FINAL REPORT
ON

ECOLOGICAL RISK EVALUATION FOR KENO HILL MINE SITE

LEVEL 1 CUSTODIAL INPUT SECTION

Prepared for:

**Department of Indian Affairs
and Northern Development**

Prepared by:

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November 2003

Printed on Recycled Paper Containing Post-Consumer Fibre

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:	**Keno Hill Mine**
Province/Territory:	**Yukon Territory**
Custodial Department:	**Department of Indian Affairs and Northern Development**
Site Location (latitude and longitude):	**Keno Hill Mine is located approximately 354 km N of Whitehorse (452 km by road) and surrounds the communities of Keno City and Elsa (63°55'N and 135°25'W).**

Provide a brief description of the site:
The Keno Hill Mine is considered to be Canada's second largest producer of silver. Over 6.8 million kg of silver was produced from over 93 mine sites. These sites are spread over an area of 26 km by 6 km located on three hills that rise to elevations of approximately 1400 m. Keno City is located within this area and is currently home to 30 to 40 residents. **Significant flow (up to 15 L/s) from at least four adits, releases metal laden mine water (up to 123 mg/L zinc) into local surface waters. Metal leaching from tailings impoundments and the Husky waste rock dump is also a major environmental concern.** **The climate is continental arctic to sub-arctic with irregular regions of permafrost. Numerous creeks drain from the three hills and eventually join with the McQuesten River. Trapping and small-scale logging operations have occurred in the area. Arctic grayling have been observed in local drainages. The McQuestern River, which the local streams drain into, is suitable habitat for juvenile Chinook Salmon.**

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
Hatch 2003. *Preliminary Site Evaluation and Prioritisation of Safety and Environmental Issues of the Keno Hill Property, Yukon*. Department of Energy Mines and Resources Government of Yukon.July.	**JULY 2003**
Public Works and Government Services Canada 2000 "Keno Valley/Dublin Gulch Environmental Baseline Assessment "Prepared for DIAND. March.	**MARCH 2000**

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: **NO**

Study Title	Study Outcomes

Has the Study been peer-reviewed? Yes/No; Comments: **NOT APPLICABLE**

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, small terrestrial animals, and downstream aquatic environments.
List chemicals of concern:
Metals, Cyanide Products, Hydrocarbons and potentially PCBs.
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: **86.5**

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**	**Soil, sediment, and groundwater has not been assessed. Testing has not been conducted for hydrocarbons or PCBs.**
Were the approximate size of site and quantity of contaminants provided?	**Size of Site: Yes Quantity of Contaminants: No**	**With the exception of tailings, size of contaminants has not been quantified.**
Are the site assessment data collected representative of the site contamination?	**Yes**	**However soils, sediment, and groundwater data have not been collected.**
Are the QA/QC (quality assurance / quality control) data acceptable?	**No**	**QA/QC assessment was not documented or discussed.**
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 Tailings: Yes Surface soil: No Sediment : No Surface Water : Yes**	**No groundwater, soil or sediment samples collected. Tailings analyzed for metals. Surface water was analyzed for metals and cyanide products.**
Has the extent of contamination been delineated (*i.e.,* horizontal and vertical contamination) in <u>all significantly impacted media?</u>	**No**	
Have background concentrations been evaluated and identified for chemicals of concern?	**Surface Water: Yes Sediment: No Surface Soil: No Ground Water: No**	**Background concentrations were only evaluated for metals in surface water.**

Information Review	Yes/No	Comments
Were the following items defined on a <u>regional and local basis</u>: 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)?	**Yes** **Yes** **No** **No** **No** **No**	**Regional surface water drainage patterns are well established.**
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: No** **Off-Site: No**	
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 details on the site.

- **Reference documents:**

1. Hatch 2003. *Preliminary Site Evaluation and Prioritisation of Safety and Environmental Issues of the Keno Hill Property, Yukon*. Department of Energy Mines and Resources Government of Yukon.
2. Public Works and Government Services Canada 2000 “Keno Valley/Dublin Gulch Environmental Baseline Assessment “Prepared for DIAND. March.

