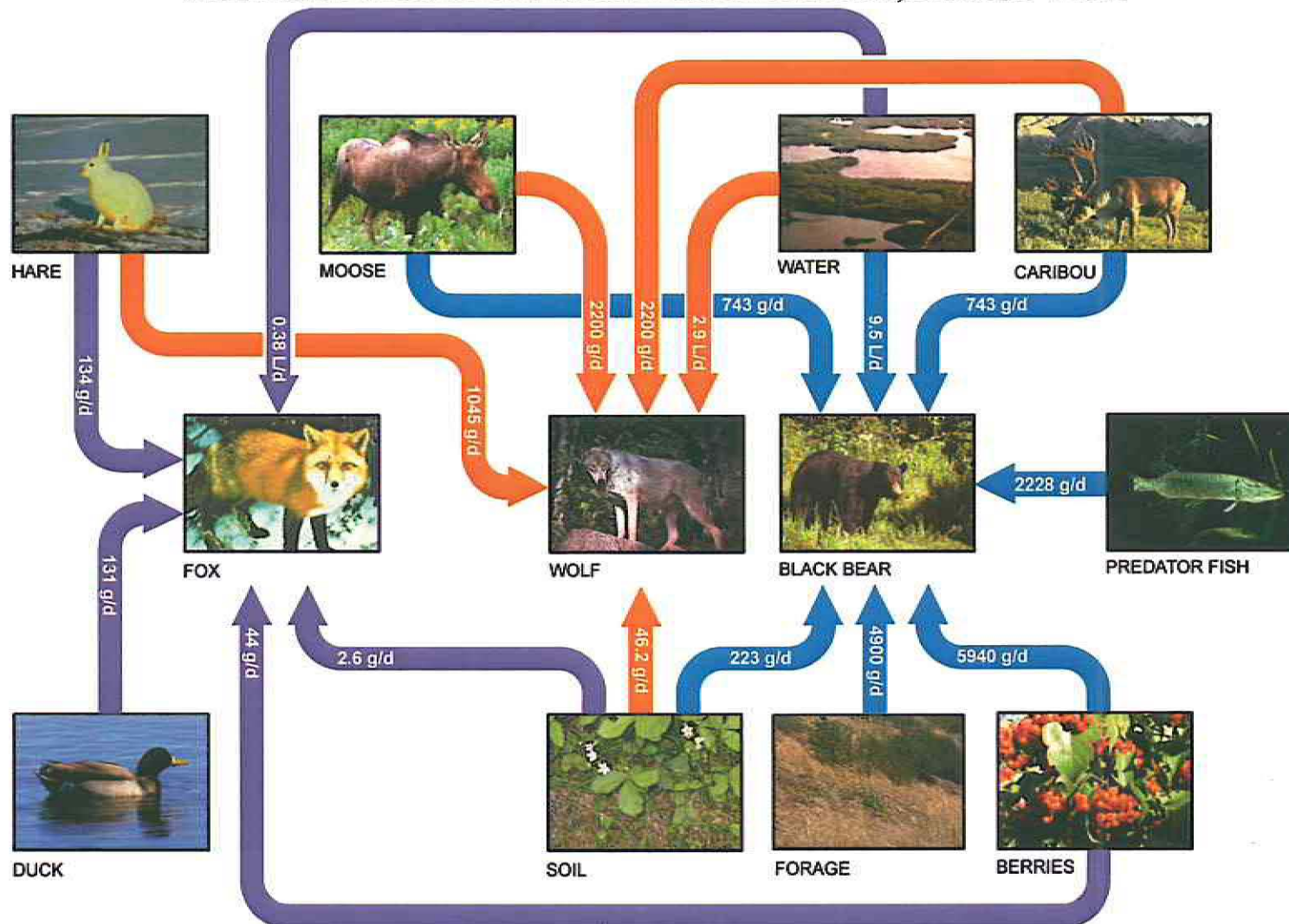
- Fish would not be harmed.
- Benthic organisms in Rose Creek would not be harmed and sediment quality in the creek will generally improve in Pelly River after implementation of the final closure and remediation plan.
- Microscopic animals in the water in Vangorda Creek at V27 (near the Vangorda/Grum pits) may be affected; however, this is limited to a small area.
- Typical algae (plants) that would be found in Rose Creek and Vangorda Creek would not be harmed by exposures to cadmium and zinc concentrations; however if very sensitive species were present, they may be harmed, but the harmful effects would only occur in a very small area.
- Unlikely that there will be any harm to animals that use the site as only the worst case concentrations resulted in intakes above levels found to result in minor health effects in test animals.

