FINAL REPORT
ON

ECOLOGICAL RISK EVALUATION FOR CLINTON CREEK MINE SITE

LEVEL 1 CUSTODIAL INPUT SECTION

Prepared for:

Department of Indian Affairs and Northern Development

Prepared by:

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

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STEP 1 SUMMARY SITE DESCRIPTION: WORKSHEET

Section A) Contact Information

Contact Name:	
Signature:	
Date of Completion:	
Position:	
Address/Phone No.:	

Site Visited?	Yes / No

Section B) Site Information

Site No.:	
Site Name:	**Clinton Creek Asbestos Mine**
Province/Territory:	**Yukon Territory**
Custodial Department:	**Department of Indian and Northern Affairs**
Site Location (latitude and longitude):	**(64^{o} 22' 23" N, 140^{o} 42' 50" W) located about 100 km northwest of Dawson City, adjacent to Clinton Creek approximately 9 km upstream of its confluence with the Fortymile River**

Provide a brief description of the site:
An abandoned asbestos mine in a region of widespread discontinuous permafrost. The mine was operated from 1967 to 1978. There are three open pits and three waste rock dumps. There is no dam at the site, however, slumped tailings have blocked Wolverine Creek and the Clinton Creek waste rock pile has blocked Clinton Creek, forming Hudgeon Lake (~115 ha). The site was decommissioned from 1978 to 1987 with most of the mining equipment and facilities removed. Two conveyor shafts, two small structures, remnant aerial tram structures, crusher building, two flooded conveyor tunnels and some abandoned equipments remain around the site. The region is dominated by mature alpine spruce forests with a mix a willow, birch, berry plants and balsam poplar. Vegetative ground cover consists of moss, lichen species, woodland grasses and wildflower species. Vegetation at the waste rock dumps and tailings lobes are extremely scarce. Hawks, owls, waterfowl, snowshoe hare, crows and beaver colonies were observed at the site. Bear, moose and possibly other game animals also occur in the vicinity of the site.

Describe the current land use: (e.g. Ag/Res/Com/Ind)	**Abandoned Mine Site**
Describe the future or potential land use:	**Natural Habitat**

FCSSAP (Federal Contaminated Site Accelerated Action Plan) NCS Scoring:

Provide the Total FCSSAP National Classification System Score for the Site:	
Provide the Total Score for Category III Receptors: Section B Environment:	/16
Score for Category III B1: Known Adverse Impact:	/16
Score for Category III B2: Potential fore Impact:	/16
Score for Category III B3: Special Considerations:	/5

Section C) Studies completed and Outcomes

List the reports or resources pertaining to the property used in the Ecological Risk Assessment (ERA) evaluation:

Report Title	Date
Royal Roads University – Applied Research Division. ***An Environmental Review of the Clinton Creek Abandoned Asbestos Mine, Yukon, Canada.***	**MARCH 1999**
UMA Engineering Ltd. ***Clinton Creek Mine Site Investigation.***	**OCTOBER 2003**

Has a screening level ERA been completed at the site? If yes, complete: **NO**

Study Title	Study Outcomes

Has a Tier 2/3 ERA; Preliminary or Detailed Quantitative Risk Assessment been completed at the site? If yes, provide a list:

Study Title	Study Outcomes

Has the Study been peer-reviewed? Yes/No; Comments: _____

Is the site under specific regulatory obligations? If yes provide a list:

Section D) High Risk Sites Statement

D1) Adverse Impact

If the response to question 1 or 2 or 3 is yes, automatically rate the site as high risk:

1) Is the site contamination known to have caused significant adverse impact or physical stress on the environment or highly valued species? **YES**
2) Could the imminent failure of a physical structure at this site have the potential to result in significant adverse effects? **YES**
3) Has an ecological risk assessment reported a risk or potential adverse impact to ecological receptors? **NO**

Significant adverse impacts would be defined as those which affect the population of a species or portion thereof in such a way as to cause a decline or change in abundance or distribution of the population over one or more generations; the impact may be localized; natural recruitment may not re-establish the population to its original level.

An insignificant impact is one that affects the population of a species in a localized area for a short period of time in a manner similar to natural variation, and would have no measureable effect on the integrity of the population as a whole.

Rating a site as high risk provides an additional qualitative indicator for Departments reviewing the site to consider when providing a final score for the site.

D2) Impact Summary

List impacted habitats/receptors:
Potential impacts on terrestrial vegetation, terrestrial mammals and fisheries
Habitat.
List chemicals of concern:
Metals, PCBs, Asbestos.
List exposure pathways:
drinking water, soil/sediment intake, food intake.