- **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	✔		
Category 3: Provincial/National Parks, ecological reserve; area of high biodiversity; sensitive arctic environments			✔
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 = 14** **SCORE = 14**		
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	**Water samples have not been tested for hydrocarbons or PCBs.**
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	
	No	Pesticides	Y	N	
	No	PCBs	Y	N	
	No	Soluble inorganics	Y	N	
	Yes	Others **(Cyanide products)**	Y	N	
Surface Sediment	**No**	Metals	Y	N	**No sediment sampling has been conducted at Keno Hill.**
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	
	No	Pesticides	Y	N	
	No	PCBs	Y	N	
	No	Soluble inorganics	Y	N	
	No	Others	Y	N	
Surface Soil	**Yes**	Metals	Y	N	**Five tailings samples were collected and analyzed for metals. No natural soils testing has been conducted at Keno Hill.**
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	
	No	Pesticides	Y	N	
	No	PCBs	Y	N	
	No	Soluble inorganics	Y	N	
	No	Others	Y	N	
Groundwater	**No**	Metals	Y	N	**No groundwater samples were collected or tested at Keno Hill.**
	No	PAHs	Y	N	
	No	PHC	Y	N	
	No	VOCs	Y	N	
	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:** **Barium** **Manganese** **Strontium**	**No** **No** **No**	**0**
Sediment	**Not Measured**	**Not Measured**	**0**
Surface Soil/Tailings	**Metals:** **Iron** **Manganese** **Strontium** **Titanium**	**Background Concentration not Available.**	**0**
Groundwater	**Not Measured**	**Not Measured**	**0**
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 = 0** **SCORE = 0**		

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** **Cadmium** **Chromium** **Copper** **Iron** **Nickel** **Selenium** **Zinc** **Cyanide Products:** **Ammonia** **Nitrate**	CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life	 **5** **5** **5** **5** **2** **2** **5** **5** **0** **0**
Sediment	**Not Measured**	Not Applicable	
Surface Soil/Tailings	**Metals:** **Antimony** **Arsenic** **Barium** **Beryllium** **Cadmium** **Cobalt** **Chromium** **Copper** **Mercury** **Molybdenum** **Nickel** **Lead** **Silver** **Tin** **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)** **For TPH: Canada-Wide Standard for Petroleum Hydrocarbons in Soil – Ecological Soil Contact from CCME 2001 residential land use.**	 **5** **5** **1** **0** **5** **0** **0** **1** **0** **0** **0** **5** **2** **0** **0** **5**

Source Matrix	Chemical Category and Parameter (please list)	Evaluation Criteria	Score (Please score each parameter in each category listed – See scoring guide below)
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)	**0**
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 = 63** **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 unstable dams containing the Elsa Tailings (4.6 million tonnes) pose the greatest hazard to wildlife. Numerous surface openings, ventilation shafts, adits, and small pits also pose physical risk to wildlife. Additionally, numerous buildings around the site are deteriorating and are very unstable.	**1. Unstable tailings dams. 2. Surface openings. 3. Unstable mine structures and buildings.**	**1. Failure or breach of the tailings dams, causing release of up to 4.6 million tonnes of tailings. 2. Collapse of underground workings. 3. Collapse of unstable mine structures or buildings.**	**1. High 2. Low 3. Low**	**5 1 1**
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 = 7** **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 – Aluminum	**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 – Antimony	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 – Arsenic	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 – 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 – Cadmium	**1**	High Low	1	High Low	**1**	High Low	1	High Low	1	High Low	**2.5**
	0.5		0.5		0.5		0.5		**0.5**		
	0		**0**		0		0		0		
Metals – Copper	**1**	High Low	1	High Low	**1**	High Low	1	High Low	1	High Low	**2.5**
	0.5		0.5		0.5		0.5		**0.5**		
	0		**0**		0		0		0		

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 – Chromium	**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 – Iron	**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 – Lead	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 – Nickel	**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 – Selenium	**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 – Silver	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 – Zinc	**1**	High Low	1	High Low	**1**	High Low	1	High Low	1	High Low	**2.5**
	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 = 22.5** **SCORE = 22.5**

[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.