FIGURE 2a
POTENTIAL WAYS OF EXPOSURE FOR CARIBOU, GROUSE, HARE, MARMOT AND SHEEP



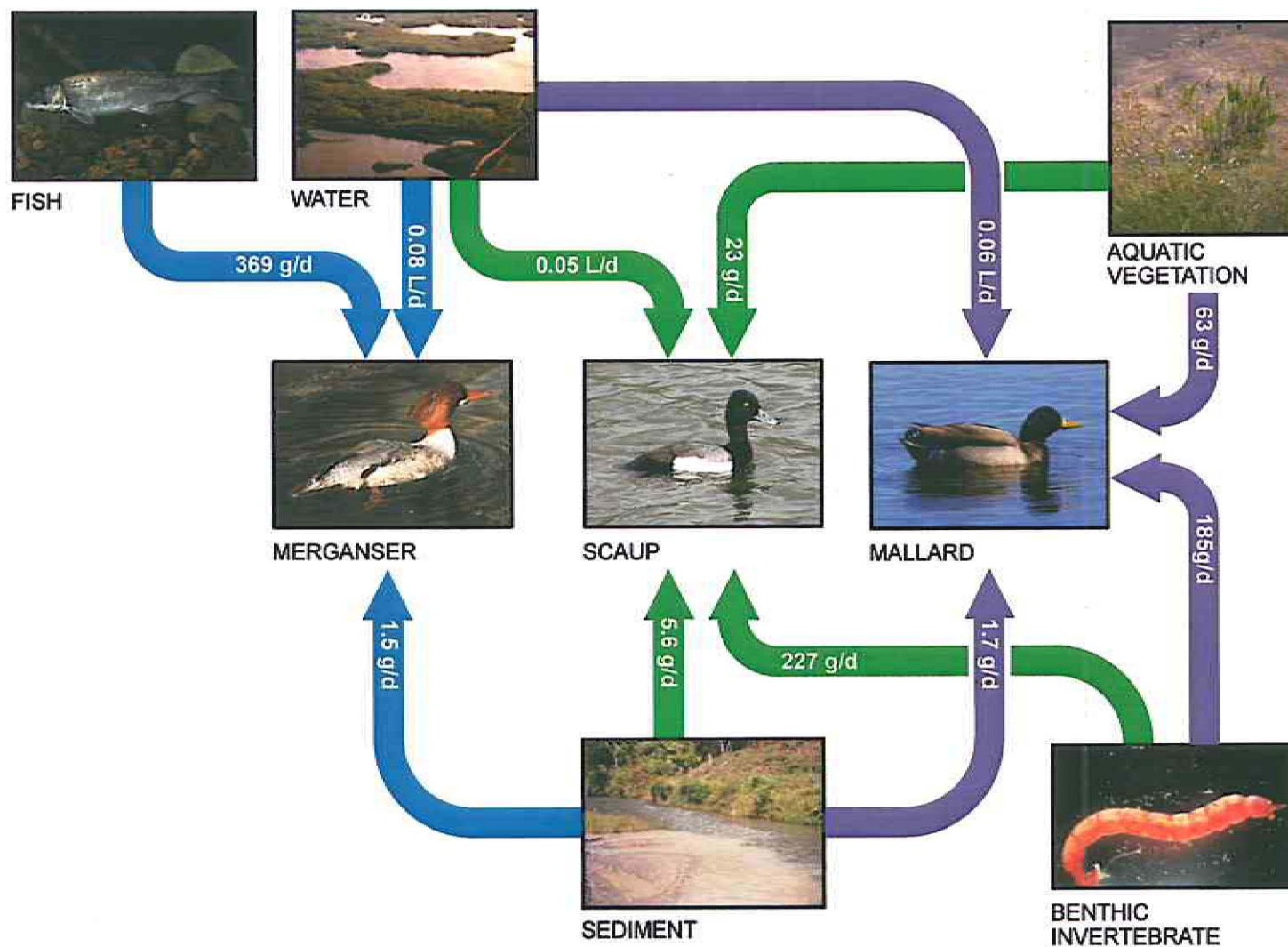
Note: All intakes are on a wet weight basis except for soil which is on a dry weight basis