Section E) Data Requirements Checklist

1. Are data requirements provided as per Step 2, the "**Data Requirements Checklist Form"**? **Yes**

Section F) Level 1 Risk Evaluation

1. Complete the Level 1 Worksheets (Step 3) and indicate final Custodial Department input worksheets score: **95.5**

Comments

Step 2 Data Requirements Checklist

Information Review	Yes/No	Comments
Has a description of the site historical activities been completed?	**Yes**	
Have chemicals of concern at the site been identified?	**Yes**	
Were the approximate size of site and quantity of contaminants provided?	**Size of Site: Yes** **Quantity of Contaminants: Yes**	**Size and volume of waste rock dumps and tailings piles were estimated**
Are the site assessment data collected representative of the site contamination?	**Yes**	**Only surface tailings samples and waste rock samples were collected to assess soil quality. For sediment samples, only those collected from Wolverine Creek were analyzed for metals. Other sediment samples were only analyzed for asbestos.**
Are the QA/QC (quality assurance / quality control) data acceptable?	**Yes**	**QA/QC assessment was documented in the reference**
Have the chemicals of concern been analyzed for in all potentially impacted media (*i.e.,* groundwater, surface soil, surface sediments, surface water, liquid phase product) or exposure pathways?	**Groundwater: No** **Surface soil: Yes** **Sediment : Yes** **Surface Water : Yes**	**No groundwater sample collected.** **Analyzed for metals and asbestos. Only 1 sample was analyzed for PCBs.** **Analyzed for metals and asbestos** **Analyzed for metals and asbestos**
Has the extent of contamination been delineated (*i.e.,* horizontal and vertical contamination) in all significantly impacted media?	**Yes**	
Have background concentrations been evaluated and identified for chemicals of concern?	**Yes**	**Background concentrations were only evaluated for metals and asbestos in soil and surface water.**

Information Review	Yes/No	Comments
Were the following items defined on a regional and local basis: a) Surface drainage pattern? b) Surficial and bedrock geology? c) Groundwater flow regimes, gradients, and velocities? d) Aquifer types? e) Groundwater and surface water use in the local area? f) Grain size analyses (if proposing fine-grained soil criteria)?	**a) Yes** **b) Yes** **c) No** **d) No** **e) No** **f) No**	
Were the ecological uses of adjacent water resources evaluated and identified?	**No**	
Were potential habitats identified, evaluated and defined: a) On-site? b) Off-site?	**On-Site: Yes** **Off-Site: Yes**	**A brief description of the flora and fauna on- and off-site was provided.**
Is the data set for chemicals of concern appropriate and well founded, considering the attributes of the habitats?	**Yes**	**Well founded based on past use of site, not the attributes of the habitats.**

Notes: Appendix A provides more details on the site.

- **Reference document -**

1. Royal Roads University – Applied Research Division 1999. *An Environmental Review of the Clinton Creek Abandoned Asbestos Mine, Yukon, Canada*. March. Prepared for DIAND.

- **Reference document not attached to submission.**

Worksheet 1 Ecological Habitat Screen

Ecological Habitat Screen **Determine the absence or presence of the following habitat within 1 km of the contaminated site:**			
	YES (Score 5)	**POSSIBLE (Score 2)**	**NO (Score 0)**
Category 1: Freshwater or Marine habitats such as wetlands, marshes, swamps, tidal flats, beaches, rivers, oceans, lakes or streams. **(Habitats identified are underlined)**	✔		
Category 2: Forested habitats and/or Grass land habitats (Region has mature alpine spruce forests)	✔		
Category 3: Provincial/National Parks, ecological reserve; area of high biodiversity; sensitive arctic environments (many different species found in area)		✔	
Category 4: Habitat supporting rare, threatened, endangered or significant (local / regional) species		✔	
Category 5: Sensitive habitat for wildlife or migratory species (including breeding or spawning areas)		✔	
Score: Please total score. A score of 20 points is the maximum total for this worksheet. If the total is greater than 20, please score 20 for this worksheet.	**SUM = 16** **SCORE = 16**		
If the answer is No (Score 0) for all the above habitats, then no potential habitat at risk is identified and no further evaluation is required.			

Worksheet 2 Chemical Identification

Worksheet 2A Chemical Identification – Data Only: No Scoring

Source Matrix	Chemical Testing Performed (Yes or No)	Chemical Category	Circle Yes or No		Comments
Surface Water	**Yes**	Metals	(Y)	N	
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	
	No	Pesticides	Y	N	
	No	PCBs	Y	N	
	Yes	Soluble inorganics	(Y)	N	
	Yes	Others - **Asbestos**	(Y)	N	
Surface Sediment	**Yes**	Metals	(Y)	N	
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	**Sediment samples in Wolverine Creek analyzed for metals. All other sediment samples only analyzed for asbestos.**
	No	Pesticides	Y	N	
	No	PCBs	Y	N	
	No	Soluble inorganics	Y	N	
	Yes	Others - **Asbestos**	(Y)	N	
Surface Soil	**Yes**	Metals	(Y)	N	
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	
	No	Pesticides	Y	N	
	Yes	PCBs	Y	(N)	
	No	Soluble inorganics	Y	N	
	Yes	Others - **Asbestos**	(Y)	N	
Groundwater	**No**	Metals	Y	N	
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	**No groundwater data are available.**
	No	Pesticides	Y	N	
	No	PCBs	Y	N	
	No	Soluble inorganics	Y	N	
	No	Others	Y	N	

Worksheet 2B – Chemical Screen – for Chemicals without Environmental Quality Criteria

Source Matrix	Chemical Category (list) and Chemical Parameters (list)	Is concentration >2 x mean background/reference location Yes/No	Score (Please score 0.5 for each Yes - Score each parameter in each category listed)
Surface Water	**Metals – Antimony** **– Barium** **– Boron** **– Chromium** **– Cobalt** **– Manganese** **– Uranium** **Others – Asbestos**	**Yes** **No** **Yes** **Yes** **Yes** **Yes** **Yes** **Yes**	**0.5** **0** **0.5** **0.5** **0.5** **0.5** **0.5** **0.5**
Sediment	**Metals – Barium** **– Cobalt** **– Molybdenum** **– Nickel** **– Selenium** **– Vanadium** **Others – Asbestos**	**No Background Available for metals** **Yes**	**0.5**
Surface Soil	**Others – Asbestos**	**Yes**	**0.5**
Groundwater	**None**		
Score: Please total score. A score of 5 points is the maximum total for this worksheet. If the total is greater than 5, please score 5 for this worksheet.	**SUM = 4.5** **SCORE = 4.5**		

Note: Environmental Data Summaries provided in Appendix B.