Worksheet 4 – Risk Summary Score

Category	Score
Ecological Habitats – Apply Score from Worksheet 1	**14**
Chemical/Physical Hazards - Apply total of scores from Worksheet 2B 0/5 2C 20/20 2D 5/5	**25**
Scale of Impact – Apply score from Worksheet 2E	**25**
Operable Pathways and Exposure Assessment - Apply score from Worksheet 3	**22.5**
Total Score	**86.5**

APPENDIX A

SITE CHARACTERIZATION AND PHYSICAL HAZARDS

SITE CHARACTERIZATION AND PHYSICAL HAZARDS

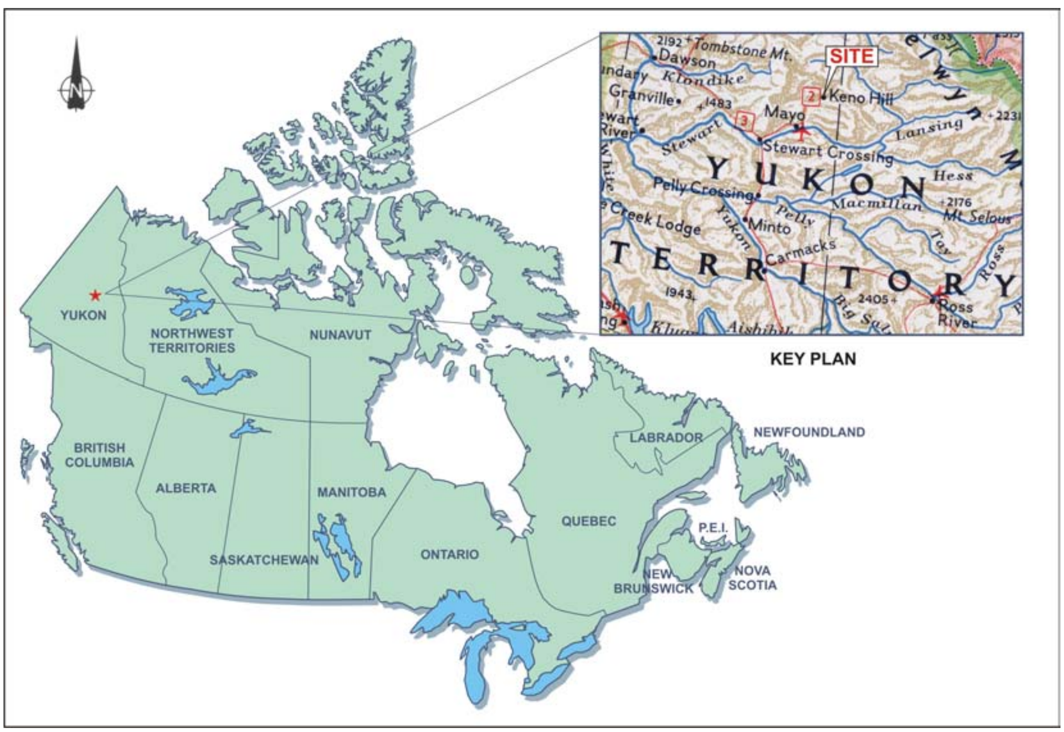
The Keno Hill site is located in the Yukon Territory and has been mined for lead, silver and zinc since the early 1900's. The last mining operations were completed in 1989 and following closure of the mine, the property was placed on care and maintenance. The Keno Hill mine is considered to be Canada's second largest producer of silver (Hatch 2003). From 1914 to 1989, about 6.8 million kg of silver was produced from 93 mine sites located around the property. The mining operations were spread over an area about 26 km by 6 km.

This section provides a brief description of the United Keno site and its physical characteristics.