FIGURE 2b
POTENTIAL WAYS OF EXPOSURE FOR BLACK BEAR, FOX AND WOLF



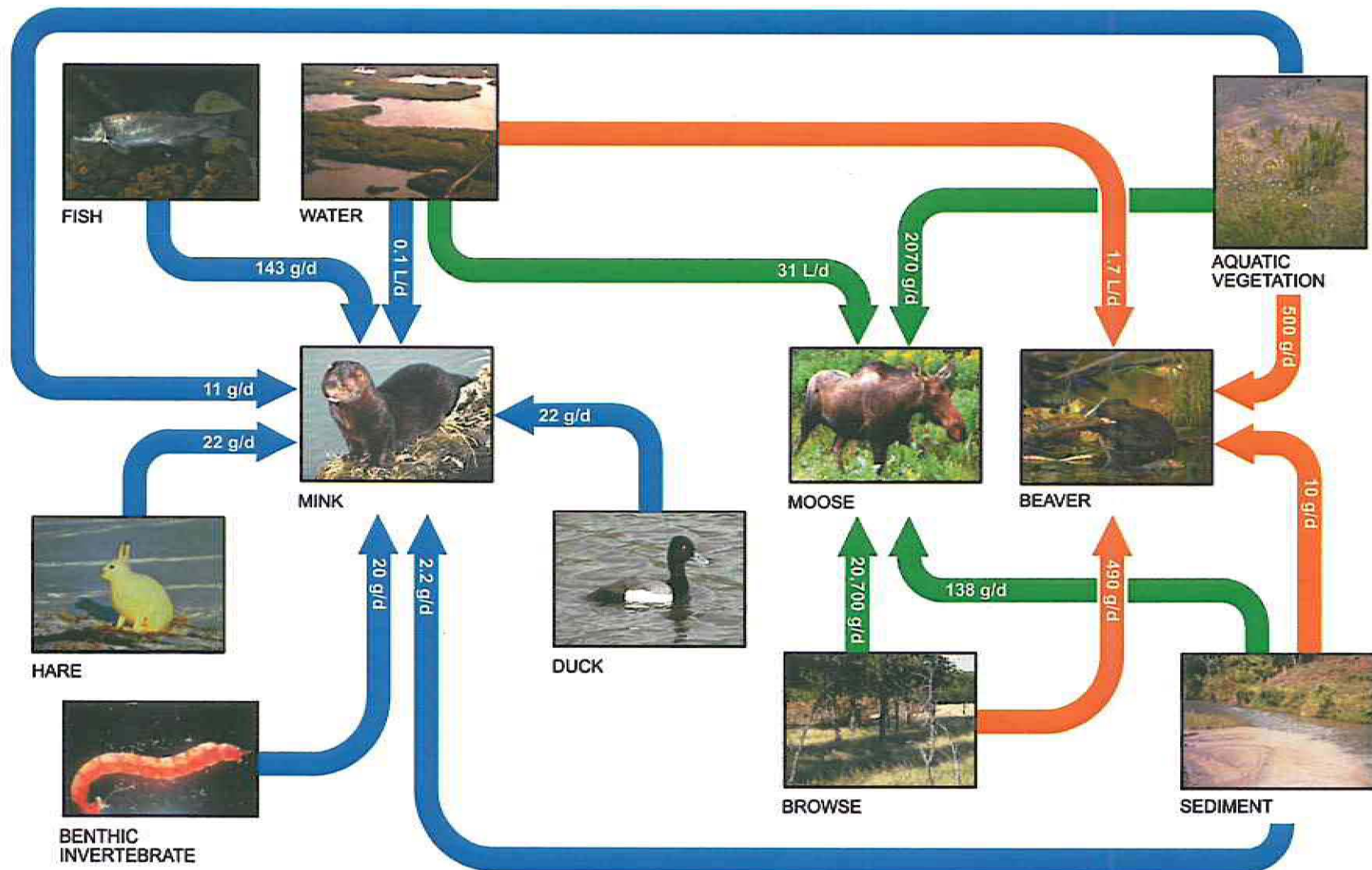
Note: All intakes are on a wet weight basis except for soil which is on a dry weight basis