Worksheet 2C Chemical Hazard Screen – Exceeding Environmental Quality Criteria and Degree of Exceedance

Source Matrix	Chemical Category and Parameter (please list)	Evaluation Criteria	Score (Please score each parameter in each category listed – See scoring guide below)
Surface Water	**Metals – Aluminum** **– Arsenic** **– Cadmium** **– Copper** **– Iron** **– Lead** **– Molybdenum** **– Nickel** **– Selenium** **Soluble Inorganics – Ammonia** **- Nitrate** **- Nitrite**	CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life	**5** **1** **5** **1** **1** **1** **0** **1** **5** **0** **0** **0**
Sediment	**Metals- Arsenic** **- Cadmium** **- Chromium** **- Copper** **- Mercury** **- Zinc**	CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life	**1** **0** **5** **0** **0** **0**
Surface Soil	**Metals- Arsenic** **- Barium** **- Cadmium** **- Chromium** **- Cobalt** **- Copper** **- Mercury** **- Nickel** **- Selenium** **- Vanadium** **- Zinc**	CCME Canadian Soil Quality Guidelines for the Protection of Environmental Health - SQGe **(Ecological component was used if available, otherwise, the generic CCME soil quality guidelines for residential/parkland were used)**	**5** **1** **0** **5** **1** **0** **0** **5** **1** **0** **0**
Groundwater	**Not Measured**	CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life X 10 (account for dilution of groundwater discharging to surface water)	

Score: Please total score. A score of 20 points is the maximum total for this worksheet. If total is greater than 20, please score 20 for this worksheet. Scoring Guide: Score 1 if exceedance is > 1 to 5 fold over guideline. Score 2 if exceedance is > 5 to 10 fold over guideline. Score 5 if exceedance is > 10 fold over guideline.	**SUM = 44** **SCORE = 20**

Worksheet 2D Non-Chemical - Physical Impact Screen

Site Conditions	Non –Chemical Stressor (please list)	Physical Impact to Environment (please specify)	Degree of Hazard / Impact (low[1] or high[2])	Score: low = 1 high = 5
The tailings failure in the past blocked Wolverine Creek and the tailings continued to be unstable. The high pit wall in Porcupine Pit is unstable. The Clinton Creek Waste Rock Dump is unstable. Active movement of the dump has continued since mine closure. The pile has slumped in 1974 and blocked Clinton Creek, forming Hudgeon Lake. There is danger of lake breaching the waste rock dam, causing a flood.	**1. Slumping of tailings piles and waste rocks dumps** **2. Breaching of waste rock dam**	**1. Possible hazard to wildlife** **2. Flooding, posing hazard to wildlife, vegetation and aquatic receptors**	**1. Low** **2. High**	**1** **5**
Score: Please total score. A score of 5 points is the maximum for this worksheet. If total is greater than 5, please score 5 for this worksheet.	**SUM = 6** **SCORE = 5**			

Worksheet 2E Scale of Impact

Habitat	Score (Range 25)
Terrestrial Contaminated Area Score 0 if no chemical impact Score 2 if <10 hectares Score 5 if >10 to 25 hectares Score 10 is >25 hectares	**10**
Aquatic Contaminated Area Score 0 if no chemical impact Score 2 if <1 hectare **OR** <50 metres downstream in a flowing watercourse Score 5 if >1 to 5 hectares **OR** >50 - <100 metres downstream Score 10 if >5 hectares **OR** > 100 metres downstream	**10**
Physical Impact on Terrestrial Area Score 0 if no physical impact Score 1 if <10 hectares Score 2 if >10 to 25 hectares Score 5 is >25 hectares	**5**
Physical Impact to Aquatic Area Score 0 if no physical impact Score 1 if <1 hectare **OR** <50 metres downstream in a flowing watercourse Score 2 if >1 to 5 hectares **OR** >50 - <100 metres downstream Score 5 if >5 hectares **OR** > 100 metres downstream	**5**
Score: Please total score. A score of 25 points is the maximum for this worksheet. If total is greater than 25, please score 25 for this worksheet.	**SUM = 30** **SCORE = 25**

Area of Contamination definition:

- the area or volume of contaminated media (soil, sediment, groundwater and surface water) that exceeds appropriate environmental quality criteria (including modified generic; risk-based site specific criteria and site specific toxicity testing).

Physical Impact definition:

- A non-chemical impact originating from a site that affects the quality of the environment or poses a potential or existing ecological risk (*e.g.*, a slope that is failing; a structure that could fail).