SITE DESCRIPTION

The United Keno site is located in the central Yukon Territory, about 354 km north of Whitehorse (see Figure A.1). Keno City and Elsa Village are in the vicinity of the site. Elsa Village is currently unoccupied following the shutdown of the Elsa Mine in 1989. At one time, 400 people lived in Elsa and there are many remaining buildings in various conditions. Keno City is currently occupied with 30 to 50 residents. It is a Yukon tourist destination on the Silver Trail, with several tourist attractions and accommodations. The area surrounding the Keno Hill site has been used for centuries by local First Nations for their traditional lifestyle.

FIGURE A.1
LOCATION OF THE UNITED KENO SITE

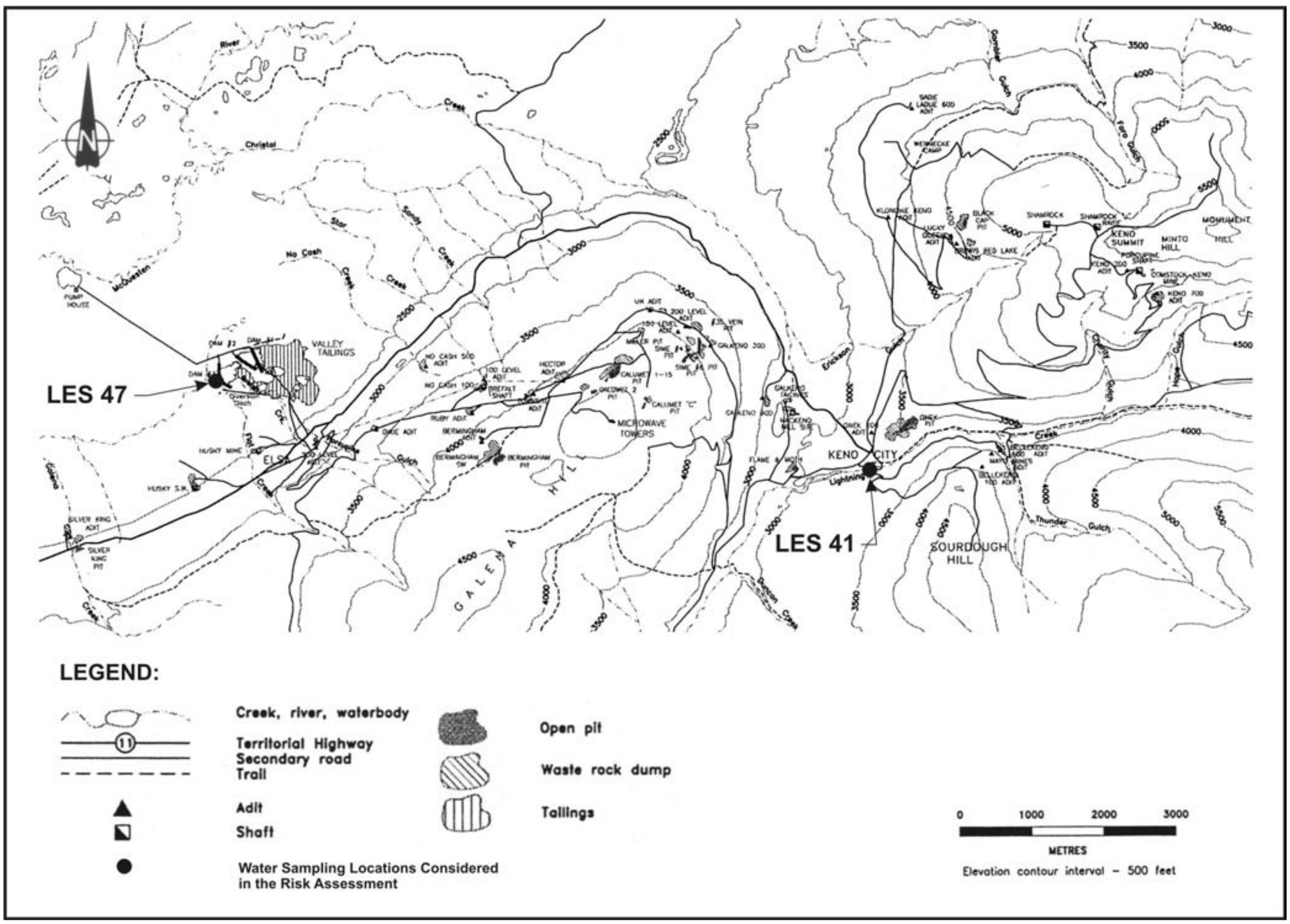


Source: National Geographic (1999).