FIGURE 2c
POTENTIAL WAYS OF EXPOSURE FOR MALLARD, MERGANSER AND SCAUP



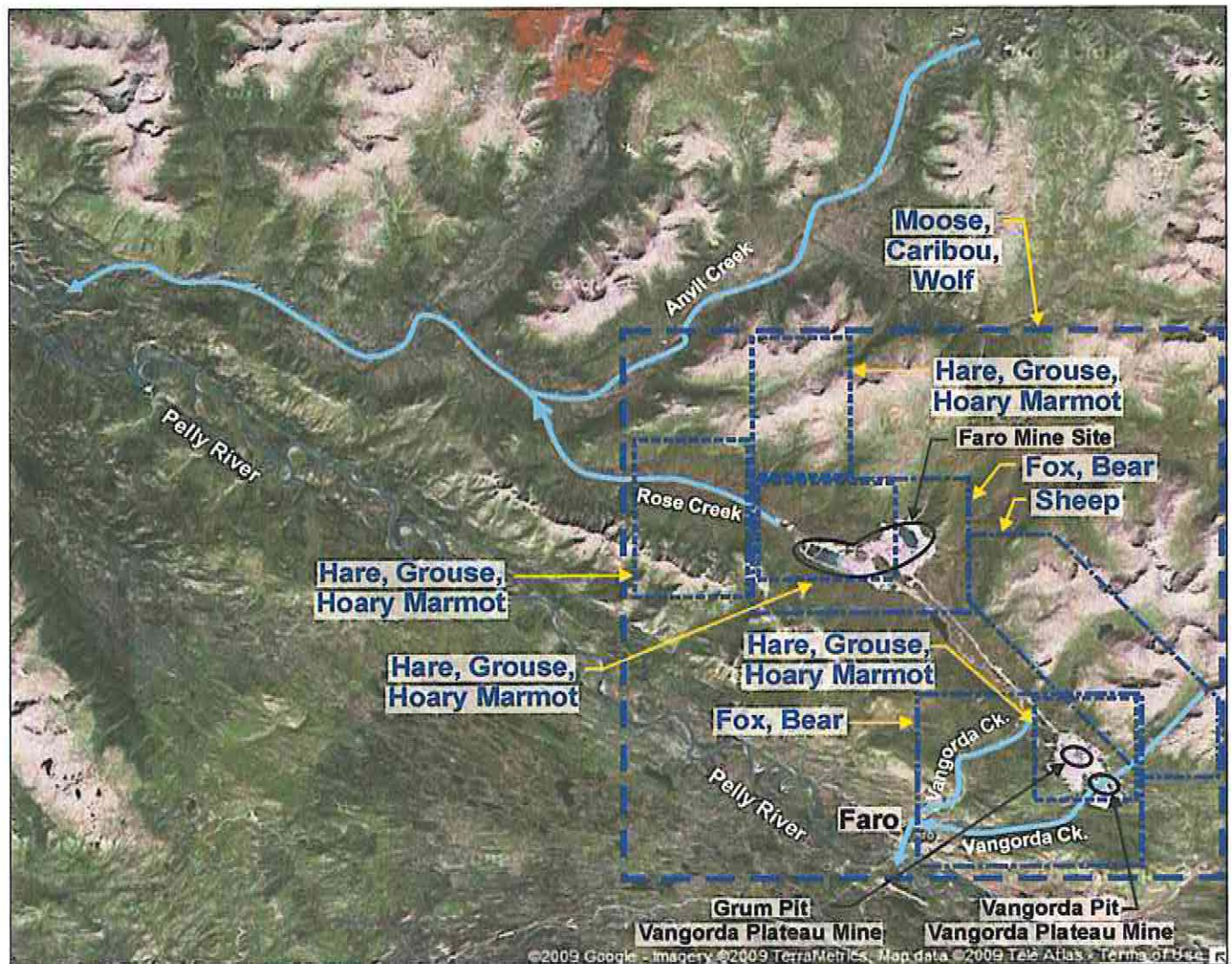
Note: All intakes are on a wet weight basis except for sediment which is on a dry weight basis