Worksheet 3 Operable Pathway and Exposure Assessment – for Chemicals Scoring in Worksheets 2B and 2C

Chemical Category and Parameter (Please list – Examples Provided Below)	Surface Water Exposure Pathway		Sediment Exposure Pathway		Soil & Direct Surface Contact Exposure Pathway		Groundwater Exposure Pathway		Other Exposure Pathway[1] - provide specifics		Additive Score
	Pathway	Exposure	Pathway	Exposure	Pathway	Exposure	Pathway	Exposure	Pathway	Exposure	Totals
Metals – Arsenic – Chromium Others – Asbestos	**1**	High Low	**1**	High Low	**1**	High Low	1	High Low	1	High Low	**(3.5 × 3) 10.5**
	0.5		0.5		0.5		0.5		**0.5**		
	0		0		0		0		0		
Metals – Cobalt – Nickel – Selenium	**1**	High Low	**1**	High Low	**1**	High Low	1	High Low	1	High Low	**(3.5 × 3) 10.5**
	0.5		0.5		0.5		0.5		**0.5**		
	0		0		0		0		0		
Metals – Barium	1	High Low	1	High Low	**1**	High Low	1	High Low	1	High Low	**1.5**
	0.5		0.5		0.5		0.5		**0.5**		
	0		0		0		0		0		
Metals – Aluminum – Antimony – Boron – Cadmium – Copper – Iron – Lead – Manganese – Uranium	**1**	High Low	1	High Low	1	High Low	1	High Low	1	High Low	**(1.5 × 9) 13.5**
	0.5		0.5		0.5		0.5		**0.5**		
	0		**0**		**0**		0		0		

Score: Please total score. A score of 25 points is the maximum for this worksheet. If total is greater than 25, please score 25. Scoring Guide: Score 1: Confirmed or measured open or operable pathway to receptor that results in an exposure Score 0.5: Possible or Potential pathway to receptor Score 0: No open or operable pathway If the exposure pathway is open for any number of chemicals within a given chemical category (Scores 1), please indicate whether the potential for exposure from this pathway is high or low, for an ecological receptor group (e.g. aquatic life; soil invertebrates, etc).	**SUM = 36** **SCORE = 25**

[1] Other exposure pathway: this may include upper trophic level consumption pathways (i.e., mink eating contaminated fish from a lake or stream, or eagles eating contaminated small mammals of fish from a site, etc.), or other small exposure pathways, such as inhalation of air/dust from a contaminated site.

Note: The sediment scorings for some of the contaminants are 0.5 because they were measured but no guideline or baseline values available.

Worksheet 4 – Risk Summary Score

Category	Score
Ecological Habitats – Apply Score from Worksheet 1	**16**
Chemical/Physical Hazards - Apply total of scores from Worksheet 2B 4.5/5 2C 20/20 2D 5/5	**29.5**
Scale of Impact – Apply score from Worksheet 2E	**25**
Operable Pathways and Exposure Assessment - Apply score from Worksheet 3	**25**
Total Score	**95.5**

APPENDIX A

SITE CHARACTERIZATION AND PHYSICAL HAZARDS

SITE CHARACTERIZATION AND PHYSICAL HAZARDS

This section provides a brief description of the Clinton Creek Asbestos Mine site and its physical characteristics.

CLINTON CREEK ASBESTOS MINE SITE DESCRIPTION

The Clinton Creek Asbestos Mine is located in the Yukon Territory, approximately 100 km northwest of Dawson City (see Figure A.1). It is adjacent to Clinton Creek, approximately 9 km upstream of its confluence with the Fortymile River. Porcupine and Wolverine creeks are local tributaries of Clinton Creek. The mine site is accessible via a gravel road along the north side of Clinton Creek near the base of the valley. A gravel airstrip is located to the north of the mill site. Figure A.2 is a general site map of the Clinton Creek Mine site.

The mine site is situated within the unglaciated Yukon – Tanana Upland with terrain consisting of a series of ridges. The valley bottoms of the ridges are at an elevation of 400 m with the highest level reaching 610 m above sea level. The site has been described to be in a region of widespread discontinuous permafrost (Stepanek and McAlpine 1992).

The mine was operated from October 1967 to August 1978 by Cassiar Asbestos Corporation Ltd. The mill buildings and associated town site, located 10 km southeast of the mine were auctioned off in 1978. Cassiar Asbestos Corporation Ltd., later Princeton Mining Corporation still owns the mine site (Royal Roads University 1999). The mine site is accessible via a gravel road from the former town site along the north side of Clinton Creek near the base of the valley (UMA 2000).

During operation, ore was extracted from three open pits (Porcupine, Snowshoe and Creek pits) along the south side of Clinton Creek. The Porcupine and Snowshoe pits are located on a hilltop. The Creek pit is located on the original alignment of Porcupine Creek. The ore body comprised chrysotile asbestos veinlets embedded in jade green serpentine (Royal Roads University 1999).