The site is accessible by a 407 km paved road from Whitehorse to Mayo and a 45 km all weather gravel road from Mayo to Keno City. Many of the mining sites around the Keno Hill area are visited by tourists. There are guiding-outfitting operations and two territorial campgrounds in the area. Trapping concessions are located within the Keno Valley area and trapping is an important way of life for many residents.

Mining occurred at 93 sites across three hills (Keno, Galena and Sourdough Hills). Lightning Creek drains to the south of the hills towards the Mayo River, which runs to the McQuesten River and on to the Stewart River. Flat Creek drains the south west side of Galena Hill, with headwaters including Porcupine Gulch, Brefalt Creek and Galena Creek. Flat Creek eventually joins the McQuesten River. Christal Creek drains the east side of Keno Hill and the north, east and west side of Galena Hill. The McQuesten River valley is to the north of the three hills. Figure A.2 provides an overview of the site.

FIGURE A.2
OVERVIEW OF THE UNITED KENO SITE



Source: Hatch (2003).

PHYSICAL FEATURES

Physical Hazards at Mine Sites

Typically, there are numerous potential physical hazards associated with abandoned mine sites. The nature of these physical hazards depends on whether the mine was an open pit or underground mining operation and to what degree closure and decommissioning measures have been implemented. The following paragraphs describe the most important hazardous features of abandoned mine sites.

Surface (Shaft) Openings

Vertical mine openings associated with underground mines include shafts, ventilation raises and surface openings associated with mine workings. 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.

Ventilation raises are typically smaller than shafts and may be scattered at multiple locations. Surface openings may also include areas where underground working have intersected the surface or areas where the surface has collapsed into the underground mine.

Adits

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

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 sulphide 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.

Open Pits

Not all mining is carried out 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 conditions. 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 (in southern mines associated with swimming) 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. The 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 saturated fines and a pond of water. Without ongoing care and maintenance, tailings dams deteriorate and are subject to failure resulting in 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 by 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.

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 United Keno Site

Table A.1 summarizes the physical features and hazards present at the United Keno Mine site. These hazards present include:

- unsealed mine openings;
- steep loose rock piles;
- open pits; and
- unstable surface structures.

Asbestos Containing Materials (ACM) in various forms exist at several of the sites assessed in this study. In most jurisdictions, ACM is defined as any material containing more than one percent (1%) asbestos. Based on this definition, most asbestos containing material found at the abandoned mine sites and former military sites (e.g. insulated piping, asbestos board) would be classified as ACM. Accidental or intentional disturbances of ACM can result in fibre release and consequently pose a health hazard to individuals handling the material. This particular health hazard has not been considered in these SLRAs.