FIGURE 2d
POTENTIAL WAYS OF EXPOSURE FOR MINK, MOOSE AND BEAVER



Note: All intakes are on a wet weight basis except for sediment which is on a dry weight basis

FIGURE 3
LOCATIONS CONSIDERED IN TERRESTRIAL ASSESSMENT



Assessment of Human Effects

The assessment of potential health effects to people who will possibly use the Faro Mine Complex in the future for hunting, gathering and trapping considered that individuals (toddler, child, adult) may camp at the site for 1.5 months. Based on information from the study team and published studies, the Faro Mine Complex is currently only used for gathering of berries, hunting and trapping; therefore, it was considered that in the future, individuals would trap small mammals, hunt large animals and gather berries from around the Faro Mine Complex but would not camp on or near the Faro or Vangorda pits. Table 1 provides a summary of the assumptions that were used to assess the future use of the site by humans. As seen from the table, it was

assumed that individuals would hunt, fish and trap animals in the study area and that the gathering of berries and medicinal plants would occur at the Faro Mine Complex. All individuals who hunt or trap at the site were assumed to take game and fish back to their communities and eat them year-round.

The different ways (termed exposure pathways) in which individuals (who use the Faro Mine Complex in the future) would be exposed to metals is shown in Figure 4. These ways of exposure were based on traditional knowledge that was gathered by the Terrestrial Effects study team, dietary information from a survey of First Nations people in the Yukon as well as professional judgement. Other information required for the risk assessment such as the amount of water someone drinks, the amount of soil someone eats, the amount of skin available for contact with soil and the body weight of an individual was obtained from data on the general Canadian population for various age ranges (i.e. 5 to 11 yr olds, 19 years and older).