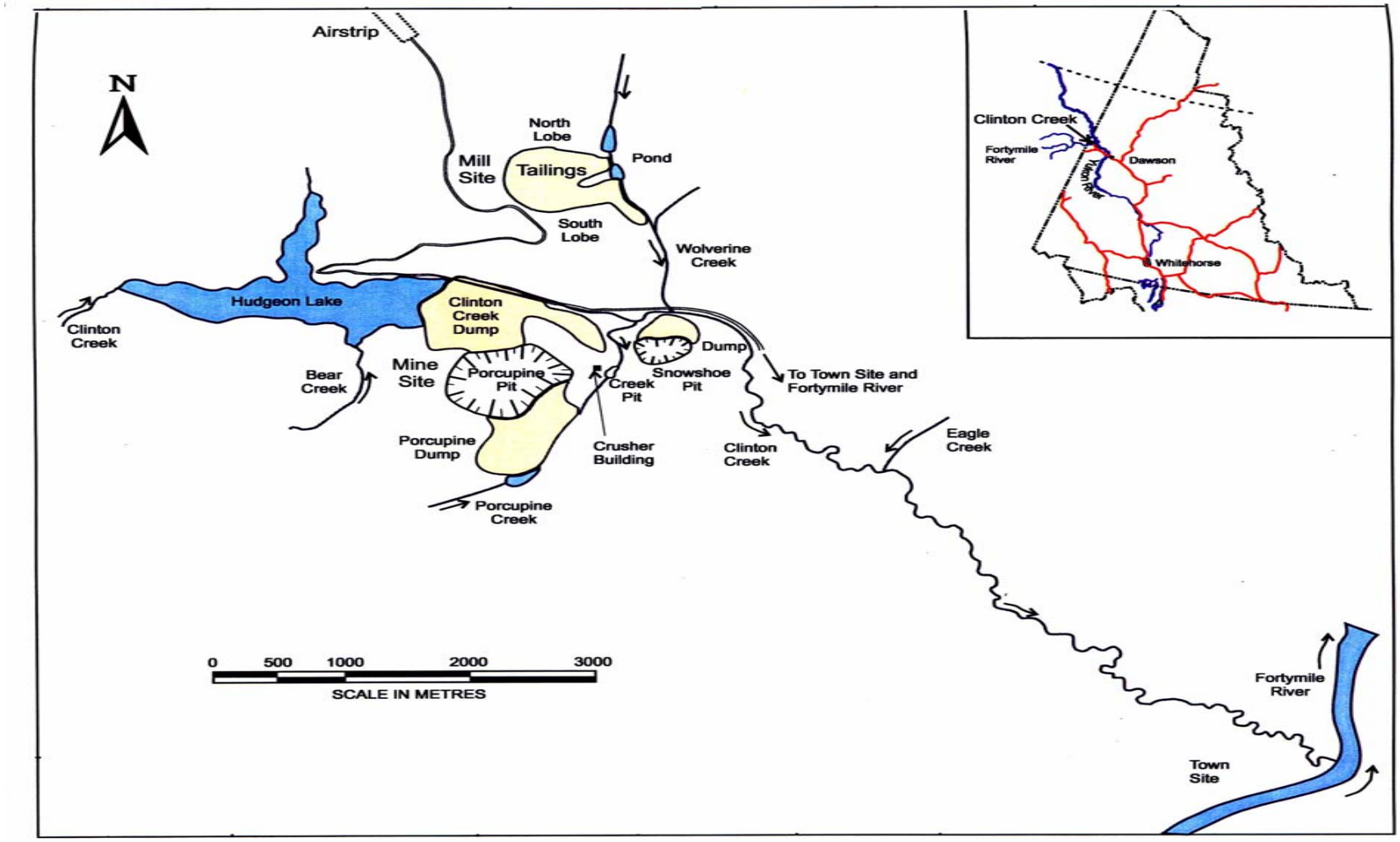
From 1978 to 1987, the Cassiar Asbestos Corporation undertook a series of decommissioning activities which included the removal of structures from the town site, removal of the main segments of the concentrator, removal of most mining equipment and facilities (except the primary crusher), re-vegetation through hydro-seeding of the town site, waste dumps and tailings piles, and the installation of erosion control measures (Royal Roads University 1999).

Waste rock from the three open pits was deposited on the valley slopes adjacent to the pits and hence, created three waste rock dumps (Clinton, Porcupine and Snowshoe). The waste rock consists mainly of argillite, phyllite, platy limestone and micaceous quartzite (Stepanek and McAlpine 1992) and the volume has been estimated at 60 million tonnes (Roach 1998). The ore was transported by an aerial cable tramway to the mill site. A dry hammer mill process was used

FIGURE A.1
LOCATION OF CLINTON CREEK MINE SITE

Source: National Geographic (1999).

FIGURE A.2
CLINTON CREEK ASBESTOS MINE SITE MAP



Source: Royal Roads University (1999).

to extract asbestos fibre from the ore. The tailings were then deposited in two lobes over the slopes of the mill site.

Waste rock deposited on the north-facing slope of the Clinton Creek valley failed and subsequent downslope movement of waste rock resulted in the blockage of Clinton Creek and the creation of Hudgeon Lake in 1974. In 1999, the surface area of Hudgeon Lake was approximately 115 ha with a maximum depth of 27 m (Royal Roads University 1999). A discharge channel from Hudgeon Lake developed at the northern perimeter of the dump and discharge from the outflow flows across the north side of the waste dump. A channel was also excavated along the eastern extremity of the toe of the waste rock mass to maintain drainage from the lake.

Waste rock placed along the Porcupine Creek valley also formed an impoundment across the creek. The downslope movement of the tailings deposits along the two lobes resulted in the partial blockage of Wolverine Creek, a tributary to Clinton Creek.

The waste rock and tailings continue to move and the long-term stability of the three blockages is not known. The probability of a breach failure in any of the blockages is considered high (Stepanek and McAlpine 1992). A breach of an existing blockage may increase the potential for the chronic or massive downstream movement of asbestos-containing sediments into the creek (Royal Roads University 1999).

The drainage area of Wolverine and Porcupine Creeks, the two main tributaries of Clinton Creek, are approximately 28.6 and 4.7 km^2 respectively. Clinton Creek drains approximately 116.6 km^2 upstream of the confluence with Wolverine Creek, increasing to 203.8 km^2 at the junction with Fortymile River. Fortymile River flows into the Yukon River 2 km downstream of the Clinton Creek confluence; which enters Alaska approximately 70 km downstream from the abandoned mine site (UMA 2000).