TABLE A.1
PHYSICAL FEATURES OF THE UNITED KENO SITE

Physical Parameter	Key Features	Characteristics	Description
Tailings Impoundments		General Information	6800 tonnes silver from >4.6 million tonnes of ore were produced from over 34 underground mine sites (425,600 tonnes of ore from one open pit).
		Total Tailings Volume	>4.6 million tonnes
		Dates of Tailings Deposition	Wernecke Mill (Keno Hill): 1924-1933; Elsa Mill (Galena Hill) 1935-1989.
	Wernecke Mill Tailings	General Information	The Wernecke Mill, 110 tpd mill at Keno Hill, was operated from 1924 to 1933 (relocated to Elsa in 1933). Tailings were assumed to be produced, but there is no mention of tailings deposition in this area.
		Additional Information	See Footnote 1
	Christal Lake/Galkeno Tailings	General Information	Mackeno Mill deposited Galkeno Tailings into Christal Creek, Christal Lake, and the eastern shore of Christal Lake.
		Tailings Volume	Approx. 40,000 tonnes
		Dates of Deposition	1952-1954
		Additional Information	See Footnote 1
	Flat Creek/Elsa Tailings (Uncontained)	General Information	Tailings were discharged from the mill and allowed to flow down Porcupine Gulch, along the adjacent hillside, and into the bog and headwaters of Flat Creek.
		Tailings Volume	See Footnote 1
		Dates of Deposition	1936-1961
		Tailings Surface Area	See Footnote 1
		Tailings Average Depth	See Footnote 1
		Avg Depth to Water Table	See Footnote 1
		Physical Stability	Unknown. Tailings remain unconfined on the hillside and in drainages.
		Geochemical Characteristics, Acid Base Accounting (ABA)	See Footnote 1
		Groundwater Seepage Rate	See Footnote 1
		Surface Discharge Rate	See Footnote 1
		Cover Type	None
		Vegetation	See Footnote 1
		Erosion	Erosion is presumably ongoing as tailings remain unconfined.

TABLE A.1 (Cont'd) PHYSICAL FEATURES OF THE UNITED KENO SITE

Physical Parameter	Key Features	Characteristics	Description
Tailings Impoundments	**Flat Creek/Elsa Tailings (Uncontained)**	Accessibility	See Footnote 1
		Additional Information	Tailings released during two dam breach episodes in the 1960s and two dam failures since 1972 have transported additional tailings (volume not determined) downstream. Tailings are reportedly up to 20 km downstream in the South McQuestern River.
	Elsa Tailings Contained Area	General Information	A series of three dams were built in sequence on the western side of the bog at Flat Creek to contain tailings.
		Tailings Volume	4.6 million tonnes
		Dates of Deposition	1962-1979.
		Tailings Surface Area	Estimated 75 ha.
		Tailings Average Depth	See Footnote 1
		Avg Depth to Water Table	See Footnote 1
		Physical Stability	See Footnote 1
		Geochemical Characteristics, Acid Base Accounting (ABA)	See Footnote 1
		Groundwater Seepage Rate	See Footnote 1
		Surface Discharge Rate	See Footnote 1
		Cover Type	Most tailings are dry and uncovered. Some tailings are under water cover (volume unknown).
		Vegetation	Approx. 10% of tailings have naturally revegetated.
		Erosion	Drainage from Porcupine Gulch continues to erode tailings downstream into Flat Creek, especially in spring.
		Accessibility	Tailings are accessible.
		Additional Information	Tailings flowed down Porcupine Gulch to the containment area. Residual tailings remain in the gulch. In 1979, a diversion ditch was built to divert water around the tailings impoundment to prevent erosion. The ditch continues to erode tailings into Flat Creek.
	Dams	General Information	Dam #1 built in 1962; Dam #2 built in 1972 and Dam #3 was built in 1979.
		Dimensions	See Footnote 1
		Type of Construction	Gravel and waste rock on top of frozen peat and silty till.
		Discharge Structure	No suitable spillways or discharge structures.
		Seepage	Seepage, although not quantified, is significant.
		Erosion	See Footnote 1