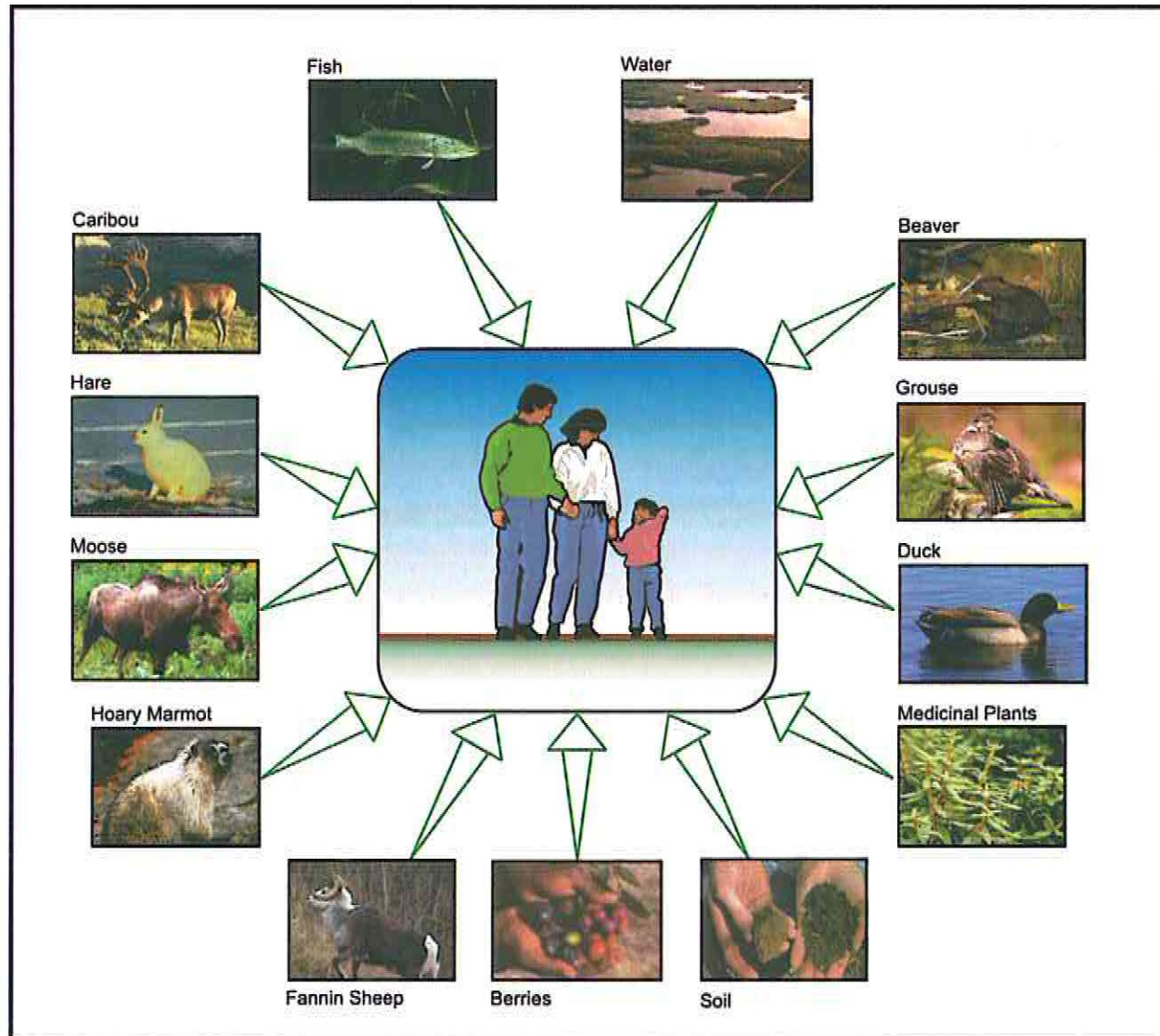
Measured concentrations of metals in caribou and moose captured at the site were used in the assessment for the final closure and remediation plan as it was assumed that since these animals roam over large distances that these concentrations would be similar in the future. Measured concentrations of metals in Labrador Tea were used in the assessment to represent all medicinal plants since the metal concentrations in the Labrador Tea were higher than concentrations measured in other medicinal plants or plant parts (i.e. sap).

The risk from exposure to metals that are known to not cause cancer was evaluated by a comparison of the calculated metal intakes by individuals to reference metal intakes that are considered to result in no health effects. Reference intakes for metals that do not result in health effects are provided by regulatory agencies such as Health Canada. For cancer causing metals such as arsenic, the calculated risks were compared to an “acceptable” risk level of one-in-one hundred thousand as provided by Health Canada.