PHYSICAL FEATURES

Physical Hazards at Mine Sites

Typically, there are numerous physical hazards associated with abandoned mine site. The nature of these physical hazards depends on whether the mine was an open pit or underground mining operation. The following paragraphs describe the most important hazardous features of the abandoned mine sites.

Shaft Openings

An open shaft is a vertical opening that may be hundreds of feet deep. A shaft may be visible or it may be hidden by debris or vegetation. Internal seepage and periodic storms or flashfloods may create deep water at the base of such shafts. In addition to the direct risk from drowning,

the presence of water can accelerate the decay of support structures, leading to cave-ins and collapses.

Adits

Adits are horizontal openings that lead to underground mine workings. Adits provide a variety of dangers, including unstable rock ceilings and walls and decayed structures that may collapse, causing a rock fall.

Open Pits

Not all mines are underground. Often large areas of the surface have been disturbed to access the minerals near the surface, altering the original contours and creating dangerous surface features. These features include open pits and/or vertical cliffs (highwalls) that are prone to collapse and unstable ground. When approached from the top, the vertical edge of a highwall may not be seen in time or may crumble, leading to a fatal fall.

Open pits can be partially filled with water, which in turn, can be highly acidic or laden with harmful chemicals. Drowning in open pits has been found to claim more lives than any of the other hazardous features of abandoned mine sites.

Waste Rock Piles

Waste rock piles are typically created at mine sites by dumping from haulage trucks or conveyor systems. These side slopes, which form at the natural angle of repose of the material, are generally unstable and thus, are subject to failure when disturbed. Hence, mine site visitors who may choose to climb these piles are at risk of serious injury.

Tailings Basins

Mining operations that featured ore processing on site usually have surface tailings impoundments. The impoundments generally are created by constructing one or more dams at low points and placement of the tailings behind the dams as a slurry. Hence, tailings impoundments characteristically contain a pond of water. Without ongoing care and maintenance, tailings dams deteriorate and are subject to failure and the subsequent release of tailings pond water and tailings solids. Because site visitors are naturally attracted to these impoundments, as they are usually easily accessible on foot or motorized vehicle, they are at risk of injury when crossing the dams or tailings surfaces.

Decayed Support Structures

Unstable equipment, scrap metal and lumber, and deteriorated buildings pose great danger to visitors of abandoned mine sites.

Underground Mines

Within a mine, the condition of structures and supports is harder to see. In many cases, shifting rock, caving walls, water and humidity cause wood to deteriorate much faster than wooden structures on the surface. With deterioration of support structures, the fractured roof or walls of a mine tunnel eventually collapse in response to vibrations and the force of gravity.

A few metres from the entrance, the mine becomes very dark. A person can easily become disoriented and lost. With a failed light source, the chances of getting out of an extensive mine, honeycombed with miles of workings, in absolute darkness, are remote.

Abandoned mines are also not ventilated. Gases such as methane, hydrogen sulfide and carbon dioxide (CO_2) occur naturally in some mines, particularly in coal mines. Pockets of carbon dioxide or other deadly gases displace oxygen with no visible sign. This is a deadly trap for the visitors of abandoned mine sites.

Explosives and Toxic Chemicals

Explosives and chemicals used in mining are often left behind when an operation is abandoned. Explosives such as dynamite and blasting caps become very unstable over time and can explode if disturbed. Storage containers, boxes, barrels and drums deteriorate, allowing toxic chemicals to leak or to combine into highly dangerous mixtures.

Physical Hazards at Clinton Creek Site

Table A.1 summarizes some of the main physical features of the site.

TABLE A.1
PHYSICAL FEATURES OF CLINTON CREEK MINE SITE

Physical Parameter	Key Features	Characteristics	Description
Tailings		General Information	Approx. 10 million tonnes of tailings deposited along dipslope below the mill, above Wolverine Creek.
		Dates of Tailings Deposition	1968 to 1978: deposited by stacker conveyor over the valley crest.
		Total Tailings Volume	Approx. 10 million tonnes (est. 26.5 million m^3).
		Tailings Surface Area	Not determined.
		Tailings Average Depth	Unknown, varies.
		Avg Depth to Water Table	Unknown, varies with location.
		Physical Stability	The South Lobe failure blocked Wolverine Creek in 1974. The North Lobe failure followed; the tailings continue to be unstable.
		Geochemical Characteristics, Acid Base Accounting (ABA)	No ABA data are available; however soil and water samples are consistently alkaline. Sulphides are not associated with the asbestos (serpentine) mine; ARD is not a concern. Although tailings are elevated in arsenic, chromium, mercury, nickel, and uranium, these contaminants were not detected in water samples.
		Groundwater Seepage Rate	Unknown.
		Surface Discharge Rate	Unknown.
		Cover Type	No cover.
		Vegetation	None.
		Erosion	Massive creep erosion, massive failures, tension cracks, etc.
		Accessibility	Accessible by foot (road washed out).
		Additional Information	Localized hot spots with elevated radiation levels in tailings (ambient air levels measured at site appear insignificant).
	Dams	General Information	None - although the slumped tailings have blocked Wolverine Creek.
		Dimensions	Not determined.
		Type of Construction	Slumped tailings.
		Discharge Structure	None, although surface water is flowing through and across the slumped tailings.
		Seepage	Not determined, although piping has been observed.
		Erosion	The North Lobe blockage is continually being eroded by Wolverine Creek.
		Stability	Tailings are continually eroding to Wolverine Creek. A reservoir has developed upstream of the tailings slump. The volume and stability of this reservoir is unknown.
		Additional Information	None at this time.