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF THE UNITED KENO SITE

Physical Parameter	Key Features	Characteristics	Description
Tailings Impoundments	**Dams**	Stability	Dam #1 breached several times in the 1960s and has failed twice since 1972. Dams were considered marginally stable in 1996 (built on permafrost). A dam assessment has not been conducted.
		Additional Information	In 1996 a toe berm was added to dam #1 and remedial lifts have been added to the subsiding dams up to 2001.
	Dykes	General Information	No dykes were identified on the site.
Pits		General Information	Beginning in 1977, several pits were excavated to develop 14 deposits. A total of approximately 425,600 tonnes of ore was produced from these pits.
		Additional Information	See Footnote 1
Underground Workings		General Information	Numerous surface openings are associated with the 34 mine sites in the area. For specific information on all the openings, please see footnote 1.
	Surface Openings	General Information	Numerous surface openings provide access to the 34 underground mines in the area.
		Volume	See Footnote 1
		Depth	See Footnote 1
		Contents of Workings	See Footnote 1
		Depth to Watertable	See Footnote 1
		Groundwater Seepage Rate	See Footnote 1
		Surface Discharge Rate	Surface discharge is occurring from 5 adits (metal-enriched; mostly neutral pH): Galkeno 300 adit: 40-50 L/sec (123 ppm Zinc); No Cash 500; Galkeno 900; Silver King; and Bellekeno.
		Stability	Ice plugs and ice plug failures are hazard (Onek adit near Keno City has had 3 documented ice plug failures).
		Accessibility	See Footnote 1
		Ventilation/Gases	See Footnote 1
		Additional Information	The Hector-Calumet workings reportedly produced over half of the total ore from 1935-1972.
	Number and Type of Opening	General Information	Onek Adit is within 100m of residents in Keno City and within 300 m of the community groundwater well supply.
		Volume	See Footnote 1
		Depth	See Footnote 1
		Contents of Workings	Flooded
		Depth to Watertable	Flooded (not determined)

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF THE UNITED KENO SITE

Physical Parameter	Key Features	Characteristics	Description
Underground Workings	**Number and Type of Opening**	Groundwater Seepage Rate	See Footnote 1
		Surface Discharge Rate	Not determined. Surface water contained 0.998 ppm Cd and 24.2 ppm Zn in 1996. Water discharges from the adit and recharges into groundwater.
		Stability	Ice plugs and ice plug failures are hazard (Onek adit near Keno City has had 3 documented ice plug failures).
		Accessibility	See Footnote 1
		Ventilation/Gases	Flooded.
		Additional Information	See Footnote 1
Waste Rock Piles		General Information	There are numerous waste rock piles (>25) around the 34 mines at this site. These piles have not been described, neither by number, volume, or characteristics of material. Waste rock is currently assumed to not be acid generating (low pH seepage is uncommon); however its long-term stability is uncertain. The one ARD waste rock pile identified is from at Husky Mine.
	Husky Mine Waste Rock Pile	General Information	This is the only waste rock pile identified creating ARD.
		Location	Husky Mine, east of Silver King, downslope of Elsa.
		Volume	See Footnote 1
		Surface Area	See Footnote 1
		Height/Depth	See Footnote 1
		Depth to Water Table	See Footnote 1
		Geochemical Characteristics, Acid Base Accounting (ABA)	Observations of iron and precipitate staining. Seepage had pH of 2.6 to 3.6 in 1999.
		Groundwater Seepage Rate	See Footnote 1
		Surface Discharge Rate	See Footnote 1
		Cover (water, soil, sand, none, etc.)	See Footnote 1
		Vegetation	See Footnote 1
		Sloped/Graded Surfaces	See Footnote 1
		Erosion	See Footnote 1
		Physical Stability	See Footnote 1
		Additional Information	See Footnote 1
	Other Waste Rock Piles	General Information	Numerous small-scale waste rock piles exist adjacent to the workings of the underground mines in the area.
		Additional Information	See Footnote 1
Infrastructure (Keno Hill)		General Information	Documented evidence of spills around the fuel and oil tanks.
Infrastructure (Mackeno Mill Site)		General Information	No information on this mill site is available. Reportedly in operation from 1952-1954.