TABLE 1
LOCATION OF THE VARIOUS DIETARY COMPONENTS FOR THE HUMAN RECEPTORS

Receptor	Drinking Water	Fish/Ducks	Large Mammals	Small Mammals	Sheep	Berries/Medicinal Plants	Soil	Time on Site (months)
Camper A	Mouth of Rose Creek	Fish: Mouth of Rose Creek Ducks: Rose Creek Downstream (X14)	Faro Mine Complex	Area close to the Faro pit (Faro S)	Mt Mye	Area surrounding Faro Mine Site (Faro S/M/N/W)	Area to west of Faro Mine site (Faro W)	1.5
Camper B	Vangorda Creek downstream (V8)	Vangorda Creek downstream (V8)	Faro Mine Complex	Area Close to Vangorda Pit (Van S)	Mt Mye	Area surrounding Vangorda Mine site (Van M)	Area surrounding Vangorda Mine site (Van M)	1.5

FIGURE 4
POTENTIAL WAYS IN WHICH INDIVIDUALS MAY BE EXPOSED TO METALS



Assessment Results for Humans

As discussed above, in the future it was assumed that individuals would use the site for the gathering of berries, trapping, hunting, and fishing for only 1.5 months per year during these activities and would take these food items back home and eat them over a 6 month period. The results showed that after the implementation of the final closure and remediation plan:

- Water in the Rose Creek, Vangorda Creek and the Pelly River will be safe to drink.
- Fish caught downstream in Rose Creek, Vangorda Creek and the Pelly River will be safe to eat.

- Animals hunted or trapped on the site will be safe to eat.
- Medicinal plants and berries collected from the site will be safe to eat.

The ingestion of moose and caribou at the site represent the largest contributor of metals for the human receptors considered in the assessment. The calculations presented in this assessment indicate that it is unlikely that there will be adverse effects to humans who use the site for gathering, hunting or trapping arising from the final closure and remediation plan. It is known that some metals such as cadmium accumulate in the liver and kidneys; therefore, consumption of moose and caribou organs should only occur on an occasional basis.

Table 2 provides a summary of the overall conclusions of the assessment.

**TABLE 2
SUMMARY OF RISK ASSESSMENT CONCLUSIONS**

Final Closure and Remediation Plan	Rose Creek Downstream- X14	Vangorda Creek Downstream – V8	Vangorda Creek Downstream – V27	Pelly River Downstream of Vangorda Creek	Pelly River Downstream of Anvil Creek
Fish	No harm to fish	No harm to fish	No fish present	No harm to fish	No harm to fish
Small plants and microscopic animals in water column	Predicted effects in sensitive plants and microscopic animals exposed to zinc and cadmium	Predicted effects in sensitive plants and microscopic animals exposed to zinc and cadmium	Predicted effects in sensitive plants and microscopic animals exposed to zinc and cadmium.	Predicted effects in sensitive plants (algae) exposed to zinc	Predicted effects in sensitive plants (algae) exposed to zinc
Worms found in the sediments	Elevated zinc concentrations but similar to historic concentrations in Rose Creek	Elevated zinc concentrations but similar to historic concentrations in Vangorda Creek	Elevated zinc concentrations may result in changes to number of different types of organisms or lower total numbers.	No harm to worms found in sediments	No harm to worms found in sediments
	Faro Site			Vangorda Site	
Animals and Birds	No harm to animals and birds that will use the site.			No harm to animals and birds that will use the site.	
Humans	No harm to people who would camp and use the site for gathering, hunting and trapping.			No harm to people who would camp and use the site for gathering, hunting and trapping.	

Note:



Significant adverse effect – based on risks to several species and exceedances >10 times benchmarks.
 No significant adverse effect – based on exceedances all <10 times benchmarks.
 Acceptable – based on no exceedances of benchmarks.