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF CLINTON CREEK MINE SITE

Physical Parameter	Key Features	Characteristics	Description
Tailings	**Dykes**	General Information	None.
Pits		General Information	Three pits on site (Porcupine, Snowshoe, and Creek). Size of pits: Porcupine Pit >> Snowshoe >> Creek.
		Volume	Not determined.
		Depth	Porcupine Pit up to 200 m deep.
		Surface Area at grade level	Not determined.
		Contents of Pit	Porcupine Pit is flooded.
		Depth to Watertable	Water at elevation 385 m asl.
		Groundwater Seepage Rate	Not determined.
		Surface Discharge Rate	Not determined.
		Slopes	Porcupine Pit: 45 to 50 degree slopes.
		Stability	North and west sides unstable: ravelling, small wedge failures, scarp movements, tension cracks, and sloughing.
		Accessibility	Unknown.
		Underground Workings In Pit	None.
		Additional Information	None at this time.
Underground Workings		General Information	No underground mining was conducted at this site.
Waste Rock		General Information	Three waste rock dumps are on-site, Clinton Creek, Porcupine, and Snowshoe Waste Rock Dumps. Only the Clinton Creek Dump is described below. The Porcupine Dump is small (approx. 3 million tonnes), and geochemically stable. The Porcupine Dump is eroding into Porcupine Creek and has created a small blockage. No information is available on the Snowshoe Dump.
		Total Waste Rock Volume/Mass	Approximately 60 million tonnes.
	Clinton Creek Waste Rock Dump	General Information	The Clinton Creek Pile has blocked Clinton Creek, forming Hudgeon Lake (up to 27 m deep; 12 million m3). The pile is composed of argillite waste rock and overburden sand, gravel, and cobbles.
		Location	N of Porcupine Pit, waste rock deposited on the south slope of Clinton Creek.
		Volume	Not determined.
		Surface Area	Not determined.
		Height/Depth	Not determined.
		Depth to Water Table	Not determined.

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF CLINTON CREEK MINE SITE

Physical Parameter	Key Features	Characteristics	Description
Waste Rock	**Clinton Creek Waste Rock Dump**	Geochemical Characteristics, Acid Base Accounting (ABA)	No ABA data are available; however soil and water samples are consistently alkaline. Sulphides are not associated with the asbestos (serpentine) mine; ARD is not a concern. Although waste rock is elevated in arsenic, chromium, mercury, and nickel, these contaminants were not detected in water samples. Localized hot spots with elevated radiation levels in waste rock (ambient air levels measured at site appear insignificant).
		Groundwater Seepage Rate	Not determined.
		Surface Discharge Rate	Not determined.
		Cover (water, soil, sand, none, etc.)	None.
		Vegetation	None.
		Sloped/Graded Surfaces	No.
		Erosion	Massive slump erosion at a rate of approx. 30-50 cm/yr as well as massive failures, tension cracks, etc. toward Clinton Creek. Clinton Creek flooding wiped out erosion control works in 1997. Downcutting and incising of the waste rock by Clinton Creek continues.
		Physical Stability	Unstable. Active movement of the dump has continued since mine closure.
		Additional Information	Waste rock has slumped and blocked Clinton Creek, forming 27 m deep Hudgeon Lake. Danger of lake breaching waste rock dam, causing outburst flood. Currently a Gabion/rip-rap drop structure / spillway is being built to prevent waste rock dam from being breached (UMA 2003).
Infrastructure (Various)		General Information	Numerous buildings remain around the site, including: two conveyor shafts, two small structures, remnant aerial tram structures (towers and terminus), crusher building, 2 flooded conveyor tunnels, and abandoned equipment (excavator, drill rig, etc.)
		Date of Construction	Varies, presumably 1968 to 1978.
		Number of Buildings	3 or more.
		Type of Construction	Steel, wood, and concrete.
		Condition/Stability	Poor/Unstable/Flooded
		Accessibility	Accessible by foot as the road is washed out.
		Additional Information	Tramway and tanks are unstable and have insecure ladders and platforms

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF CLINTON CREEK MINE SITE

Physical Parameter	Key Features	Characteristics	Description
Utilidor		General Information	A utilidor housing water and steam piping runs across the mill site (UMA 2003): Approx. 3 m below surface. Concrete, lined with boiler plate material. 6 openings to utilidor; 1.2 m to 2 m x up to 3 m deep. 5 openings within buildings or concrete foundations. 1 metal shaft, covered with insecure plywood.
		Date of Construction	Uncertain, presumably 1968 to 1978.
		Number of Buildings	1 Subsurface concrete structure.
		Type of Construction	Concrete, lined with boiler plate material.
		Condition/Stability	Stable.
		Accessibility	6 insecure openings.
		Additional Information	Shaft poses greatest physical hazard of openings.
Tank Farms		General Information	Two large above ground diesel storage tanks (ASTs) exist on site (approx. 4 m tall, 10 m wide).
		Type of Tanks and Number	2
		Contents and Volume	Unknown.
		Condition of Tanks	Rusting.
		Containment	No.
		Documented Spillage	No, however hydrocardon staining and odours were documented on site.
		Additional Information	Insecure ladders, insecure roof surfaces (popular with game hunters), and insecure hatch openings.
Fuels, Chemicals, PCBs		General Information	A detailed site inventory of chemicals and reagents has not been conducted or provided at this time as most studies have focused on the eminent hazards associated with mine waste instability.
Additional Physical Hazards		General Information	Slopes into flooded conveyor ramps may pose a hazard, especially in winter (UMA, 2003).