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF THE UNITED KENO SITE

Physical Parameter	Key Features	Characteristics	Description
Infrastructure (Elsa)		General Information	Town of Elsa inhabited by up to 400 people from 1929 to 1989.
		Date of Construction	1929-1980s
		Number of Buildings	Numerous (>57), including industrial buildings (poor condition), and school, recreation center, swimming pool building, bunkhouse, etc in relatively good/fair condition.
		Type of Construction	Varies, wood and steel.
		Condition/Stability	Varies from poor to good.
		Accessibility	Unknown
		Additional Information	21 buildings reportedly contain asbestos.
Tank Farms		General Information	Not determined, although numerous above and below ground fuel and oil storage tanks are reportedly on-site.
		Type of Tanks and Number	See Footnote 1
		Contents and Volume	See Footnote 1
		Condition of Tanks	See Footnote 1
		Containment	See Footnote 1
		Documented Spillage	See Footnote 1
		Additional Information	See Footnote 1
Fuels, Chemicals, PCBs	**PCB**	General Information	A comprehensive audit or inventory of hazardous waste has not been done for the Keno Mine Site.
		Contents and Volume	A PCB storage building in on-site, however contents of the shed and historical use of PCBs is unknown.
		Container Type and Number	See Footnote 1
		Condition of Containers	See Footnote 1
		Evidence of Leakage/Spillage	See Footnote 1
		Documented Incidents or Spills	See Footnote 1
		Additional Information	See Footnote 1
	Contaminant Type	Type of Contaminant	Numerous hazardous materials and containers exist on-site, including: above and below ground fuel and oil storage tanks, 8 solid waste dumps, flotation reagents, and other chemicals.
		Volume	See Footnote 1
		Condition of Container	See Footnote 1
		Evidence of Leakage/Spillage	Documented evidence of spills around the fuel and oil tanks.

TABLE A.1 (Cont'd)
PHYSICAL FEATURES OF THE UNITED KENO SITE

Physical Parameter	Key Features	Characteristics	Description
Fuels, Chemicals, PCBs	**Contaminant Type**	Documented Incidents or Spills	Not determined
		Additional Information	Reportedly no explosives or cyanide on-site.
Additional Physical Hazards		General Information	See Footnote 1

Note: 1. See individual site reports prepared by PWGSC (2000) for details.

APPENDIX B

SUMMARY OF MAXIMUM MEASURED ENVIRONMENTAL DATA

KENO HILL MEASURED DATA

Prepared by: Justin Stockwell

Checked by: Mo-Ki Tai

Keno Hill - Tailings Concentrations (ppm)

	Background		CCME	Measured	Score	
Contaminant	**Mean**	**2xMean**	**Guideline**	**Maximum**	**Background**	**CCME**
Sb		0	20	230	-	5
As		0	17	1800	-	5
Ba		0	500	606	-	1
Be		0	4	0.6	-	0
Cd		0	10	174	-	5
Co		0	50	9.5	-	0
Cr		0	64	35.1	-	0
Cu		0	63	149	-	1
Fe		0		130000	-	-
Mn		0		50100	-	-
Hg		0	12	1	-	0
Mo		0	10	4	-	0
Ni		0	50	23.5	-	0
Pb		0	300	8100	-	5
Ag		0	20	149	-	2
Sr		0		51	-	-
Sn		0	50	6	-	0
Ti		0		802	-	-
V		0	130	63	-	0
Zn		0	200	9960	-	5
SUM					**0**	**29**

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

Keno Hill - Surface Water Concentrations (ppm)

	Background		CCME	Measured	Score	
Contaminant	**Mean**	**2xMean**	**Guideline**	**Maximum**	**Background**	**CCME**
Al	0.03	0.06	0.005	0.08	-	5
Ba	0.044	0.088		0.05	0	-
Cd	0.003	0.006	0.000017	0.044	-	5
Cr	0.009	0.018	0.001	0.018	-	5
Cu	0.003	0.006	0.002	2.65	-	5
Fe	0.096	0.192	0.3	1.58	-	2
Mn	0.015	0.03		0.015	0	-
Ni	0.01	0.02	0.025	0.19	-	2
Se	0.03	0.06	0.001	0.09	-	5
Sr	0.048	0.096		0.057	0	-
Zn	0.004	0.008	0.03	3.85	-	5
Ammonia[a]	0.0025	0.005	1.54	0.463	-	0
Nitrate	0.03	0.06	13	0.276	-	0
SUM					**0**	**34**

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.