As seen in Table 2.1, the main areas of concern for the Clinton Creek Asbestos mine site are:

- unstable waste rock dumps and tailings piles that may lead to massive flooding;
- presence of asbestos on site; and
- failures and erosion of the tailings may transport eroded tailings downstream to the receiving creeks.

APPENDIX B

SUMMARY OF MAXIMUM MEASURED ENVIRONMENTAL DATA

CLINTON CREEK MEASURED DATA

Prepared by: Mo-Ki Tai
Checked by: Mo-Ki Tai

Clinton Creek - Soil Concentrations (ppm)

	Background		CCME	Measured	Score	
Contaminant	**Mean**	**2xMean**	**Guideline**	**Maximum**	**Background**	**CCME**
Sb	85	170	20	100	-	-
As	52.25	104.5	17	321	-	5
Ba	1099.75	2199.5	500	981	-	1
Be	2.15	4.3	4	3	-	-
Cd	0.75	1.5	10	2	-	0
Cr	1149.5	2299	64	1650	-	5
Co	58.75	117.5	50	111	-	1
Cu	27	54	63	30	-	0
Pb	200	400	300	300	-	-
Hg	0.087	0.174	12	0.444	-	0
Mo	15	30	10	20	-	-
Ni	1139.25	2278.5	50	2300	-	5
Se	2.6	5.2	1	3.5	-	1
Ag	8.5	17	20	10	-	-
Sn	35	70	50	50	-	-
V	36.75	73.5	130	34	-	0
Zn	69.5	139	200	133	-	0
PCBs			1.3	0.05	-	-
Asbestos-Chrysotile (%)	2	4		40	0.5	-
SUM					**0.5**	**18**

CCME Soil Quality Guidelines based on ecological component where available.
Otherwise, generic residential/parkland guidelines were used.

Clinton Creek - Surface Water Concentrations (ppm)

	Avg. Background		CCME	Measured	Score	
Contaminant	**Mean**	**2xMean**	**Guideline**	**Maximum**	**Background**	**CCME**
Nutrients						
Ammonia Nitrogen[a]	0.02	0.04	1.54	0.017	-	0
Nitrate Nitrogen	0.129	0.26	13	0.499	-	0
Nitrite Nitrogen	0.001	0.002	0.06	0.023	-	0
Total Metals						
Al	0.035	0.069	0.005	0.188	-	5
Sb	0.0005	0.001		0.023	0.5	-
As	0.00055	0.0011	0.005	0.017	-	1
Ba	0.05	0.1		0.06	0	-
Be	0.001	0.002		0.01	-	-
B	0.1	0.2		5.3	0.5	-
Cd	0.00005	0.0001	0.000017	0.00025	-	5
Cr	0.001	0.002		0.005	0.5	-
Co	0.0003	0.0006		0.0015	0.5	-
Cu	0.002	0.004	0.002	0.005	-	1
Fe	0.12	0.24	0.3	0.67	-	1
Pb	0.0005	0.001	0.001	0.0025	-	1
Mn	0.02	0.05		0.2	0.5	-
Hg	0.00005	0.0001	0.000026	0.00005	-	-
Mo	0.001	0.002	0.073	0.01	-	0
Ni	0.0035	0.007	0.025	0.092	-	1
Se	0.002	0.004	0.001	0.016	-	5
Ag	0.00002	0.00004	0.0001	0.0002	-	-
Tl	0.0002	0.0004	0.0008	0.002	-	-
Sn	0.0005	0.001		0.005	-	-
Ti	0.01	0.02		0.01	-	-
U	0.003	0.006		0.01	0.5	-
V	0.03	0.06		0.03	-	-
Zn	0.005	0.01	0.03	0.05	-	-
Asbestos - Chrysotile (millions/L)	4.65	9.3		152.5	0.5	-
SUM					**3.5**	**20**

CCME Freshwater Guidelines for the Protection of Aquatic Life

a - Ammonia CCME Criteria:

Assuming pH of 7.5 and Temperature of 20 ^{o}C yields a guideline of 1.54 mg/L ammonia

CLINTON CREEK MEASURED DATA

Prepared by: Mo-Ki Tai
Checked by: Mo-Ki Tai

Clinton Creek - Sediment Concentrations (ppm)

	Background		CCME	Measured	Score	
Contaminant	**Mean**	**2xMean**	**Guideline**	**Maximum**	**Background**	**CCME**
Sb		0		100	-	-
As		0	5.9	11	-	1
Ba		0		223	-	-
Be		0		3	-	-
Cd		0	0.6	0.6	-	0
Cr		0	37.3	1670	-	5
Co		0		89	-	-
Cu		0	35.7	26	-	0
Pb		0	35	300	-	-
Hg		0	0.17	0.08	-	0
Mo		0		10	-	-
Ni		0		1920	-	-
Se		0		1.6	-	-
Ag		0		10	-	-
Sn		0		50	-	-
V		0		30	-	-
Zn		0	123	97	-	0
Asbestos-Chrysotile (%)	0.5	1		10	0.5	-
SUM					**0.5**	**6**

CCME Interim Sediment Quality Guidelines

Measured value is below method detection limit and is assumed to be at MDL.
These values were not carried forward into the assessment.